



# Wildland Urban Interface Fire Colloquium Proceedings June 2009



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**This space for GIS map depicting WUI Fire  
impacted states to be on inside cover**

# **Proceedings of the Wildland Urban Interface Fire Protection Research Colloquium**

**California Polytechnic State University,  
San Luis Obispo, CA  
June 17-18, 2009**

Cover photo: San Diego Union-Tribune

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# **Wildland Urban Interface Fire Protection Colloquium**

## **Preface**

The Wildland Urban Interface Fire Colloquium, held June 17-18, 2009, was one in a series of four hazards colloquia co-sponsored and funded by two Department of Homeland Security Science and Technology (DHS S&T) Directorate organizations, the Infrastructure and Geophysical Division (IGD) and the Office of University Programs (OUP). Other Colloquia in this series addressed coastal hazards (December 2008), geotechnical earthquake engineering (July 2009) and tsunamis (October 2009).

Each hazards colloquium convened scientists, academics, and policy-makers to discuss the current state of research and identify knowledge gaps. Topics centered around the phenomenology of natural hazards and the impact of natural hazards on the built and natural environment. The outcomes of the colloquia were used to assemble individual Proceedings reports similar to the document you are about to read. The Proceedings describe the colloquium discussions and the research topics and knowledge gaps identified by participants.

Each colloquium involved the efforts of several individuals within DHS S&T and the Center of Excellence (COE) for Natural Disasters, Coastal Infrastructure, and Emergency Management (DIEM).

*DHS S&T:* Chris Doyle, Acting Director, IGD and Matt Clark, Director, OUP developed the concept of the hazards colloquium series and provided the necessary funding. Mary Ellen Hynes, Director of Research, IGD, and Heidi Whiteree, Program Manager, OUP, guided the DIEM COE throughout the Colloquium planning process to ensure DHS S&T's goals were fully understood and addressed.

*DIEM COE:* The University of North Carolina at Chapel Hill is the research co-lead institution for the DIEM COE, under the direction of Gavin Smith, Executive Director, and Rick Luettich, Principal Investigator. DIEM COE partner institution California Polytechnic State University-San Luis Obispo spearheaded the Wildland Urban Interface (WUI) Fire Colloquium planning process under the leadership of Skip Parks and Dan Turner. These experts convened an outstanding group of individuals to lend their expertise and unique perspectives to the discussions of these critical research topics. Local, state, and federal emergency service responders provided an excellent field trip to illustrate first hand problems they faced during recent major WUI fires in Santa Barbara, California.

Local, State, and Federal fire protection agencies in Santa Barbara County, California provided an excellent tour of recent WUI fires that have impacted their region. The organizations provided each participant with an excellent 123 page compendium of maps, diagrams, images, pre-plan samples, lessons learned and their thoughts for solutions. In addition to the loss in property and environmental damage 16 firefighters have been killed battling wildland and WUI fires in this area during the last 40 years; a staggering number. The extraordinary effort put forward by the members of these agencies to explain their concerns and needs is an indication of the importance of finding solutions to the WUI fire problem.

*Colloquium Participants:* The subject matter experts assembled for the Wildland Urban Interface Fire Colloquium contributed their time and knowledge not only during the colloquium, but also throughout the Proceedings composition process. This Proceedings report relies on their combined input to convey the broad research agenda described. A complete list of Colloquium participants appears in Appendix A.

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## Executive Summary

Wildland Urban Interface (WUI) fires are not wildland fires and they are not urban fires; rather they are a fire type unique unto themselves that requires solutions that are designed to address this uniqueness from a preparedness, response and recovery perspective. Simply stated, WUI fires occur where burning structures and burning vegetation contribute to the fire spread. While WUI fires have been a nationwide problem for more than 150 years, the problem is expanding as more people move into the wildland areas of the country. WUI fire protection and prevention issues have become critical in the United States due to the loss of lives, property, critical infrastructure, threat to the economy and the social fabric of communities.

The Infrastructure and Geophysical Division of the Department of Homeland Security Science and Technology Directorate, through the University of North Carolina-Chapel Hill managed Center of Excellence in Natural Disasters, Coastal Infrastructure, and Emergency Management (DIEM) convened a focused research colloquium to solicit insight from academic, industry and government experts on bio-geophysical research issues pertaining to wildland urban interface (WUI) fire protection. The Wildland Urban Interface Fire Research Colloquium was held at California Polytechnic State University, San Luis Obispo, California June 17 & 18, 2009. Bio-physical refers to biological and geophysical conditions that relate to the WUI fire problem such as vegetation, weather, terrain, building materials and infrastructure. Social dynamic issues investigated were restricted to economics and evacuations specifically related to WUI fires.

Prior to the Colloquium, participants were provided with several publications related to WUI fire issues (Appendix C). Participants were asked to review the material, consult with their colleagues and come to the Colloquium with a list of top research topics in the field of Wildland Urban Interface fire protection. In addition to the pre-colloquium review material, participants were asked to complete worksheets identifying challenges and research topics for each of the three major areas of the WUI fire problem based on their observations during the Santa Barbara tour. Individual preparation prior to the colloquium, keynote presentations and observations from the Santa Barbara site visit served as the foundation for the small group discussions.

The workshop included keynote addresses from Kate Dargan, CA State Fire Marshal; Chris Dicus, Professor, Cal Poly State University; and Jack Cohen, Fire Research Scientist, US Forest Service. The addresses focused on the uniqueness of the wildland urban interface fire protection problem and core bio-geophysical issues in wildland urban interface fire protection. The workshop included a tour of recent wildland urban interface fires that occurred in the Santa Barbara, California area that provided dramatic real world illustration of the complexities of WUI fires.

Focusing on bio-geophysical technological issues, the research group identified priority research topic areas to frame a research agenda focused specifically on the wildland urban interface fire problem. Short and long-term research priorities were identified in the areas of Preparedness, Response, and Recovery.

The high priority research areas that emerged from the workshop participants included:

- New efforts need to be explored to best define the WUI fire problem and to develop new research methods and analysis tools to help reduce the impacts of these fires. Previous approaches have not kept pace with the expanding problem.
- Improved ignition resistant community and building design tools and materials related to new developments and retrofitting existing developments should be developed.
- New tools and technologies to assist the first responder community in safely and effectively suppressing these wildland urban interface fires should be developed.
- New tools or better utilization of existing remote sensing and information gathering and dissemination technology is needed to provide real time situational awareness to first responders.
- New tools are needed to better analyze the true cost of WUI fires from damages, suppression costs, and cascading impacts to the economy from the fire.
- Loss of critical infrastructure or interruption of critical services because of WUI fires can have significant and far reaching affects; resilient designs need to be developed.
- New tools and technologies are needed to speed the recovery process and return the community's environment, infrastructure, economy, and social fabric to normal.

## ***Introduction***

The mission of the Department of Homeland Security (DHS) is to protect the Nation from all threats to society's safety and security, whether those threats originate from malicious intent or from natural disasters. The DHS Science and Technology Directorate is charged with developing and transitioning innovative technologies and processes to security applications. The mission of the Directorate's Infrastructure and Geophysical Division (IGD) is to support research and development and provide solutions for protecting our Nation's critical infrastructure. This includes advancing emergency preparedness, mitigation and response capabilities as well as improved understanding of geophysical natural hazards.

Wildland urban interface fires are becoming an increasingly serious and costly natural hazard in the United States. Through the University of North Carolina, Chapel Hill managed DHS Center of Excellence in Natural Disasters, Coastal Infrastructure, and Emergency Management (DIEM), Mary Ellen Hynes, Director of Research for IGD, commissioned a series of research colloquia focused on natural hazards phenomenology, including wildland urban interface fires. California Polytechnic State University, San Luis Obispo, CA. (Cal Poly), a university partner in DIEM, served as the host for this WUI fire colloquium on June 17 & 18, 2009 (Appendix B.) Cal Poly has academic and research programs that focus on forestry and wildland urban interface fire protection, community planning and design, fire protection engineering, and landscape design.

The WUI Fire Research Colloquium began with welcoming remarks from Mary Ellen Hynes, DHS S&T Infrastructure and Geophysical Division, and Gavin Smith, Executive Director of the Center of Excellence in Natural Disasters, Coastal Infrastructure and Emergency Management (DIEM) at University of North Carolina-Chapel Hill.

The Colloquium included a gathering of WUI fire research scientists, academics, responders, policy experts, and practitioner agency administrators (Appendix A). The colloquium attendees included the following disciplines: wildland firefighters, urban firefighters, emergency management, forestry, fire science research, remote sensing and visualization, economics, national fire prevention, fire marshals, city and regional planning, fire protection engineering, climatology, evacuation methodology and post-fire forensics. Since WUI fires are a nationwide problem, the colloquium members not only represented the diverse professional disciplines but were from several geographical regions of the United States as well.

Colloquium participants were tasked with developing a research agenda by identifying research questions focused on the bio-geophysical characteristics of WUI fires that remain unanswered. While the socio-economic dimension of WUI fires is critical, other than economics and evacuations, the group focused on the bio-geophysical dimension. The WUI fire discussion was divided into the following three primary research areas:

- Preparedness/Mitigation issues,
- Response issues, and
- Recovery issues.

Within the Preparedness, Response, and Recovery categories the colloquium members were asked to consider the following sub-categories:

- WUI Fire Behavior and Modeling that includes suppression actions
- WUI Fire Command Training Simulators
- WUI Response System Capability Gaps
- WUI Post Fire Forensics
- WUI Fire Critical Infrastructure Protection
- WUI Fire Resilient Built Environment
- WUI Fire Evacuation Methodology-(i.e. Sheltering or other methodology)
- WUI Fire Geo-Physical Burned Area Recovery-
- WUI Fire Changes Related to Climate Change

### ***Colloquium Participants***

The group of scientists, academics and practitioners represented a broad cross section of the profession. Prior to the Colloquium, participants were provided with several publications related to WUI fire issues (Appendix C). Participants were asked to review the material, consult with their colleagues and come to the Colloquium with a list of top research topics in the field of Wildland Urban Interface fire protection. In addition to the pre-colloquium review material, participants were asked to complete worksheets identifying challenges and research topics for each of the three major areas of the WUI fire problem based on their observations during the Santa Barbara tour. Individual preparation prior to the colloquium, keynote presentations and observations from the Santa Barbara site visit served as the foundation for the small group discussions.

The participants identified WUI fire research topics and a recommended course of action. Within each of the broad focus areas, specific research topics were identified, categorized as short or long term research projects, and prioritized by the colloquium participants.

### ***Purpose of the WUI Fire Research Colloquium***

The purpose of this colloquium was to examine the WUI fire problem from a bio- geophysical science perspective in order to determine a research agenda that may bring cutting edge science and technology solutions to bear on the WUI fire problem. WUI fires burn more than houses; businesses and critical infrastructure are often damaged or destroyed by these fires. The cost in lives, injuries, homes and lost business and cost to suppress the fires is increasing at an alarming rate. The most damaging



Critical electrical grid transmission lines are frequently located in WUI fire areas and damaged by WUI fires. Photo: D. Turner

large fires have occurred in the last decade and with increasing frequency. Critical infrastructure, such as mountaintop communications sites, railroad trestles, electrical transmission networks, and military facilities that our nation depends on are often times damaged by these fires.

### ***What are Wildland Urban Interface Fires?***

Simply stated, WUI fires occur where burning structures and burning vegetation contribute to the fire spread. Wildland urban interface fires are not wildland fires; they behave differently and

***Wildland Urban Interface (WUI) fires are not wildland fires and they are not urban fires; rather, they are a unique fire problem that requires solution sets designed to address this uniqueness.***

create different challenges. Wildland urban interface fires are not urban fires; they behave differently and create different challenges. Too often solutions for WUI fire issues are relegated to federal land management agencies that have wildland fire problems to resolve. The WUI fire problem has more to do with community development, land use and building standards than wildland fire; functions that are not the

responsibility of agencies such as US Dept of Agriculture and US Dept of Interior. Recognition and understanding of the unique nature of the WUI fire problem is essential to defining the problem that will guide research that leads to better solutions.

Dan Turner, Executive Director of the Urban Forest Ecosystem Institute, Cal Poly, challenged the participants to focus on strategies that will make a positive difference in WUI fire outcomes with new research. Research that will break the cycle of escalating costs, damages, and the frequency of WUI fires. The key areas they considered are summarized below:

#### **Challenges:**

- **Preparedness Research Strategies**
  - Reduce WUI fire costs and losses by improving community resilience and responder preparedness through scientific bio-geophysical research.
  - Fire cause reduction research. Preventing unwanted fires is the most effective method of reducing costs and losses.
  - Training simulators and other tools to prepare responders
  - WUI specific fire behavior research and modeling
  - Resilient community, infrastructure, landscape and building design
- **Response Research Strategies**
  - Improving situational awareness, intelligence gathering, and real time responder location
  - Developing real time intelligence gathering and dissemination tools

- **Recovery Research Strategies**
  - Public and private land rehabilitation issues
  - Economic modeling of cascading impacts of WUI fires
- **Mitigation Research-Community Design, Built Environment and Critical Infrastructure Protection Research Strategies**
  - How do we design more resilient communities
  - How do we retrofit existing communities to make them more resilient
  - Critical infrastructure impacts during and after WUI fires are significant

### ***The Wildland Urban Interface Fire Problem***

WUI fires have been part of the United States fire protection problem for more than 150 years, the largest loss of life from a WUI fire occurring in Peshtigo, Wisconsin in 1871. During the last 50 years these fires have become more frequent, more complex, and more damaging. While the WUI fire focus is often on the West or Inter-Mountain West, serious WUI fires are occurring across most of the United States. WUI fire losses are increasing as more people move from urban settings into areas that are identified as wildland urban interface. In the last decade, many lives have been lost, thousands of buildings have been damaged or destroyed, critical infrastructure has been impacted and billions of dollars in suppression costs, damage repair and recovery costs have been expended.

A significant part of the problem is a poor understanding of what Wildland Urban Interface fires are. Many focus on the term "wildland" and assume it to be a forest fire solution; others see the term "urban" and assume it is a structure fire problem. In both cases they are wrong; WUI fires are a combination of both types of fires and require blended solutions. Previous approaches, solutions and remedies have been off the mark and not kept pace with the growth of the problem. Many solutions proposed 40 years ago (that have yet to be proven effective) are still being recommended with poor results; therefore a new examination and definition of the WUI fire challenge may be required.

***"Current after action report solutions are too narrowly focused and comprised of discipline specific, "Silo" solutions that are disconnected from other critical stakeholders. We need to look at the WUI fire problem from a holistic perspective."-Dan Turner, Cal Poly***

*Keynote presentations were used to define the problem:*

**1. Keynote presentation: State Fire Marshal Kate Dargan: *Shaping the Battlefield***

Kate Dargan, California State Fire Marshal provided an opening keynote address entitled “*Shaping the Battlefield*” that identified the scope of the WUI fire problem and how the lack of clear definition causes confusion and create obstacles to solutions. Her perspective is that



2003 Cedar Fire San Diego, CA  
Photo: K. Dargan

“wildland fires” are not causing the “WUI fire” problem, but rather WUI fires are causing negative impacts for appropriate wildland fire use. Wildland fires that burn vegetation, are a natural part of the ecosystem and are primarily an environmental quality issue. The issues surrounding appropriate solutions for purely wildland fires are frequently misunderstood, with poor results. WUI fires are not wildland vegetation fire problems but a “property loss problem” that, because of this misunderstanding, actually complicate use of beneficial wildland fires. Clarifying the definition of WUI fires is an important part of the larger problem.

Properly preparing the WUI areas that people have built in prior to the fire is the key to a successful firefighting mission. In Dargan’s words “it is less about preparing for the battle...and more about preparing the battlefield itself.” “Shaping the battlefield” refers to setting the conditions for success and decisive operations. If we “Shape the battlefield” such that if a wildland fire burns through an area and no significant damage occurs to the built environment or infrastructure we have a proper solution. This requires fire protection systems and community and building designs that are in concert with the flammable vegetation, weather and location hazards. If the battlefield (WUI area) is prepared properly, the battle (fire fight) will go much better.

***“If we Shape the Battlefield such that if a wildland fire burns through an area and no significant damage occurs to the built environment or infrastructure we have a proper solution.”- Kate Dargan, CA State Fire Marshal***

**WUI “Battlefield” problems :**

- Building Standards, buildings need greater ignition resistance
- Fire Fuels Management and Defensible Space, we don’t really know what works and what doesn’t
- Community Planning and Land Use Planning Risk assessment and mitigation strategies are not appropriate for problem
- We don’t fully understand the consequences of climate change and its affect on the WUI problem

- We do not have adequate training and education programs that prepare public officials, emergency responders and the public in the unique issues of WUI fires

**“Battle” (fire fight) capability enhancements necessary to make the fight more successful:**

- We do not have timely and adequate situational awareness capabilities during the early phases of WUI fires. We need to develop quick and easy tools to determine fire’s location, predicted fire behavior, intensity, direction of travel, and accurate location of responders and assets at risk
- We do not have adequate ability to utilize remote sensing technology to help enhance situational awareness and pre-event planning
- We do not have the capability to gather and deliver macro and granular critical information to fire personnel and others for pre-fire planning, response and post fire analysis in a timely manner

**2. Dr. Chris Dicus: 2009 Australia Fires and “Prepare, Leave Early or Stay and Defend” Policy presentation**

Dr. Chris Dicus, Professor, Cal Poly State University provided a presentation of his research and observations during the 2009 WUI fires in Australia. Australians experience many of the same issues regarding WUI fires as the United States. Dr. Dicus had been conducting WUI fire research in Australia from December 2008 and was present during the extreme WUI fire scenario that occurred in Southeastern Australia in February 2009. He returned to the U.S. to attend this

*“Fires are necessary, fire disasters are not...disasters occur when people and the built environment are involved”*.-Dr. Chris Dicus, Cal Poly

WUI Fire Research Colloquium and share his research perspective. Southeastern Australia was experiencing the most extreme fire weather in recorded history and several fires were burning at once in the State of Victoria. His presentation focused on his research and the physical conditions that existed in the Marysville area of Victoria, Australia on Black Saturday, the day 173 citizens were killed in major WUI fires. A specific focus of his research was on the Australian national policy of

individual preparedness and responsibility for wildland urban interface fire protection. The policy is known as, “Prepare, Leave Early or Stay and Defend.” The principle concept is for people to prepare their property and themselves in order to know what to do in the case of a fire. After they have done appropriate **Preparation**; their options are then to **Leave Early** or **Stay and Defend**. Adequate preparation is the key to fully understanding whether to Leave Early or Stay and Defend based on current conditions. What the preliminary post fire analysis indicates is many people were not adequately prepared or aware of the dangers they faced and as a result made poor decisions. Decisions to stay often resulted in deaths; delayed decisions to leave often resulted in deaths. In some situations the fire behavior was so extreme and rapid that people did not have adequate warning about the imminent threat and could not leave. Their only choice was to stay but, because they were not adequately prepared, several died. Dr. Dicus stated that “Fires

are necessary, fire disasters are not...disasters occur when people and the built environment are involved.” Research priorities in both biophysical and socio-economic areas are necessary to reduce damages and loss of life.

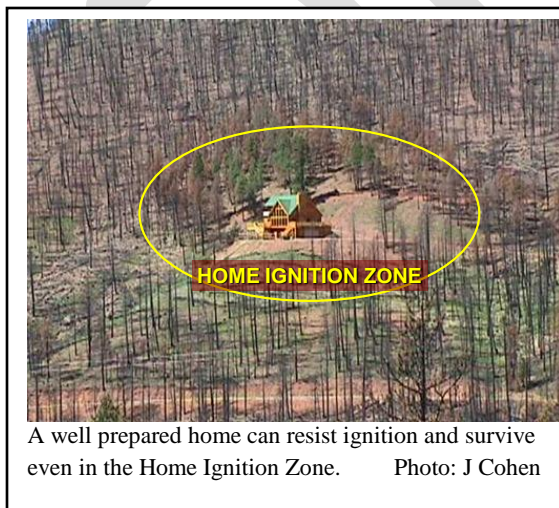
### 3. Jack Cohen, US Forest Service Fire Sciences Laboratory: *Home Destruction During Extreme Wildfires*

Jack Cohen, US Forest Service, Fire Sciences Laboratory, Missoula, MT presentation focused on *Home Destruction During Extreme Wildfires*. This presentation also focused on the difference between wildland fires and WUI fires. “Without people, wildfires are just natural disturbances, this interaction of people and wildland fire determines the wildfire problem”. The second point of Cohen’s presentation was that the focus on the forest fire component is miss directed; it is the ignition of the structures that is the problem. “If the forest burns and homes don’t ignite, homes don’t burn; if homes don’t burn, the WUI fire problem does not exist. This suggests we should address the WUI fire disaster in terms of home ignitions...not as a forest fire”



*“If homes don’t ignite, homes don’t burn; if homes don’t burn, the WUI fire problem does not exist.” - Jack Cohen, US Forest Service*

Cohen described the full scale timber crown fire experiments he conducted in the Northwest Territories. The research focused on the required radiant heat exposure and direct flame contact required to ignite and sustain combustion. His findings showed that 30 meters (100 feet) of separation from flame or radiant heat source (even of timber crown fire intensity) was adequate to prevent most building ignitions. Humans may not be able to survive in those radiant heat conditions but the buildings did not sustain combustion after the crown fire moved past. Cohen defined this 30 meter area around buildings as the “Home Ignition Zone (HIZ).” Proper management of the ignitable materials in the HIZ is very effective in eliminating structural ignitions and thereby reducing the WUI fire problem.



A well prepared home can resist ignition and survive even in the Home Ignition Zone. Photo: J Cohen

Cohen's presentation also disputed the belief that the main cause of multiple building fire losses during WUI fires is mainly from the burning vegetation spreading the fire from building to building. He showed several examples where entire WUI neighborhoods had been burned, yet the flammable vegetation was still unburned. *In these situations, the agent that spreads fire from*



Scripps Ranch area, San Diego, CA. Homes burned but Eucalyptus trees are unburned.  
Photo: J Cohen

*building to building was not the vegetation, but rather radiant heat or embers from the neighboring structures that were burning.* Cohen described the most common cause of building ignitions during WUI fires as being windblown firebrands or embers (glowing combustion). High winds are a common factor during extreme WUI fire events and contribute to the spread of millions of flying embers. The embers originate from burning vegetation or burning buildings, are carried by wind, land on combustible material, and ignite it. These flying embers have commonly been observed traveling up to 1 kilometer (1/2 mile). This wind driven flying

ember fire ignition situation is a primary cause of multiple building fires, often times overwhelming the fire fighting operations.

There simply is not enough equipment or personnel that can be mustered to stay ahead of windblown ignitions and remain with the saved buildings within the burned area to prevent subsequent ignitions or re-ignitions. This building to building fire spread scenario is a more common urban fire problem, not a wildland fire problem. Cohen demonstrated several instances where the wildland fire stopped when the forward edge reached a developed area but the fire continued as an urban conflagration with no vegetation burning. Cohen's presentation reinforced the concern about the failure of the historical approach to the WUI problem by only reducing the flammable vegetation. It is not practical to clear all flammable vegetation for distances of up to 1 km (1/2 mile) from structures, nor can we space buildings 1 km apart. Cohen emphasized that the solution lies with the design of the community and reducing the ignitability of the built environment in WUI areas. By reducing the threat of simultaneous multiple building ignitions, firefighting operations will become more effective, and damages and injuries will be reduced.

### Key points of Cohen's presentation:

- Wildland fires are an ecological process and inevitable during extreme conditions and we cannot stop them.

- We have not done enough to separate the WUI fire problem from the wildland fire problem. There is too much focus vegetation management and not enough focus on reducing structure ignitions.
- There following facts are not well understood and therefore lead to application of incorrect solutions to stop WUI fires:
  - If homes do not ignite, there is no WUI fire problem.
  - WUI fires occur when fire changes from wildland fuel to urban fuel.
  - High intensity *wildland* fires typically do not spread through dense residential developments; however, where the wildland fire stops a WUI fire that causes severe destruction begins by spreading from building to building.
  - Homes are part of the available WUI fire fuel and their burning contributes significantly to fire spread.
  - Homes are primarily ignited from flying embers where there is more than 30 meters of distance from radiant heat or flame sources.
  - Homes often ignite from embers hours after the wildland fire has passed and firefighters have moved on.

## *Santa Barbara, California WUI Fire Tour*

Colloquium participants boarded a bus for a tour of recent WUI fires in the Santa Barbara, California area. Local, state, and federal fire, law, and emergency management agencies made presentations and shared their perspectives during the tour. The following agencies participated in planning and delivering the presentation during this tour:

- City of Santa Barbara (Fire)
- Montecito Fire Protection District
- County of Santa Barbara (Fire, Sheriff, and Emergency Management)
- California Department of Forestry and Fire Protection (CAL FIRE)
- US Forest Service-Los Padres National Forest
- National Oceanographic and Atmospheric Administration (NOAA)

Historical fires are a strong indicator of future fire occurrence. Much like other natural hazards, severe wildland and WUI fires often reoccur in the same locations. The spread of development into areas that have a history of severe wildland fires will almost certainly lead to a severe WUI fire in the future. Santa Barbara has experienced several devastating WUI fires during the last 50 years. After each fire, lessons

were learned and efforts were made to improve performance and reduce impacts for the next fire.

Lessons learned from previous WUI fires, such as the Coyote fire (1964); Romero (1971), Sycamore Fire (1977), Honda Fire (1977), Paint Fire (1991), Gaviota Fire (2004) and Zaca Fire (2007) in the Santa Barbara area were used to guide adjustments in strategy and tactics for preparedness, response, and recovery by the

jurisdictional agencies. Three significant WUI fires occurred in 2008 and 2009. Gap Fire (July 2008), Tea Fire (November 2008) and Jesusitas Fire (May 2009). The Santa Barbara area agencies used these recent WUI fires to help illustrate to the colloquium the complexity the WUI fire problem in a real world setting. The May 2009 Jesusitas fire burned into the area previously burned six months earlier during the November 2008 Tea fire. Colloquium participants had the opportunity to view the area recently burned area (Jesusitas) and were able to compare it to one

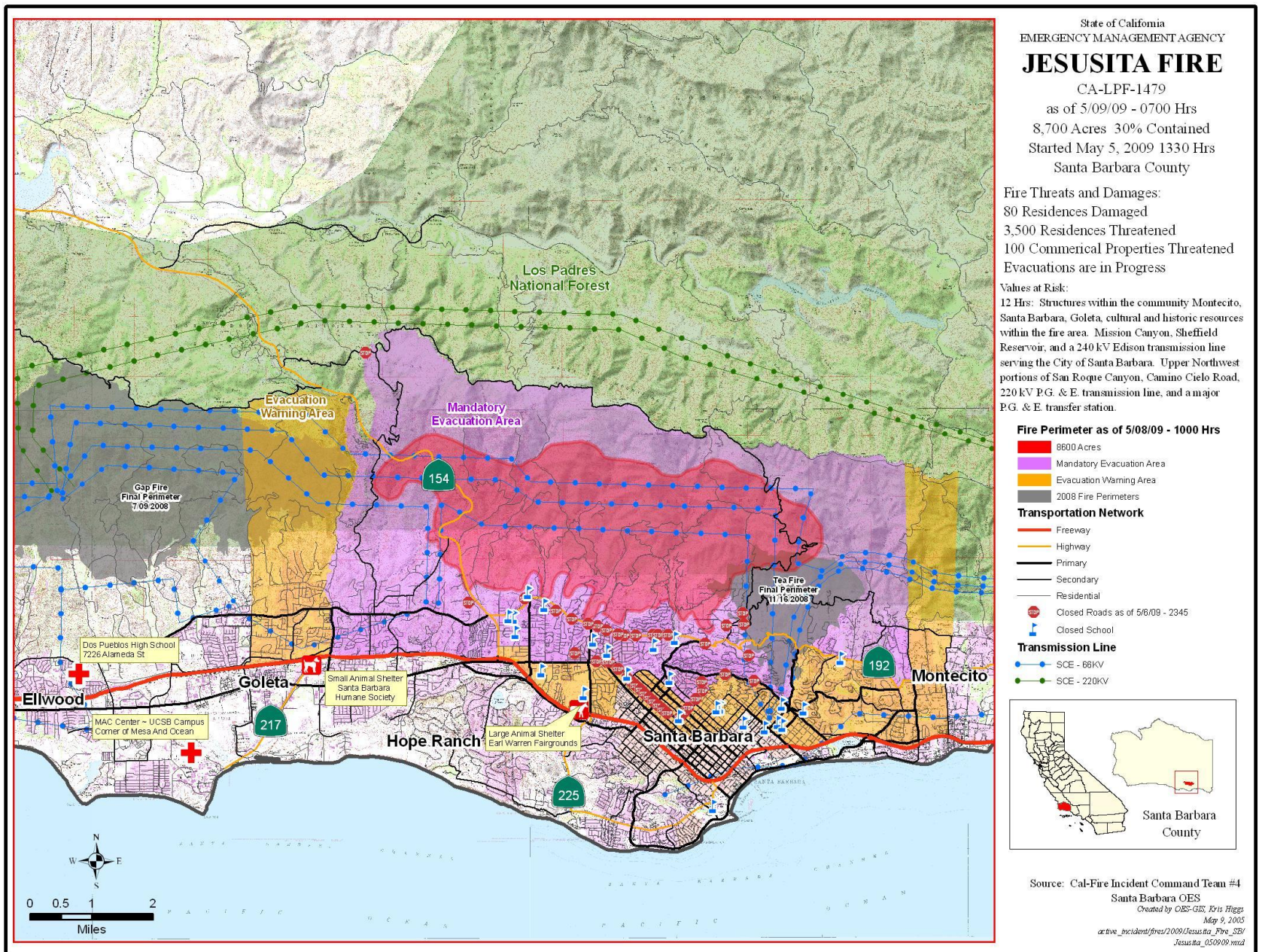


Jesusitas Fire May 2009. Fire is burning in WUI areas across an 8 mile front in the communities of Goleta, Santa Barbara, and Montecito (from left to right.) This area has experienced repeated severe WUI fires for more than 50 years. The Sycamore Fire in 1977, Paint Fire in 1990, and Tea Fire in 2008 destroyed hundreds of structures. Photo: Santa Barbara

that burned six months prior (Tea). The Jesusitas Fire operational map **on the next page** depicts evacuation areas and the boundaries of the three recent fires. It is interesting to note that much of the areas burned in the earlier Coyote Fire, Sycamore Fire and Paint Fire areas were re-burned in these latest fires. This further illustrates the importance of solutions that address structural ignitions as well as vegetation management mitigation measures. Whether burned or cut, the vegetation grows back as quickly as one year (or in the case of the Tea Fire area, six months) and is available to burn again. Vegetation removal or modification requires a constant maintenance mode. Structural ignition reduction mitigations usually only have to be done once and then last for several years or in some case the life of the building.



Pyro-cumulus convection column over Santa Barbara during Zaca Fire 2007. Photo: D Turner



The colloquium participants were escorted to three sites so they could observe the current situation and hear presentations from fire, law enforcement, and emergency management staff. At each site the Santa Barbara agency presenters used the location to illustrate and frame their presentations. Several important messages were delivered by the Santa Barbara group; the value of interagency coordination and cooperation at all levels of government emerged as one of the most critical. WUI fires do not stop at jurisdictional boundaries, in fact these fires burned in several jurisdictions simultaneously. Without strong pre-planning, training, and cooperation the impacts would have been significantly worse. The new, next fires for the Santa Barbara area were a focus for the colloquium participants' research agenda thoughts.

**Response issues the Santa Barbara groups identified are:**

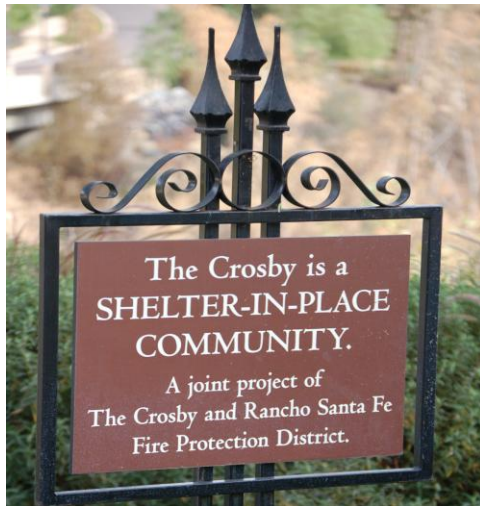
In the early stages of a WUI fire critical life safety decisions often are made with very limited situational awareness information. Incident Commanders do not have usable access to the important information components they need to make truly informed decisions. Critical situational and fire weather information (where is the fire now, what is burning now, predicted fire behavior, where is the fire spreading to, when will it get there, what is threatened, real time location of firefighting resources) is often not readily available or usable. Most times the critical questions above cannot be answered in the early phases of the fire. This lack of situational awareness can lead to underestimating the risk or placing people in situations that are unsafe. Remote sensing technology is not readily available to Incident Commanders in early phases of WUI fires to help them determine answers to many of the questions above.

During WUI fires it is common to order 50 to 100 mutual aid fire resources to assist due to the potential for multiple simultaneous structure fires within the first hour of the fire. Several hundred additional resources are often ordered within the first few hours. These mutual aid resources are often not familiar with local areas, do not have maps, and may not be aware of localized hazards. However, due to the urgency and lack of adequate time and personnel to conduct these briefings mutual aid crews are often sent to assignments without maps, weather briefings, knowledge of adjoining forces, or a clear understanding of the assignment because the Incident Command/staff have limited access to the critical information themselves. Providing this information to mutual aid resources is time consuming and labor intensive, yet critical for their safety and effectiveness of the operational outcome. Information exchange or briefings delivered while en route could expedite safe fire crew engagement.

Radio and critical situation information communications between these mutual aid resources is usually a large challenge. Even areas with inter-operable communications "bridges" do not provide for adequate number of operational frequencies for safety and efficiency.

There is considerable debate and contradicting agency policy direction about the safest place for fire responders to seek refuge during WUI fire burn over situations. Is it safer to seek shelter in

structures, in vehicles, in the open, in fire shelters, or other locations? Firefighter safety is at the highest risk levels during these events and indecision is a path to injury. There are several instances where firefighters have taken shelter inside threatened structures during burn over conditions and survived. However, five (5) US Forest Service firefighters died burning a burn over during a WUI fire in Riverside County, none of them took shelter inside the structure they were protecting because of policy conflicts.



The actual causal reason for loss of civilian lives in WUI fires is not well documented in the United States. While medical examiners list the cause of death from burn injuries; it is not clear why the citizens found themselves at such risk. Evacuating a fire area too late is commonly blamed on most of these deaths there has not been a study done in the United States to validate these assumptions. Australia clearly leads the US in fact finding related to civilian deaths and safety measures.

Finding solutions for the safe sheltering of people during extreme fire behavior should be a high priority for research scientists.

**Rancho Santa Fe community designed to provide safe refuge from WUI fire if residents cannot evacuate. Photo D Turner**

### **Recovery issues the Santa Barbara groups identified are:**

Environmental, economic, critical infrastructure and social recovery from WUI fires is complicated.

**Environmental** rehabilitation or burned area recovery in WUI fires is important. "Linked" or secondary disasters such as mudslides, water quality issues, or extreme erosion caused by the loss of natural vegetative cover are common. When wildland fires occur on public lands the land management agency can undertake erosion or post burn rehabilitation measures. WUI fires almost always occur on private land where necessary measures are more complicated to achieve. However the work necessary on private land is often more

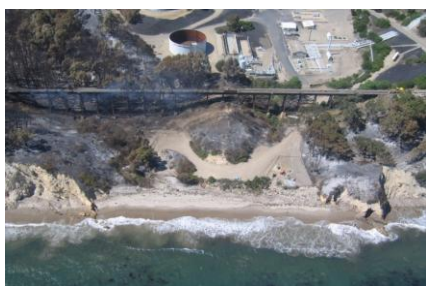


Without burned area rehabilitation, post fire soil erosion can cause damage to water supply reservoirs or mudslides. Photo D. Turner

critical than the public land in order to protect infrastructure and reduce damages from “linked hazards” caused by the WUI fire.

**Economic losses and recovery** from WUI fires extend beyond the damaged buildings or structures. Loss of jobs from destroyed businesses, cost of alternate housing during reconstruction, infrastructure damage and resultant cascading losses to people and businesses that depended on that infrastructure, lost productivity, and cost of suppressing the fire are all components of the true costs and losses.

**Critical infrastructure losses are significant.** During the Gaviota Fire in 2004 freight and passenger railroad traffic was disrupted for several days because of fire damage to a critical



Railroad Trestle destroyed and petroleum processing plant damaged during the 2004 Gaviota Fire. Photo: C Dicus

wooden railroad trestle. The resulting economic losses cascaded well beyond the cost to replace the trestle. Businesses and organizations that were dependant on their “just in time” deliveries had to adjust production schedules. Rail freight shipment revenue was lost. During the 2008 Gap Fire a critical electrical transmission facility was compromised resulting in loss of electrical power to thousands of customers in the south coast area of Santa Barbara County. **Other infrastructure sites that provide water treatment, water storage and pressure for firefighting, communications sites, and industrial**

**facilities including space launch facilities at Vandenberg Air Force Base have been threatened or damaged by WUI fires in this area.**

**Social normalization and return to a sense of safety is the social recovery objective.** This is much more complicated in a WUI fire than recovery from wildland fires or individual urban structure fires. The complexity, similar to severe storms, is caused by the widespread damage to the built environment and social structure of a community. Re-population of an evacuated area is



Re-population and re-building plans should be developed prior to the fire. Photo: D Turner

an important public relations and community social recovery issue. Like evacuations, this must be closely coordinated between law enforcement and fire agencies. Safety, infrastructure and timely communication to citizens as to when they can re-populate their neighborhoods are critical components of the decision process. Often times the rebuilt structures or infrastructure cannot meet current codes due to land use restrictions or physical site conditions (e.g. roads that are too narrow may not be improvable.) There is incredible pressure to rebuild as quickly as possible and waive new code requirements. Mitigation methods to reduce vulnerability in these foreseeable situations should be in place in advance.

## **WUI Fire Problem Descriptions:**

The following problem areas were identified by the Santa Barbara multi-agency coalition:

### **Preparedness issues the Santa Barbara groups identified are:**

#### **Community design:**

- Most structures were built prior to new WUI fire building codes and are more susceptible to ignition
- Retrofitting existing buildings to reduce ignitability is difficult
- Ember producers; wood shake roofs, wood decks, landscape design, combustible buildings, woodpiles are common in older construction
- Fences, sheds, and wooden play structures contributed to the fire spread
- Narrow roadways created ingress, egress, and evacuation problems
- Water delivery system inadequate, often due to loss of electrical power grid
- Lack of collaborative vision regarding community design at community, city, county, regional level for fire resilient designs has led to WUI disaster prone areas

#### **Critical Infrastructure:**

- New fire starts were caused by arcing power lines (wind whipped lines)
- Loss of electrical power to the “grid” from damaged transmission lines and towers is a critical; causing cascading problems from loss of pumping facilities for water to fight the fire to life support equipment in convalescent care facilities
- Water systems were unable to meet demand caused by multiple simultaneous fires and loss of electrical power
- Rail systems have been impacted by damage to structures (wooden trestles) and railroad ties rendering rail system out of service, causing cascading economic impacts
- Communication sites are located on mountaintops and are very susceptible to fire damage causing loss of emergency and public communication capability

#### **Hazard Reduction:**

- Resistance from community for large scale vegetative fuel reduction programs compounds wildland fuel accumulation
- 100 foot clearance of flammable vegetation requirement is effective but difficult to enforce and the vegetation grows back rapidly
- Public education programs for homeowner training is inadequate
- Ignition resistant building design is not taken into consideration adequately so that rebuilding efforts and new development are resilient to WUI fires
- It is not adequately understood that ornamental vegetation contributes to fire spread as much as native vegetation

## **The Santa Barbara Group did have some Evacuation Planning Successes!!**

- During 2007 Zaca Fire, a large scale evacuation plan for the Santa Barbara area was developed with CAL FIRE Incident Management Team incorporating local law and fire into one action plan, this plan was utilized during these fires with good success.
- Previous fire evacuation experience during other WUI fires and lessons learned proved valuable for these new fires.
- Local agencies had previously conducted three (3) evacuation exercises in areas burned during Tea and Jesusitas fire. These exercises resulted in better prepared responders and public members.
- Special needs and vulnerable populations were addressed in the plan with good success.
- Telephonic Emergency Notification System (Reverse 911©) worked well on Gap, Jesusitas, and Tea fires. They did discover that in order to improve notification speed with the telephone notification system “notification zones” should be pre-programmed into the software.
- Large and small domesticated animal evacuation is challenging but critical and can complicate evacuations.
- “Shelter-in-place “ (non-evacuation) areas were all pre-identified and pre-approved and no injuries to public members occurred in these areas.

## **WUI Research Needed to Address Problems**

### **Research priorities identified by Fire Marshal Dargan were:**

- We must clearly define the WUI fire problem.
- Develop better understanding of WUI fire forensics and ignition mechanisms.
- Develop standardized forensic analysis tools/processes.
- Establish better data collection and sharing methodology protocols and technology (prior to, during, and post fire).
- Develop situational awareness technology (prior to, during, and post fire) and means to distribute the information in a timely manner.
- Develop simpler and better applications of remote sensing technology during initial phases of the WUI fire.

### **Dr. Dicus' Research priorities**

- Improve structural ignition reduction technologies.
- Develop better understanding of the role of ornamental landscape plants versus native vegetation as fuel.
- Develop economical and effective ignition resistant structure materials.
- Improve response information technology systems to gather and disseminate appropriate data.
- Improve public preparedness, warning, evacuation, sheltering and recovery methodologies.
- Improve understanding of the linkages between WUI fires and secondary disaster (floods, mudslides, and water and air quality contamination) and developing better reduction methodologies.
- Develop methods and guidelines for rebuilding/retrofitting communities in a WUI resilient and sustainable manner.

## **Preparedness Research Strategies**

- First and foremost: We must clearly define the WUI fire problem.

## **Fire Behavior and Ignition Reduction**

- Develop better understanding of WUI fire forensics and ignition mechanisms.
- Develop better fire behavior prediction and fire behavior tools that incorporate the WUI environment and fire spread factors not just wildland fire characteristics
- Develop standardized forensic analysis tools/processes.
- Improve fire cause reduction research. Preventing unwanted fires is the most effective method of reducing costs and losses.
- Improve structural ignition reduction technologies.
- Develop better understanding of the role of ornamental landscape plants versus native vegetation materials in use, flammability and contribution to the WUI fire problem.

## **Firefighter Preparedness**

- Develop or improve on firefighter training programs that prepare wildland firefighters and urban firefighters for WUI fires including safe operating areas, safety zones, and safe shelter options during burn over conditions.
- Develop fire situation simulators for fire fighter training that duplicate real world conditions.
- Research the current Red Flag Warning criteria and determine if there could be a new system that is scaled to the observed and predicted fire weather (similar to scaling used for hurricane categories) to better communicate the hazard and risk.
- Develop methods to provide quicker and better fire weather forecasting support to Incident Commanders and Incident Management Teams, with better categorization of expected impacts.

## **Community and Building Design**

- Develop economical and effective ignition resistant structure materials.

- Develop better WUI fire resilient community, infrastructure, landscape and building design.
- Develop economic method to retro-fit structures that are not WUI fire code compliant.
- Design electrical system grid design to reduce damages and increase resilience from WUI fires to keep the electrical grid operational.
- Design electrical grid to prevent or reduce fire starts from electrical distribution systems (tree branch contact, wire slaps, and other causes).
- Develop better water systems to handle probable surge capacity with back-up pumping systems.
- Design railroad and highway system infrastructure to be more resilient to WUI fire impacts when that hazard is present.
- Research how agencies can better educate the public, work with the environmental community, and get financial support for implementation of WUI fire resilience projects.

## **Response Research Needed:**

- Develop real time situational awareness technology that is easy to use and available to incident commanders prior to and during the initial phases of the fire. Where are the fire's boundaries, what is the fire's current and predicted fire behavior, what assets are at risk, where are the first responder resources in relation to the fire and assets at risk. Where are people that are at risk, what is their best escape route or sheltering methodology for the situation and method to distribute this information in a timely manner.
- Develop simpler and better applications of remote sensing technology during initial phases of the WUI fire.
- Develop method to utilize fire apparatus, equipment and firefighters as data sensors in a mesh network.
- Research and develop improved fire firefighter tactical operations for structure protection on WUI fires for safer and more efficient operations. Including the appropriate use of aircraft designed for this mission.
- Research needs to occur to determine safest locations for firefighters and public to take shelter when entrapped in a WUI fire burn over situation (inside structures, outside areas, or in vehicles).
- Develop real time first responder location and status tools and tracking system that includes two way communications of first responder unit's current real time location and status and status of the incident.
- Improve response information technology systems to gather and disseminate appropriate data. Develop a system to provide information to responding resources electronically while they are responding to the fire and update them when they are at the scene (maps, weather summaries, pre-plans, communication plans, situation, and hazards.)
- Develop a Common Operating Picture system to integrate information gathered and disseminated (with actions taken) by the various disciplines that are operational at a WUI fire.
- Develop method to provide easier access to better and usable weather data for spot weather forecasts during WUI fires.
- Develop economical communications systems that allow inter-operable communications between multiple dissimilar frequency bands
- Improve public preparedness, warning, evacuation, sheltering and recovery methodologies.

### **Recovery Research Needs:**

- Develop improved post fire analysis protocols and methodologies to better understand effectiveness of mitigation and fire fighting operations
- Improve understanding of the linkages between WUI fires and secondary disaster (floods, mudslides, and water and air quality contamination) and developing better reduction methodologies.
- Develop improved economical methods for environmental rehabilitation on private lands when the rehabilitation has community wide impacts.
- Develop mitigation measures to reduce risk that can be used to offset reconstruction site limitations. Develop methods to retrofit communities that have been damaged but cannot be brought up to current code standards because of site limitations such as too narrow of road right of ways.
- Develop improved economic impact analysis and methodology to calculate the true cost and losses from WUI fires including damages, suppression costs, cost to provide fire protection, cascading economic impact from loss of use of a resource or facility, and lost jobs.
- Develop methods and guidelines for rebuilding/retrofitting communities in a WUI resilient and sustainable manner.
- Develop improved community, infrastructure and structure resiliency design to reduce the impact of WUI fires.

**WUI Fire Colloquium GOAL: Reduce WUI fire costs and losses by improving community resilience and responder preparedness through scientific bio-geophysical research.**

**Overview of Colloquium Research Topic Selection Methodology**

Prior to the Colloquium, participants were provided with several publications related to WUI fire issues (Appendix C). Participants were asked to review the material, consult with their colleagues and come to the Colloquium with a list of top research topics in the field of Wildland Urban Interface fire protection. In addition to the pre-colloquium review material, participants were asked to complete worksheets identifying challenges and research topics for each of the three major areas of the WUI fire problem based on their observations during the Santa Barbara tour. Individual preparation prior to the colloquium, keynote presentations and observations from the Santa Barbara site visit served as the foundation for the small group discussions.

***Small Group Breakout Process***

Following Jack Cohen's presentation, colloquium participants were assigned to one of three



small breakout groups that reflected the colloquium diversity. Each group had at least one representative from the response community, academia, and an agency administrator. Three rounds of small group dialogue sessions were held. A separate session was held for each of the three major focus areas: Preparedness, Response, and Recovery. Members were asked to identify current research efforts, challenges and present their viewpoints for short-term and long-term research priorities. Within the major categories of Preparedness, Response, and Recovery the

following subcategories were identified for the members to consider:

**Preparedness:**

- Fire Behavior and Modeling that includes the built environment and suppression actions
- Command Simulators that allow trainees to apply differing strategies and tactics
- Critical Infrastructure Protection
- Resilient Built Environment design and engineering
- Climate change

**Response:**

- Response System Capability gaps in processes, equipment, or training
- Evacuation Methodology-(i.e. “Shelter in Place” or Ready, Set, Go!)
- Critical Infrastructure Protection
- WUI Fire Behavior and Modeling including built environment and suppression actions
- Climate change

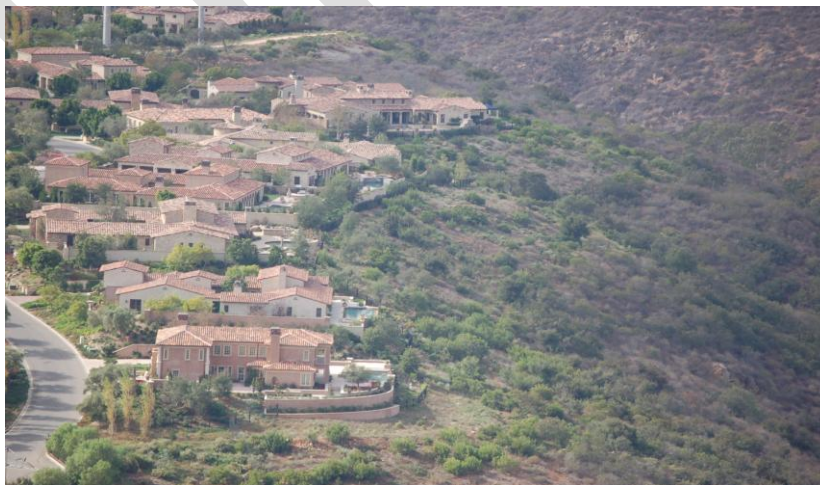
**Recovery:**

- Geo-Physical Burned Area Recovery-including natural and built environment
- Post Fire Forensics including built environment ignition and causal factors
- Fire Resilient Built Environment design and engineering
- Economic impacts
- Flood-Mudslide cycle
- Climate Change

Each group identified research topics as ‘statements of research needed’ then distilled the list to the three highest short-term and three highest long-term research priorities for each of the major focus areas.

Colloquium participants were also asked to identify specific criteria associated with each of the research priorities. The additional criteria to be considered were:

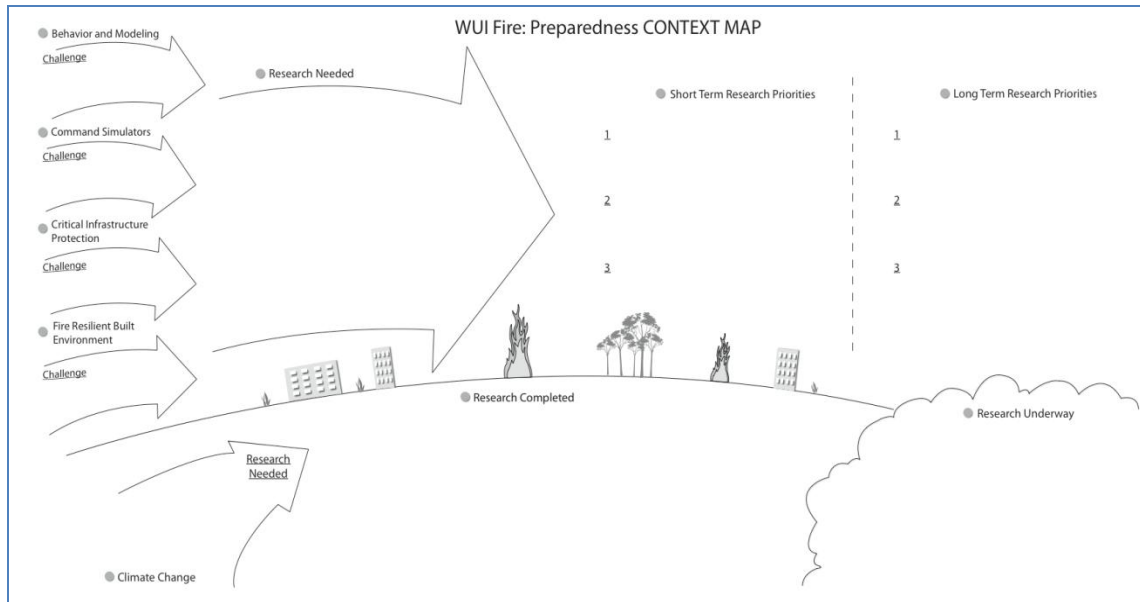
- Is this “gateway” research that must be done first to enable research in other areas
- Is the potential “payoff” in knowledge or dollars high? (HIGH payoff was defined as resulting in significant advancement of knowledge, dollars saved, losses avoided)
- How difficult is this topic to research or resolve (easy / difficult)
- Maturity of Research (is this new groundbreaking research or an existing area)



This wildland urban interface community was designed to resist ignitions from burning vegetation and flying embers. Even though the 2007 Witch Fire in San Diego burned through the area there were no structural losses. Photo: D Turner

## Research Topic Discussions and Prioritizations

### Sample Context Map



### Small Group Presentations and Discussions

Using the context map pictured above, participants were asked to:

- 1) Identify one big challenge for each sub-category in this focus area. 'Challenges' relates to what the group needs to understand the problem in geophysical terms.
- 2) Identify completed and current state of the art research in this area.
- 3) Identify research priorities across all sub-categories.
- 4) Consider list of criteria and determine top three short-term research priorities and three long-term research priorities: Identify which criteria were used for each of the short and long term research priorities. Express research priorities as 'statements of research needed.'



Research topics are prioritized by participants.  
Photo: J Ruiz

### ***Large Group Presentations and Discussions***



All participants listen to presentations from small groups. Photo: J Ruiz

After the small groups completed their assignments; the larger group came back together to hear the presentations and findings. Each of the small groups presented their recommendations to the entire group. All colloquium participants were allowed to express comments and ask questions. This process was repeated three times, with each group presenting priorities relating to Preparedness, Response, and Recovery.

### **Results of breakout Sessions:**

From the list of identified research topics each group distilled their list to the most important for each major subject area. The topics that did not fall into the highest priority topics are still important. All research topics are listed in Appendix D of this document.



Colloquium participants prioritize research topics and discuss greater context applications. Photo: J Ruiz

# Preparedness and Mitigation

## SHORT TERM PRIORITIES

- Develop a physics based Fire and loss definition
  - Clarify what is a WUI fire- geography, density, home environments, fuels
  - Develop forensics and data collection standards for WUI fires
  - Understanding WUI fire building exposures and susceptibility to ignition/ collect pre/post fire data
  - Distinguish the characteristics of WUI fires that differ from wildland fires
  - Define differences between new and existing built environments and relationship to WUI fires
- Identify current WUI fire training capability gaps
- Communicating fire severity/conditions
  - Best ways to gather and move info to all
  - Strengthen the relationship between incident management and Emergency Operating Centers
- Determining impacts of mitigation
  - Conduct a scale analysis to define the need for a model
  - Evaluate importance of ignition mechanisms
  - Develop new ways to characterize structure, landscape and material performance during WUI fires
  - Need to know how effective 100 foot defensible space really is

## LONG TERM PRIORITIES

- Develop models that measure fire spread from vegetation through buildings and infrastructure
  - Develop Improved WUI fire behavior models
  - Turning fire behavior models into decision/protection models to train responders
  - Accurate prediction of fire progress and behavior
- Use remote sensing/web to transfer that knowledge to all
  - Use remote sensing info on house to house basis to determine risk and mitigations
- Advanced materials that are more fire resistant and their potential integration into WUI buildings
  - Moving fire protection info to fire mitigation info to fire action info
- Develop better understanding of what fire brands ignite and how to prevent ignition of structures
- Potential impact and importance of simulations (planning, collective / communities)
  - Develop and expand training and simulation

# Response

## SHORT TERM PRIORITIES

- Decision support tools
  - Current situation information (real time) - Methods for gathering and disseminating weather, maps, hazards, threats, fire behavior
  - Real time location of firefighting resources ID existing tools and techs to locate/inform/deploy firefighters
  - Real time mapping of all phases/actions of fire
  - ID ways to use cell phones to notify/track/inform public
  - Fire equipment become data sensors
  - Which tools are deployable in real time needs
- ID various safety and health exposures to firefighters and public in WUI fires
  - Personal Protective Equipment Smoke exposure hazard
- Response and decision support training
  - Rapid response technology (Effective)Real time dynamic Incident Action Plan (IAP)
- Firefighter Personal Protective Equipment – safety
- Aircraft resources designed appropriate to the operational stresses of this mission
- Other suppression, mitigation or mechanical barrier technologies (besides hand line construction or water)
- True Cost of WUI fires including, mitigation, suppression and recovery
  - Cost-Benefit of mitigation
- Threat of intentional WUI fires causing catastrophic impact

## LONG TERM PRIORITIES

- Develop command and control tech for situational awareness/multiple users/info data sharing/real time
  - Warning system methods work best in terms of cost and maintenance
- Critical Infrastructure design appropriate for hazard
  - Keep operational during emergency
  - Resilient to damage from WUI fire
- Flammability differences between native and ornamental vegetation used in landscaping
- Increase public and firefighter survivability and safety
  - Fire Brand detection system
  - Redesigning critical infrastructure (so response can focus on lives)
  - Develop fire evacuation and public engagement protocols
- Non-traditional suppression systems
  - Fire brand detection systems
  - Mechanical barriers
- Evaluate new and existing ways to fight WUI fires- strategy

# Recovery

## SHORT TERM PRIORITIES

- Develop standardized POST FIRE ‘case study’ damage assessment methods
  - Develop standard WUI fire report data collection
  - Post fire analysis of incident management effectiveness
  - Post fire assessment needs to be standardized and studied
  - Evaluate tools and methods for post fire determination of building ignition mechanisms
  - Analyze and create a focused set of data on structural ignitions post-fire
  - Develop cost-benefit of loss avoidance through mitigation and suppression
- Relative importance of post-fire hazard recovery efforts
  - Evaluate what has/has not worked well in re-population/recovery
- Determine relative safety of buildings/structures and quickly communicate
  - ID and map all parties that evaluate safety or damage based info
- Research hazard to hazard linkages (e.g. mudslides)
- Hazard mitigation measure effectiveness monitoring
- Develop a model to show true Cost/benefit of fire, including suppression, economic, mitigation.
- Research public health affects related to WUI fires

## LONG TERM PRIORITIES

- Develop Life safety case study methodology
- Redesign critical infrastructure
  - Long term studies on effects/impacts of various treatments
- Decision support tools for:
  - Re-population
  - Re-construction
  - When to / How to restrict reconstruction
- Create ability to “visualize” incidents for investigation and training
- Treatment Impacts and effects
  - Research modification of vegetation to create species that can take root much faster and is more fire resistant
- Develop remote sensing capability to determine if buildings are safe

### ***Greater Context and Application:***

Much of the attention related to the WUI fire problem is focused on California and the West. However, the WUI fire problem exists in most every region of the United States. The largest loss of life in a WUI fire in the United States occurred in Peshtigo, Wisconsin in 1871 when more than 1,000 people were killed, entire towns were destroyed, and millions of acres of forest were burned. The map on the previous page illustrates the states that have a WUI fire problem. In order to put the appropriate focus and national context to the WUI problem colloquium members were asked to compare priority areas in the context of WUI fires both inside and outside California. The purpose of this discussion was to consider additional research topics which may have been missed during the course of the colloquium. At the end of the three rounds of large group discussions, each participant was provided with the list of priority research topics which had been identified by the groups throughout the day.

Factors identified during this phase were:

- California gets much of the news attention, but WUI fires occur nationwide
- WUI fires are not events that are isolated to small geographic regions of the country 43 of the states have communities that are at risk of WUI fires today or will as urbanization encroaches into wildland areas
- Each region has:
  - Different fire regimes and weather patterns
  - Different vegetation types
  - Different cultures and attitudes toward the problem
  - Different attitudes toward regulation
- Wildland is not just “forests”, but include grasslands, shrub lands, and other cover types.
- Critical Infrastructure is frequently incapacitated during the fire or damaged by the fire
- There are many stakeholders, public agencies (federal, state and local), private property owners, and citizens
- Mitigation is key to long term solutions
- Other countries with WUI fire issues (Spain, France, Australia, Portugal) look to United States for solutions and partnerships
- Wildland fire and WUI fire create serious impacts to critical watersheds
- There should be a national WUI fire resource mobilization system that inter-connects local, state and federal resources in one system.

### ***Distant Future Research***

In closing, participants were asked to envision the ideal future tools, technologies and capabilities of WUI fire preparedness, response, and recovery absent from any technological or

other constraints. Participants looked 50 years into the future and brainstormed these imaginary future capabilities or situations; the following are some of the ideas that were generated.:

- Geo-synchronous orbiting remote sensing platforms for fire use
- Use social networking media as sensors for gathering, processing, and feeding information during WUI fires
- Develop sensors that will detect and target ignition sources
- Computer controlled fire curtains that close remotely
- Public adopt a cultural mindset change to self preparedness and self sufficiency
- Firefighter Personal Protective Equipment that automatically adjusts to allow for thermal cooling (to avoid heat exhaustion) or to thermal protection like a aircraft rescue fire fighting proximity suit (to avoid burn injuries) based on environmental conditions
- Portable device that weighs no more than 40 pounds and can lay down 100 yards of effective fire control line without having to cut vegetation
- Smoke management technology that eliminates health hazard caused by smoke
- Fire resistant structures that allow fire to burn through them freely without causing damage
- Remote control bulldozers to construct and burnout fire line in hotter areas
- Robot fire fighters placed in high intensity areas
- Environmentally friendly spray to render vegetation non-flammable
- Family, business WUI fire evacuation pod or shelter
- 



Homes and businesses built in wildland areas require extraordinary actions on the part of citizens and response personnel. It is a deadly serious business, not a spectator sport. Air tanker drop near home during the GAP Fire near Santa Barbara, July 2008. Photo: S. Weiner, LA Times

## Summary

The WUI fire problem is expanding faster than ever and spreading to more areas each year. Previous research approaches have not kept pace with this expanding problem. The WUI Fire Research Colloquium held at Cal Poly, San Luis Obispo helped to frame the wildland urban interface fire problem in a new context. The research group determined new efforts need to be explored to best define the WUI fire problem and to develop new research solutions and tools to help reduce the impacts of these fires.

WUI fires are not wildland fires and they are not urban fires; rather they are a fire type unique unto itself that requires solutions that are designed to address this uniqueness from a preparedness, response and recovery perspective. Reducing structural ignitability, resilient community design, and infrastructure protection and resiliency is critical to reducing the disastrous impacts of this hazard.

WUI fire protection problems are a critical issue in the United States due to the loss of lives, property, infrastructure, threat to the economy and the social fabric of communities. The workshop included keynote addresses from Kate Dargan, CA State Fire Marshal, Chris Dicus, Professor Cal Poly State University, and Jack Cohen, Fire Research Scientist, US Forest Service. The addresses focused on the uniqueness of the wildland urban interface fire protection problem; “Prepare, Leave Early or Stay and Defend” individual preparedness models used in Australia, and flammable “wildland vegetation” versus “structural ignitability” as core issues in wildland urban interface fire protection.

The workshop included a tour of recent wildland urban interface fires that occurred in the Santa Barbara, California area. These fires provided dramatic illustration of the complexities of managing this unique type of fire problem. Colloquium participants heard from emergency response professionals that are delivering WUI fire protection at the real world level; they shared their concerns and WUI fire research recommendations.

The colloquium participants identified research gaps and priorities and research questions focused on the bio-geophysical, fire technology science characteristics of WUI fires that remain unanswered.

Researchers need to develop new tools and technology to assist the first responder community in safely and effectively suppressing these wildland urban interface fires by improving understanding of the bio-geophysical dynamics, better training and education directed toward the uniqueness of his problem and improved situational awareness capabilities. Research is needed to improve community and building design tools related to new developments and retrofitting existing developments to make them more ignition resistant. We must design our critical infrastructure so that it is resilient to the effects of WUI fires and remains operational during and

after WUI fires. New techniques need to be developed to analyze the true cost of WUI fires from mitigation, protection, fire damage, suppression costs, and cascading impacts to the economy from the fire. New tools, technology and methods must be developed to speed the recovery process and return the community's economy and social fabric to normal.

**The highest priority geophysical research topics included:**

### **Preparedness Research Strategies**

- First and foremost: We must clearly define the WUI fire problem. Create a better definition and criteria that represent the Wildland Urban Interface (WUI) problem in its true context as neither a wildland fire nor an urban fire. Recognizing that structural ignitions are the primary factor that differentiate WUI fires from “wildland fires” and result in different mitigation and response strategies and methods.
- Develop a clearly defined and standardized data collection and analysis methodology for community design, pre-fire planning, training, response, WUI fire fatalities, post fire forensics, and recovery that is properly scaled to meet the nature of the problem.

### **Fire Behavior and Ignition Reduction**

- Develop better understanding of WUI fire forensics and ignition mechanisms including standardized forensic analysis tools/processes.
- Develop better fire behavior prediction and fire behavior tools that incorporate the WUI environment and fire spread factors not just wildland fire characteristics
- Improve fire cause reduction research and improve structural ignition reduction technologies. Preventing unwanted fires is the most effective method of reducing costs and losses.
- Develop better understanding of the role of ornamental landscape plants versus native vegetation materials in use, flammability and contribution to the WUI fire problem.

### **Community and Building Design**

- Develop building components and assemblies that resist ignition from flying embers and other heat sources as determined by post fire building ignition analysis and other techniques. Develop economical and effective ignition resistant structure materials. Develop economic method to retro-fit structures that are not WUI fire code compliant.
- Research the WUI Fire impact to critical infrastructure during and after the fire and develop methods to improve resilience to WUI fires.

- Design electrical system grid design to reduce damages and increase resilience from WUI fires to keep the electrical grid operational.
- Design electrical grid to prevent or reduce fire starts from electrical distribution systems (tree branch contact, wire slaps, and other causes).
- Develop better water systems to handle probable surge capacity with back-up pumping systems.
- Design railroad and highway system infrastructure to be more resilient to WUI fire impacts when that hazard is present.
- **Develop better WUI fire resilient community, infrastructure, landscape and building design.** Research how agencies can better educate the public, work with the environmental community, and get financial support for implementation of WUI fire resilience projects.

### **Firefighter Preparedness**

- Identify training gaps and develop training programs for responders encompassing the total uniqueness of WUI fires including simulators that address changing conditions and reflect trainee inputs for strategies and tactics. Develop or improve on firefighter training programs that prepare wildland firefighters and urban firefighters for WUI fires including safe operating areas, safety zones, and safe shelter options during burn over conditions.
- **Develop simulation tools and modeling programs that incorporate the uniqueness of the WUI fire environment for use in training incident commanders and responders, for use in community planning, for use in decision support during response, for predicting fire behavior, for visualization in post fire forensics.**
- **Research new methods of mitigation, protection and suppression of WUI fires including examination of properly designed aircraft resources.**
- **Research the current Red Flag Warning criteria and determine if there could be a new system that is scaled to the observed and predicted fire weather (similar to scaling used for hurricane categories) to better communicate the hazard and risk.**
- **Develop methods to provide quicker and better fire weather forecasting support to Incident Commanders and Incident Management Teams, with better categorization of expected impacts.**

## Response

- Develop real time situational awareness technology that is easy to use and available to incident commanders prior to and during the initial phases of the fire. Where are the fire's boundaries, what is the fire's current and predicted fire behavior, what assets are at risk, where are the first responder resources in relation to the fire and assets at risk. Where are people that are at risk, what is their best escape route or sheltering methodology for the situation and method to distribute this information in a timely manner.
- Research needs to occur to determine safest locations for firefighters and public to take shelter when entrapped in a WUI fire burn over situation (inside structures, outside areas, or in vehicles).
- Develop methodology and technology to gather and disseminate critical data in a timely manner during emergency response. To include critical situation status, location of assets at risk, location of responders, public information, and evacuation status.
  - Develop method to utilize fire apparatus, equipment and firefighters as data sensors in a mesh network.
  - Incorporate remote sensing technology into initial attack fire incident commander's daily use tool kit.
  - Develop real time first responder location and status tools and tracking system that includes two way communications of first responder unit's current real time location and status and status of the incident.
  - Improve response information technology systems to gather and disseminate appropriate data. Develop a system to provide information to responding resources electronically while they are responding to the fire and update them when they are at the scene (maps, weather summaries, pre-plans, communication plans, situation, and hazards.)
  - Develop a Common Operating Picture system to integrate information gathered and disseminated (with actions taken) by the various disciplines that are operational at a WUI fire.
- Develop methodology to assess WUI fire suppression strategy and tactics effectiveness
- Research and develop improved fire firefighter tactical operations for structure protection on WUI fires for safer and more efficient operations. Including the appropriate use of aircraft designed for this mission.
- Develop method to provide easier access to better and usable weather data for spot weather forecasts during WUI fires.

- Develop economical communications systems that allow inter-operable communications between multiple dissimilar frequency bands

### Public Evacuation and Safety

- Develop public warning, sheltering, and evacuation programs that are scaled to the nature of the hazard, risk, and community demographics.
- Better understand the components of the WUI fire that affects public health and safety, including air quality and responder personal protective equipment designed for this environment.

### Recovery Research Needs:

- Improve understanding of the linkages between WUI fires and secondary disaster (floods, mudslides, and water and air quality contamination) and developing better reduction methodologies.
- Develop improved post fire analysis protocols and methodologies to better understand effectiveness of mitigation and fire fighting operations. Develop improved economic impact analysis and methodology to calculate the true cost and losses from WUI fires including damages, suppression costs, cost to provide fire protection, cascading economic impact from loss of use of a resource or facility, and lost jobs.
- Develop improved economical methods for environmental rehabilitation on private lands when the rehabilitation has community wide impacts.
- Develop mitigation measures to reduce risk that can be used to offset reconstruction site limitations. Develop methods to retrofit communities that have been damaged but cannot be brought up to current code standards because of site limitations such as too narrow of road right of ways.
- Develop methods and guidelines for rebuilding/retrofitting communities in a WUI resilient and sustainable manner.



Private property owner assistance program for post fire burned area rehabilitation. San Diego County 2007. Photo: D Turner

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## **Appendix B: WUI Fire Research Colloquium Agenda**

### **Wildland Urban Interface Fire Protection Research Colloquium Agenda:**

#### **Wednesday, June 17**

- 0730 Continental Breakfast at Poly Canyon Village
- 0800 Meeting begins
- 0805 Welcome address
- 0815 Introductions of participants
- 0900 **Keynote-Kate Dargan, CA State Fire Marshal: *Shaping the Battlefield***
- 1000 Board bus for tour of Santa Barbara area fires
- 1200 Lunch (provided during tour)
- 1600 Reconvene at Cal Poly to review tour findings
- 1900 Hosted Group Dinner-

**Keynote: Chris Dicus, Professor, Cal Poly, SLO: *2009 Australian Fires***

#### **Thursday, June 18**

- 0730 Continental Breakfast at Poly Canyon Village
- 0800 Meeting begins
- 0805 **Keynote-Jack Cohen, US Forest Service, Fire Science Laboratory: *Home Destruction During Extreme Wildfires***
- 0845 Facilitated small group discussions and presentations  
Research topic areas identified and prioritized
- 1200 Lunch (hosted)
- 1330 Facilitated small group discussions and presentations continue  
Research topic areas identified and prioritized
- 1600 Greater Context, Application, and “Buck Rogers Moment”
- 1645 Wrap up and close out
- 1700 Adjourn

## Appendix C: Publications Provided for Review

- **Grand Challenges for Disaster Reduction**  
**A Report of the Subcommittee on Disaster Reduction**  
  
Executive Office of the President of the United States  
National Science and Technology Council, Second printing 2008
- **MEGA FIRES: The Case for Mitigation. The Witch Creek Wildfire, October 21-31, 2007;** Institute for Business and Home Safety. 2008
- **Wildland Fire Management**  
**Actions by Federal Agencies and Congress Could Mitigate Rising Fire Costs and Their Effects on Other Agency Programs:**  
**Statement of Robin M. Nazzaro, Director Natural Resources and Environment**  
  
United States Government Accountability Office  
*Testimony Before the Subcommittee on Interior, Environment, and Related Agencies, Committee on Appropriations, House of Representatives*
- **Quadrennial Fire Review 2009: Final Report January 2009:**  
**Federal Wildland Fire Agencies and National Association of State Foresters, 2009**  
  
The Quadrennial Fire Review (QFR) is a strategic assessment process that is conducted every four years to evaluate current mission strategies and capabilities against best estimates of the future environment for fire management. This integrated review is a joint effort of the five federal natural resource management agencies and their state, local, and tribal partners that constitute the wildland fire community. The objective is to create an integrated strategic vision document for fire management.
- **A Collaborative Approach for Reducing Wildland Fire Risks to Communities and the Environment: 10-Year Strategy Implementation Plan: Congressional Direction for the 10-Year Comprehensive Strategy**  
  
Conference Report for the Fiscal Year 2001 Interior and Related Agencies Appropriations Act (Public Law 106-291) ; 2006

## Appendix D: Additional Identified Research Topic Areas

The following tables list the identified research topics that were considered by the colloquium participants. All of these topics were considered worthy of further investigation.

### PREPAREDNESS TOPIC

	Challenge Area	Research Needed
1	Wildland Fire Modeling does not take built environment factors into consideration	Develop new models that properly represent built environment spread factors
2	Improve visualization/modeling methodology for training, planning, forensics, and response	Incorporate existing technology and develop new technology to develop interactive realistic computer modeling designed for WUI environment
3	Life safety evacuation or sheltering strategies/designs for public that cannot evacuate	Homeowner usable designs that provide life safety shelter for entrapment or inability to evacuate situations
4	Smoke generation and dispersion for air quality and health exposure	Develop modeling and monitoring methods for smoke dispersal for air quality and health exposure
5	Built environment new and existing construction-differences	Define the difference in solution sets for retrofitting existing and new construction
6	Appropriate material testing for ignition resistance-component vs. assembly, ways to characterize material performance in use	Construction materials should be tested as assemblies in addition to individual components to test resistance to ignition
7	Determine the relative importance of ignition mechanisms, ember, convective, and radiant heat sources and how to prevent ignition from each.	Develop standardized methodology for testing and measuring embers (spotting), radiant heat, and convective heat sources as they pertain to ignitions and how to prevent them  Property owner incentives to mitigate hazard and reduce risk
8	Vegetative fuel clearance effectiveness	Validate the effectiveness of vegetative fuel clearances (30 foot, 100 foot, etc)
9	How to extinguish small residual	Develop automatic detection and suppression systems

	fires after main fire front has passed	specifically designed for WUI ignition situations
10	How effective are retrofit options to reduce ignitions	Testing labs for wind driven embers and radiant heat exposure resistance and effectiveness of retrofit devices
11	Exposure vs. ignition, diagnostic and predictive uses to quantify vulnerabilities to ignition	Develop methods to measure probability of ignition under various exposure conditions
12	Easy to use field fire commander weather (wind, Relative Humidity) and fire behavior calculator	Develop a weather and behavior modeling tool that can easily be used by fire commanders during early stages of fires or in developing fire pre-plans.
13	How significant are the various factors that lead to ignitions and spread	Develop scale analysis model to determine at what resolution the ignition and spread factors are important.
14	Fire Predictive models for Community Planning and Design, evacuation modeling, and	Develop community planning level fire predictive/modeling system for use in community and/or subdivision design to include fire behavior and evacuation system design
15	Critical Infrastructure is susceptible to catastrophic damage from WUI fires	What methods can be developed to mitigate risk from unintentional and intentional damage?
16	Training gaps exist between wildland firefighters and urban firefighters as it relates to WUI fires	Conduct gap analysis and training needs assessment and design for course specifically designed for WUI fire environment including decision processes and data necessary to support them
17	There are no standard methods for measuring or assessing various protective strategies	Develop quantitative / qualitative methods for evaluating protection strategies for communities
18	Values at risk, linkages to other hazards (flood, mudslide, water storage/quality issues) are not well defined	Develop methodology for measurement of impacts to all vales at risk and linkages to other follow-on hazards that are set in motion by the WUI fire
19	How to quickly and efficiently communicate hazards to the public and communities	Explore use of existing or new technology or methods to communicate the hazard and risk public members face during WUI fires so they can choose wisely to evacuate or take other protective measures
20	Landscape materials contribute to the ignition of structures and spread of fire, yet little research	Assess currently used ornamental landscape materials for flammability, ember production, fire spread, and resistance to ignition.

	as been done on current plant materials or other landscape materials	
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DRAFT

## RESPONSE TOPICS

1	Incident Commanders during early phases of WUI fires need the ability to rapidly assess weather, fire behavior, values at risk, and firefighter deployment in a rapidly evolving situation	Develop mobile command platforms that have automatic vehicle/asset location, GIS, fire modeling that utilizes current fire weather, behavior, and other conditions, with real time updates on weather, first response personnel, and public.
2	Fire commanders in WUI fires often have limited experience in fires of this magnitude and very limited opportunities to train or simulate the situations and decisions necessary to effectively manage these events.	Develop training simulators that provide real life experience in managing WUI fires that allow for changeable conditions and reflect results based on fire commanders inputs allowing trainees to try different strategies and tactics including allocation, reallocations and implications of decisions
3	Incident commanders and fire resources often have difficult time keeping each other updated on critical status changes in a real time or timely manner	Develop methodologies to communicate situation status, fire conditions, locations, other conditions to responding resources while they are in route and at scene including weather, maps, fire behavior, locations, current conditions
4	It is difficult for incident commanders to communicate information to all that need/desire it in a timely fashion, including responders, media, public, law enforcement, Emergency Operating Centers	Develop rapid information communication technology that allows for dissemination of accurate information in a timely fashion
5	Evaluation of alternative strategies/methods of suppression techniques is anecdotal and not quantitative based. We should evaluate how we fight WUI fires, right equipment, right deployment, right place, etc	Develop methodology of measuring evaluating effectiveness of various strategies with conflicting issues and resources including what roles the public/non responders fill during WUI fires
6	Evacuations and sheltering in place strategies are not sufficiently developed for the WUI environment. One size does not fit	Evacuation strategies need to be developed for differing fire conditions and circumstances, including modeling, decision points, information for the public, information for law enforcement and Red Cross and protective methods for those that can not evacuate

7	WUI fire fatality data is anecdotal	Develop standard methodology and develop data for fire caused fatalities in WUI fire situations
8	WUI fire fatalities occur in various settings, what are the conditions that enhance survivability?	Research on WUI fire survivability for responders and public that are entrapped
9	Perimeter line construction methods have not changed much for 50 years	Investigate and develop new perimeter line construction methods appropriate for WUI fires
10	Structural ignitions often occur (from residual embers) after main fire front has passed and fire crews re deployed	Develop ember detection system and/or suppression methodologies that address this problem
11	First responder Personal Protective Equipment (PPE) designed for the WUI fire environment is lacking	Identify PPE needs and develop appropriate PPE that includes air quality, heat, and flying ember protection
12	Fire agencies are using firefighting aircraft that are primarily retired from some other use and retrofitted for firefighting in the WUI environment	Analyze the appropriateness of designing aircraft specifically designed for use in WUI fire and other fire assignments
13	Post fire effectiveness evaluations are anecdotal. Lessons learned and adjustments to strategies and tactics are best developed by quality analysis of WUI fire activities	Develop in depth methods for post fire effectiveness analysis that includes strategy, tactics, resource utilization, and alternative strategies and cost effectiveness
14	Gathering current fire. Weather, situation data real time. Can fire equipment become data sensors that communicate that information back to a command post in an easily usable manner?	Develop fire equipment based data sensors and communication methodology that assesses weather, location, and other data for incident commanders from equipment deployed on fires

## RECOVERY TOPICS

1	Evaluate collateral hazards- flooding, mudslides, economic losses resulting from WUI fires	
2	Burned area erosion control methods on private land are complicated to achieve	Develop methods for private property owners to mitigate fire effects to reduce post fire erosion that can lead to follow on hazards or disasters such as mudslides, flooding, or water quality damage
3	Better understanding of the relationship between structures threatened versus damaged or saved is necessary	Develop methodology to analyze the situations that improve structural saves when threatened by WUI fires including use of remote sensing and other technology
4	Hazard mitigation is primarily focused on vegetative fuel modification. How cost effective is it?	Determine the tactical and economic effectiveness of vegetative fuel modification and other mitigation methods. Post fire review of mitigation effectiveness
5	Community recovery socially and economically should be a consideration of the cost or impact of WUI fires	Develop methodology to evaluate and measure the socio-economic impact of WUI fires including appropriate recovery methods and stimulants
6	What are the true costs of WUI fires?	Evaluate and analyze the cost of mitigation, cost of protection, cost of suppression cost, cost of direct losses, and cost of indirect losses. Create model to evaluate these components
7	How do communities rebuild after WUI fires?	Analyze success and failures in rebuilding communities following WUI fires. Develop best practices guidelines for cost effective fire safe rebuilding