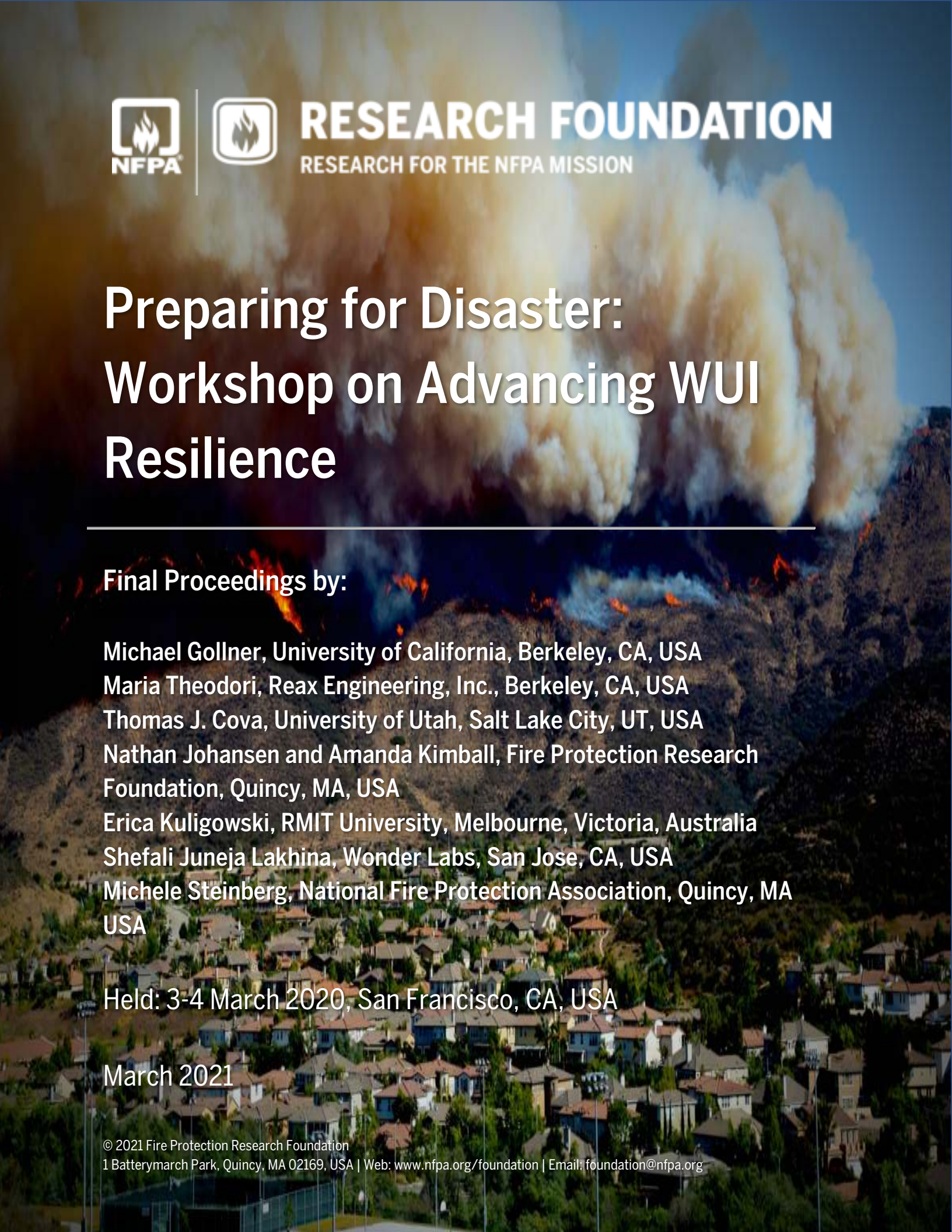

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Preparing for Disaster: Workshop on Advancing WUI Resilience

Final Proceedings by:

Michael Gollner, University of California, Berkeley, CA, USA
Maria Theodori, Reax Engineering, Inc., Berkeley, CA, USA
Thomas J. Cova, University of Utah, Salt Lake City, UT, USA
Nathan Johansen and Amanda Kimball, Fire Protection Research Foundation, Quincy, MA, USA
Erica Kuligowski, RMIT University, Melbourne, Victoria, Australia
Shefali Juneja Lakhina, Wonder Labs, San Jose, CA, USA
Michele Steinberg, National Fire Protection Association, Quincy, MA USA

Held: 3-4 March 2020, San Francisco, CA, USA

March 2021

1 Batterymarch Park, Quincy, MA 02169, USA | Web: www.nfpa.org/foundation | Email: foundation@nfpa.org

Preliminaries

This workshop was supported by:

This is a workshop summary report and the information contained herein is based on the input of numerous professionals and subject-matter-experts. While considerable effort has been taken to accurately document this input, the final interpretation of the information contained herein resides with the report author. The content, opinions and conclusions contained in this report are solely those of the authors and do not necessarily represent the views of the Fire Protection Research Foundation, NFPA, Technical Panel or Sponsors. The Foundation makes no guaranty or warranty as to the accuracy or completeness of any information published herein.

About the Fire Protection Research Foundation

The Fire Protection Research Foundation plans, manages, and communicates research on a broad range of fire safety issues in collaboration with scientists and laboratories around the world. The Foundation is an affiliate of NFPA.

About the National Fire Protection Association (NFPA)

Founded in 1896, NFPA is a global, nonprofit organization devoted to eliminating death, injury, property and economic loss due to fire, electrical and related hazards. The association delivers information and knowledge through more than 300 consensus codes and standards, research, training, education, outreach and advocacy; and by partnering with others who share an interest in furthering the NFPA mission. All NFPA codes and standards can be viewed online for free.

NFPA's membership totals more than 65,000 individuals around the world.

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Preparing for Disaster:
Workshop on Advancing WUI Resilience

Summary Report and Recommendations from the March 2020 Workshop held in San Francisco, California

Fire Protection Research Foundation
National Fire Protection Association
University of California, Berkeley
Reax Engineering, Inc.

Michael Gollner, Maria Theodori, Thomas J. Cova, Nathan Johansen, Amanda Kimball, Erica Kuligowski, Shefali Juneja Lakhina, and Michele Steinberg

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FORWARD AND ACKNOWLEDGEMENTS

This report serves as a summary of proceedings from the two-day workshop titled, *Preparing for Disaster: Advancing WUI*[1] *Resilience,* that was held on March 3-4, 2020 in San Francisco, California. The workshop was made possible in large part by financial support from the National Fire Protection Association (NFPA). The majority of funds were allocated toward travel and accommodation costs for workshop speakers and participants representing non-profit organizations and public service agencies. Attendees also included representatives from academia and industry, including stakeholders, researchers, and practitioners from various fields that each play an important role in the bigger picture of "advancing WUI resilience". Such diversity in attendance was intentional and key to aspirations of the workshop; inciting conversation across disciplines allows an opportunity to better understand and subsequently address real-world challenges through development of solutions that build upon the unique strengths and experiences of the individuals present in the room.

A note of acknowledgement is given to the lead organizers who spent several months in planning and preparation for the workshop since its inception in 2018: Maria Theodori (*Reax Engineering Inc.* and *University of California, Berkeley*), Michael Gollner (*University of California, Berkeley*), Amanda Kimball (Fire Protection Research Foundation), Michele Steinberg (National Fire Protection Association) and Birgitte Messerschmidt (National Fire Protection Assocation).

Appreciation is also expressed to the company Arup, especially Ibbi Almufti and Kenny Buyco for their hospitality and generosity in allowing us to use much of their San Francisco office for the two-day workshop.

The utmost gratitude is extended to all workshop participants listed below who traveled from near and far in the United States and contributed to the lively, insightful discussions.

Soon after we concluded this workshop in early March 2020, our lives were upended by the global COVID-19 pandemic. Later in the year, historic wildfires affected so many of us across the American West. These cascading disasters led to delays in the release of this workshop report. Nonetheless, we hope the report presents readers with timely solutions and recommendations for achieving wildfire resilience.

[1] WUI: wildland-urban interface

ATENDEE LIST

Name	Affiliation*	Name	Affiliation*
Alex Acuña	Enterprise Community Partners	Mike Lepisto	Arup
Ibbi Almufti	Arup	Eric Link	National Institute of Standards and Technology
Christopher Anderson**	Salo Sciences	Jamie Lydersen	CAL FIRE
Nathan Bengtsson	Pacific Gas and Electric Company	Alex Maranghides***	National Institute of Standards and Technology
Kenny Buyco	Arup	Robert Marshall	Whisker Labs
Jeanette Cobian	University of California, Berkeley	David Marvin**	Salo Sciences
Tom Cova**	University of Utah	Jerry McAdams**	Boise Fire Department
Lucian Deaton	National Fire Protection Association	Birgitte Messerschmidt	National Fire Protection Association
Greg Dillon**	United States Forest Service	Rebecca Miller	Stanford University
Cristina Echeverria	Strategic Growth Council	Miranda Mockrin***	USDA Forest Service
Frank Frievalt	Mammoth Lakes Fire Protection District	Molly Mowery**	Wildfire Planning International
Michael Gollner	University of California, Berkeley	Richard Mullane	HASSELL
Daniel Gorham	Insurance Institute for Business & Home Safety	Marla Pourrabbani	Swiss Reinsurance Company
Jenny Gregory	Whisker Labs	Steve Quarles	University of California Cooperative Extension
Edith Hannigan**	CA Board of Forestry and Fire Protection	Jim Quiter	Arup
Steven Hawks**	CAL FIRE	Xingyu Ren	University of Maryland-College Park
ShihMing Huang	Sonoma Technology, Inc.	Jesse Roman	National Fire Protection Association
Kevin Johnson	Pacific Gas and Electric Company	David Sapsis**	CAL FIRE
Erdem Karaca	Swiss Reinsurance Company	Charles Scudiere	University of California, Berkeley
Amanda Kimball	Fire Protection Research Foundation	David Shew	National Fire Protection Association
Crystal Kolden**	University of Idaho	Zoe Siegel	Greenbelt Alliance
Erica Kuligowski**	National Institute of Standards and Technology	Craig Smith	Jupiter Intelligence
Anukool Lakhina	Wonder Labs	Michele Steinberg**	National Fire Protection Association
Shefali Juneja Lakhina	Wonder Labs	Maria Theodori	Reax Engineering, Inc.
Ren Larson**	The Arizona Republic	Jean-Pierre Wack	Spatial Informatics Group
Chris Lautenberger**	Reax Engineering, Inc.	Roy Wright	Insurance Institute for Business & Home Safety
Tami Lavezzo	Sonoma Technology, Inc.	Hanyu Xiong*	University of California, Berkeley

*Affiliation at the time of the workshop. **Speaker ***Speaker, remote

1.0 INTRODUCTION

Motivation and objectives

Current Wildland-Urban Interface (WUI) building codes and community design requirements or guidelines do not provide a consistent method of assessing site-specific wildfire risk (beyond a single structure) and informed disaster resilience measures. Even for those requirements and guidelines that exist, they are not consistently applied across all communities in hazard-prone areas. Losses from the 2018 Camp Fire in California alone reached over 80 human lives, $8.5 billion dollars, and almost 19,000 structures[2] (Badger and Foley, 2019). Soon after this workshop the 2020 fire season across the State of California burned an unprecedented 4.39 million acers, destroyed almost 10,000 structures, and claimed 31 lives[3]. Similar devastation occurs yearly and in other parts of the world - e.g., Portugal, Greece, Chile, Australia. Communities affected by wildfire disaster typically lack proper preparation, which exacerbates the recovery process. Greater attention to these issues and multilateral collaboration is urgently needed as the increasing trend of large wildfires is expected to continue, and become more widespread, under a changing climate.

In efforts to catalyze critical actions, experts and stakeholders from across the US and in subjects relevant to community wildfire risk and WUI disaster resilience gathered for a 2-day interactive workshop in California in March 2020. The objectives of the workshop were to:

1. Identify immediate and realistic actions to resolve research and market gaps between wildfire risk and WUI disaster resilience; and
2. Outline the steps required to execute development of holistic, accessible, and sustainable solutions.

Workshop discussion themes

The following subthemes of WUI resilience were examined during the 2-day workshop:

1. The State of the WUI Problem and Projections for the Future
2. Land Use and Wildfire Protection Planning
3. Technologies for Risk Assessment and Planning
4. Outreach and Community Action
5. Notification and Evacuation
6. Long-Term Trends and Market Challenges

The workshop was structured around expert presentations (provided in Appendix A) followed by breakout group discussions and presentations (provided in Appendix B). Besides facilitating discussion and cooperation between attendees from many different backgrounds, the setup allowed for a record of reporting and discussions that took place.

[2]Camp Fire. Available online: https://www.fire.ca.gov/incidents/2018/11/8/camp-fire/ (accessed on 11 February 2021).
[3]2020 National Large Incident Year-to-Date Report. National Interagency Fire Center. December 21, 2020. Archived from the original (PDF) on December 29, 2020. Retrieved January 13, 2021.

Prior to the workshop, a survey was sent to invitees to collect preliminary thoughts regarding the discussion themes identified above. This survey further served as an opportunity for individuals who could not attend the workshop in person to contribute their thoughts, as well as an opportunity for presenters to consider the information in preparation of their materials. The pre-workshop survey questions were then repurposed or modified into discussion prompts during the workshop breakout sessions, which helped to incite conversation amongst the small groups. Both the survey and discussion prompts are included in Appendix C. The complete set of survey responses is provided in Appendix D. A word map created from survey responses is shown below, where a focus on communities clearly stands out as a key focus for WUI resilience.

Figure 1: Word map generated from survey responses, highlighting the community-based approach necessary for WUI resilience.

Additional key topics for further investigation

While the workshop themes and ensuing discussions covered a vast selection of subtopics under the realm of WUI resilience, it is acknowledged that several additional key subject areas were not addressed with the limited time available over two days. A non-exhaustive list is provided below of those missed topics that are also necessary aspects of holistic strategizing to improve community resilience against wildfire.

- Emergency Operations and Response Strategies
- Post-Fire Recovery
- Public Health and Smoke Impacts

While some of these topics were recognized and brought up in discussion and materials within the report, they were not a major focus and should be a focus of further work.

Report organization

The remainder of this summary report is organized as follows:

- Section 2 outlines the key recommended solutions and actions that workshop participants identified and deliberated upon.
- Section 3 highlights the aligned research and development that is needed to catalyze and enable those solutions.
- Section 4 provides the detailed outcomes from the workshop organized by the six themes mentioned above.
- Section 5 lists the cited references.

- Appendix A has the pre-event survey questions and workshop breakout group discussion prompts organized per theme as mentioned above.
- Appendix B is the full set of responses that was gathered from the pre-event survey.
- Appendix C appends the speaker presentations that were delivered during the workshop.
- Appendix D appends presentations from breakout groups for each topic discussion, serving as a record of breakout discussions during the workshop.

2.0 RECOMMENDED SOLUTIONS, ACTIONS AND RESEARCH NEEDS

During the course of the workshop, breakout groups were formed to discuss problems facing WUI resilience and actions and solutions to make a difference to these problems. At the conclusion of the workshop a list of actions, solutions, and research needs were compiled from all topics discussed and an attempt was made to rank these actions. However, the effort was inherently difficult, as so many actions could be taken to affect change. Multiple cuts were taken both during and after the workshop to arrive at the list presented below, highlighting major themes and opportunities to affect change. Following the broad themes outlined throughout the workshop, key recommendations and actionable solutions are provided on the following page.

PRIORITIZED ACTIONS AND SOLUTIONS

- ***Provide sustained support and engagement***
  - Funding, financial models, and staffing for maintenance, mitigation, and outreach
  - Improve overall communication and collaboration between stakeholders through new partnerships (insurance, products, government, construction, real estate, etc.)
- ***Improve and expand education and outreach to new stakeholders***
  - Expand outreach to include schoolchildren, insurance sector, government, etc.
  - Create curricula to train architecture, landscape design and other fields on WUI mitigation principles
- ***Improve planning and mitigation***
  - Standardize notification and warnings on a national scale (e.g., NWS Alerts)
  - Streamline agency responsibilities
  - Improve protection of critical infrastructure
  - Develop a voluntary wildfire resistance rating for structures (e.g., LEED)
  - Streamline approval for vegetation management (e.g., NEPA)
- ***Develop and apply technology***
  - Increase use of satellite/real-time data for decision making and event reconstruction
  - Automated early wildfire alerts and redundancies in communications systems
  - Develop risk maps that incorporate home ignition risks at both community and individual parcel scales
- ***Provide temporal-based prioritization of mitigation and solutions***
  - Prioritize cost-effective retrofits, fuel modifications, etc.

PRIORITIZED RESEARCH AND DEVELOPMENT NEEDS

While a number of solutions were found to be actionable, there were many areas where continued research and development were necessary, if not key to making advancements.

- ***Prioritize evacuation and notification***
  - Involve social science, develop challenging coupled fire-evacuee scenarios, and advance the acquisition and dissemination of real-time data on fire spread and evacuation models to inform decisions
  - Increase focus on challenges of evacuating vulnerable populations
- ***Standardize quantification and visualization of risk***
- ***Develop improved test methods for construction materials and assemblies***
- ***Model fires from wildland to WUI (building fire spread)***
  - Improve ember modeling, including from wildland and structural fuels
- ***Understand impacts of smoke, contamination, etc. on public health***
- ***Quantify the cost of fire***
  - Quantify the cost between incentivizing retrofits vs. post-fire damage
  - Cost-benefit analysis of individual and community mitigation actions
- ***Improve data collection and build a repository***
  - Improve methods to collect real-time data on fire spread and evacuation
  - Build a field sensor network
  - Improve spatial and temporal resolution for satellite fire detections
- ***Improve WUI research infrastructure in the US***
  - Build facilities, maintain funding and expand coordination

DETAILED ACTIONS AND SOLUTIONS

The previously shown prioritized recommendations comprise a framework for future action but many more details were provided for these actions throughout the workshop. These have been summarized here more broadly into specific actions. These are categorized into three timescales: short-term actions to be taken now, mid-term actions that will take some time and investment, and long-term actions that will need considerable development or support before implementation. These timescales were thought of as estimates based on time to implementation, for instance a mid-term designation given to many actions that were relatively straightforward but had further barriers to implementation. While these thresholds guided our discussions and are used in more nuanced subject reporting later in this document, it was found that topic-based recommendations would be clearest to present to the wider community. Still, we highlight the actions below to indicate the timescale needed to implement these recommendations.

Sustained Support

- Programs for mitigation, outreach, etc. should be continually supported to remain effective [short-term]
- Can other sources of funding (private foundations, etc.) be found to support mitigation and outreach efforts while government support is secured? [short-term]
- Include staffing for outreach and mitigation as well as funds to support individual parcel and community-wide mitigation measures [mid-term]
- Financial models should be created that provide sustained maintenance (e.g., vegetation management) as well as retrofits for vulnerable communities [long-term]

Engagement

- Improve overall communication and collaboration between stakeholders through new partnerships: [short-term]
    - Partner with real estate agents, home builders, and insurance agents. (especially in communicating risk).
    - Commercial partnerships (e.g., incentives with home improvement stores)
    - Engage with construction industry to develop “safer” products
    - Engage with insurance industry and regulators to “price for risk”
    - Engage with critical infrastructure and utility operators for planning and mitigation
    - Engage with international partners (research and government) to share best practices
    - Partner with the Occupational Safety and Health Administration (OSHA) for personal protective equipment (PPE) regulations
- Increase fire service involvement in mitigation and communication of risk [mid-term]
- Increase involvement of tribal and indigenous partners for cultural burning and risk and mitigation awareness [mid-term]

Education and Outreach

- Continue to improve and expand education and outreach to new stakeholders
    - Children and schools [mid-term]
    - Insurance customers [mid-term]

    - Government officials and legislature (California is a model in some ways) [mid-term]
- Connect WUI fire resilience to sustainability – e.g., carbon cost of rebuilding [mid-term]
- Create curricula to train architects, landscape designers, planners, etc. on WUI design principles [mid-term]
- Inform investigative and documentary journalists so they are educated about the "full picture" of wildfire with thoughtful reporting. [mid-term]
- Integrate these concepts into curricula for fire service "marketing" based on existing understanding of social sciences [mid-term]
- Outreach and awareness programs to prevent human-caused ignition [mid-term]
- Share cost-effective retrofit guidance [mid-term]
- Improve overall communication of responsibility and risk [mid-term]
- Communicate hazards associated with post-fire [mid-term]
- Use lessons learned globally to communicate strategies. [mid-term]
- Increase the number of community experts for outreach and education [long-term]
- Improve methods to translate risk and research to citizens [long-term]

Planning

- Integrate community wildfire protection plans (CWPP) into local hazard mitigation plans [mid-term]
- Standardize notification and warnings on a national scale [long-term]
- Automate early wildfire alerts and improve redundancies in communications systems [long-term]
- Streamline agency responsibilities [long-term]

Mitigation

- Increase protection of critical infrastructure and system hardening (e.g. utilities - both ignitions from utilities & grid resilience) [mid to long-term]
- Develop a voluntary wildfire resistance rating for structures (i.e. LEED) [long-term]
- Expand the Firewise USA® program to the municipal level: enlarge footprint [long-term]
- More Certified forestry professionals for vegetation management [long-term]
- State and federal agency streamlining approval for vegetation management (NEPA) [long-term]

Technology and Risk Mapping

- Develop risk maps that incorporate home ignition risks at both community and individual parcel scale [mid-term]
- Implement personalized and accessible risk evaluations [mid-term]
- Increase use of satellite and other real-time data for decision-making and post-event data collection [mid-term]
- Improve data collection, including pre-event data (such as defensible space inspections) to understand the impact of mitigation during post-event investigation (e.g., DINS data in CA). [mid-term]
- Improve spatial and temporal resolution of satellite-based fire detections [long-term]

- Add redundancies in communication systems including adoption of wired analog systems in some areas [long-term]

DETAILED RESEARCH AND DEVELOPMENT NEEDS

While a number of solutions were found to be actionable, there were many areas where continued research and development were necessary, if not key to making advancements towards more WUI-resilient communities. Again, we followed a format of topically themed recommendations followed by a designation of short, mid, and long-term timescales for research and development.

Research Infrastructure

- A dedicated funding system is needed to study WUI fires, including for:
    - Development of test and design standards (e.g. NIST) [short-term]
    - Teams for post-event analyses and data maintenance [mid-term]
    - Ongoing support of fundamental and applied research [long-term]
    - Developing consistency, which is key to respond to crises and train a skilled workforce [long-term]
- Establish public-private partnerships such as hubs/ecosystems for testing and research [mid-term]
- Core research and testing facilities are needed that are geared to WUI fires in the United States, such as fire wind tunnels, ember facilities, and associated fire testing laboratories, especially in the Western US. [long-term]

Data

- Create a WUI data-sharing repository for pre- and post-event data [mid-term]
- Research how to collect and apply real-time loss data [mid-term]
- Improve post-fire data collection [mid-term]
    - Landslides, mudslides, erosion
    - WERT, BAER (federal level, rehab of burnt area)
    - Long-term data on community recovery post fire.

Technology

- Develop methods to collect real-time structure loss data [mid-term]
- Build a field sensor network [mid-term]
- Develop real-time fire modeling tools which can be tied to evacuation and notification to inform decisions [mid-term]
- Increase utilization of existing satellite information [mid-term]
- Develop immersive technologies for fire suppression and management training (e.g., gamification) [mid-term]
- Improve technology for alert and warning systems, even including hard-wired systems where applicable [mid-term]
- Improve the spatial and temporal resolution of current fire detection from satellites [long-term]

Development of Guidelines and Analyses

- Develop a methodology for holistic performance-based design (PBD) for WUI communities [mid-term]

- Develop guidance for resilient rebuilding that exceeds current code requirements [mid-term]
- Standardize visualization of risk in CWPPs [mid-term]
- Investigate co-benefits of retrofits and actions alongside vegetation management (potentially conflicting strategies) [mid-term]
- Integrate fire-safe planning best practices into land use planning best practices and curricula as a whole [mid-term]
- Analyze the total life cycle cost of wildfires [mid-term]
- Quantify cost between incentivizing retrofit vs. post-fire damages [mid-term]
- Compare mitigation costs to potential savings through risk reduction [mid-term]
- Research effectiveness of sustained funding for outreach and mitigation programs [mid-term]
- Estimate climate change mitigation/adaptation and associated costs, as well as cost of inaction, cost of co-benefits [mid-term]
- Investigate economics and costs associated with real estate, banks and mortgage that may motivate risk reduction [mid-term]
- Perform cost-benefit analysis of individual and community actions [mid-term]

Evacuation

- Develop evacuation planning templates [short-term]
- Incorporate a range of social science theories and methods [mid-term]
- Include additional behavioral data for traffic models and evacuation models [mid-term]
- Develop challenging coupled fire-evacuee scenarios [mid-term]
- Develop standards for evacuation planning and notification [mid-term]
- Determine the role and develop guidelines for shelter in place [mid-term]

Outreach

- Develop metrics to assess outreach programs [mid-term]
- Improve understanding of risk perception and mitigation measure adoption [mid-term]

Fire Modeling

- Develop models capable of simulating fire spread into and within WUI communities [mid-term]
- Standardize quantification of risk and develop a framework for mapping risk to WUI communities [mid-term]
- Utilize fire models for real-time simulations to aid in evacuations and fire management [mid-term]
- Utilize fire models for next-day fire risk calculations that are highly localized (e.g., targeted community rather than county-level fire danger warnings). [mid-term]
    - Improve ember modeling science and simulation tools

Testing and Standards

- Compare international WUI building codes and outcomes [short-term]
    - Studies to quantify effectiveness of outreach and mitigation measures
- Quantify retrofit effectiveness [mid-term]
    - Features, exterior/interior sprinklers, home spacing, etc.
- Develop test methods and codes for construction materials and assemblies [mid-term]

- Incorporate additional research on recovery and all-hazards research [mid-term]
- Improve understanding of firebrands (embers) [long-term]
- Improve and standardize community-wide design principals rather than parcel-level only [long-term]
- Further understand the impacts of wildfires on public health [long-term]
- Create a general and uniform model for mitigation [long-term]
- Pilot community where rebuilding has been done
- Engage with user groups early in development of solutions [long-term]

3.0 DETAILED WORKSHOP OUTCOMES

The information below follows the format of the workshop where topics were presented by expert speakers who offered a review of the problem and current solutions, followed by discussion and reporting by breakout groups. We present a summary of presentations offered by speakers, followed by a brief summary of discussions and outcomes.

3.1 THE STATE OF THINGS: THE PROBLEM, ITS HISTORY & FUTURE PROJECTIONS

Theme overview

The goal of the first session was to introduce the audience to the Wildland-Urban Interface (WUI), problems encountered, potential solutions, and where we may go in the future. A series of presentations by two leading researchers framed the problem while we followed up with group discussions to further characterize the scope of the problem. The definition of WUI is not always clear, but the Federal Register in the United States defines it as "where humans and their development meet or intermix with wildland fuel" (Glickman and Babbitt, 2001). These are often segregated into the classic interface of a community of structure abutting undeveloped land, an intermix with undeveloped land intermixed between structures, or finally an occluded interface, where undeveloped land exists within a city or suburb (Radeloff et al., 2018). Regardless of definition, we treat the WUI here as an area where human development may be affected by wildfires, whether they directly spread into the community or start fires that may later lead to conflagrations within an urban development. Definitions aside, the WUI constitutes a region where nature and human development must learn to coincide and live together.

A Case Example of WUI Resilience

The first speaker, Crystal Kolden from the University of Idaho (now the University of California, Merced) presented examples of wildland-urban interface (WUI) resilience based largely on experiences in Southern California entitled "*Mitigating the inevitable: a success story and lessons learned from Montecito during the 2017 Thomas fire*" based largely on work presented in a paper by the presenter (Kolden and Henson, 2019). The presentation highlighted a recurring theme – that while wildfires are inevitable, wildfire disasters are not. Making communities defensible to these inevitable large-scale wildfires is key to preventing a wildfire from becoming a disaster.

The Thomas fire served as an example where community actions played a role in reducing potential wildfire damage. During the incident there were 0 fatalities, entrapment or injuries, while only 7 primary residence and 7 guest houses were lost, while 37 parcels sustained some level of structure damage. This is in comparison to other similar wind-driven fire events, such as the 1990 Painted Cave Fire in Santa Barbara where over 500 homes and 1 civilian life were lost. Key actions were taken in advance of the fire to make the community more defensible. Defensible space surveys were conducted on individual homes, highlighting exterior features that could be modified and maintenance in defensible space surrounding structures. A survey of some roadways and driveways was also conducted, where overhanging fuels created potentially hazardous conditions for response or evacuation. A fuel treatment network was devised to try to mitigate these fuels, including a neighborhood chipping program to encourage and facilitate homeowner action. A detailed CWPP was also created, which included detailed mapping of pre-attack zones and homes to plan suppression given a wildfire event. More details are available in Kolden and Henson (2019).

Importantly, these actions required a community partnership, where actions that could be taken by individuals and the community combined to result in mitigation that could affect change. Individual actions included defensible space, evacuation preparedness, fire-resistant construction, and structure hardening while community actions include road widening, controlled burning, fire breaks and agency coordination. Together, these actions translate into increased fire resilience of communities. It was important to recognize here how actions taken on individual properties serviced the greater good, as fires often propagate from one structure to another (Maranghides and Mell, 2011).

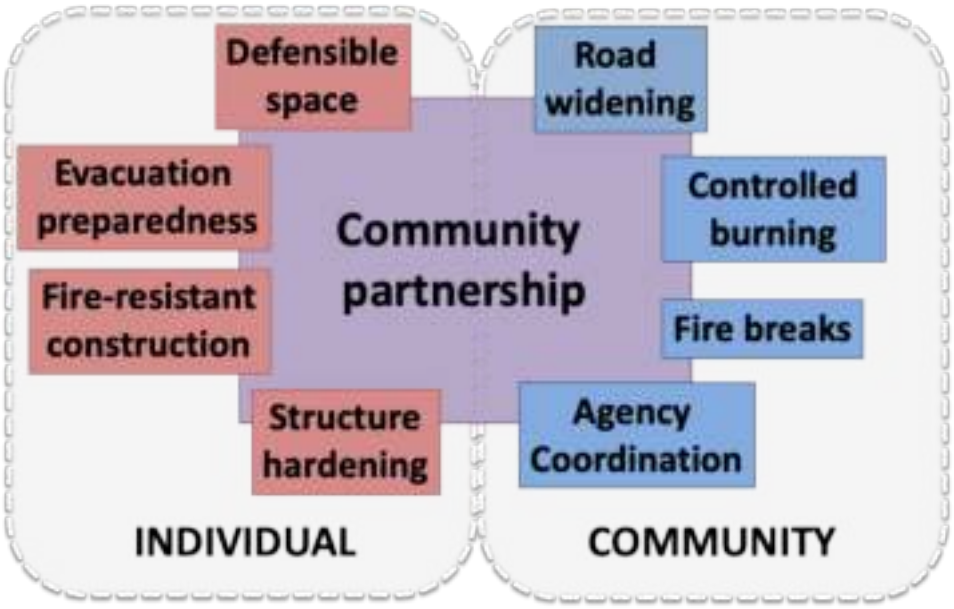

Figure 2: Components of WUI defensibility, adapted from Kolden and Henson (2019).

Ultimately, a key to obtaining resilience was posited to be learning to adapt and live with fire. Ecosystems surrounding communities have adapted to live with fire for millennia, however our communities often have not. Incorporating principles of hardening communities, defensible space, prescribed fire, and generally more knowledge sharing, and adaptation have the potential to significantly avoid wildfire disasters in the future (Bowman et al., 2020).

Structure Vulnerabilities and Post-Event Investigation

Our second speaker, Alexander Maranghides (National Institute of Standard and Technology), presented results from a series of detailed accident investigations of three past WUI fire disasters: the Witch and Guejito fires in Southern California, Amarillo fires in Texas, and the Waldo Canyon fire in Colorado. WUI fires were distinguished from urban fires as exposed structures often outnumber firefighting resources, meaning that structures need to withstand exposure from fires on their own. These resources can often be overwhelmed when extreme fire behavior conditions result in large-scale ignitions of structures by embers (small burning particles that loft from the main fire plume) or structure-to-structure ignition.

There are unique aspects of WUI fire exposure that have been identified. Fire spreads by different means: radiation or convection from the main fire front when fuels abut structures, direct flame

contact from small flames existing within defensible space surrounding homes, and embers or firebrands. Defensive or mitigative actions on individual homes can also affect neighbors, in particular, in medium or high-density construction neighborhoods where home-to-home spread can occur. Reducing parcel level combustibles reduces likelihood of structure ignitions, but mitigation of risk isn't linear—because of events with home-to-home spread risk is intrinsically interlinked throughout a community.

Detailed investigations have revealed critical vulnerabilities and trends which can't be gained from nationwide databases, such as DINS (cite) reporting. For instance, in the investigation of the Witch and Guejito fires, 100% of structures with wood shake roofs and 24% of Spanish style tile roofs were destroyed, highlighting the importance of roofing in fire prevention. Similar observations were made regarding direct suppression, which was found to be the most effective means in reducing structure losses (Maranghides et al., 2009, 2013). However, determining whether defensive actions occurred on a structure (e.g., suppression by a fire crew) while exposed to a fire takes considerable investigative work and often is not available without detailed post-event reconstruction. Together, exposure from the fire to the structure is a critical element predicting its ultimate damage or survival in a fire.

Many home features have been found to be receptive to fire and ember exposure from wildland vegetation. Reviews are given by Mell et al. (2010), Gollner et al. (2015), Caton et al. (2017), and Hakes et al. (2017) while many features are noted during post-event reconstruction as well. Some of these features include features on a residence or nearby structures, outlined below in Maranghides presentation in Table 1. Ultimately, combustible features have an ignition regime and, if ignited, can generate their own fire and ember field that exposes other areas of the structure, propagating the fire beyond an initial point of exposure.

Table 1: Features receptive to fire and ember exposure on structures

Residence	Attached Combustibles	Detached Combustibles	Secondary Structures
•Eaves •Vents •Siding •Window and door frames •Garage door	•Decks •Pergolas •Awnings	•Fences •Playsets •Wood piles •Railroad ties •Mulch/ground debris •Retaining walls	•Sheds •Barns •Car Ports

Past investigations have also highlighted the issue of structure-to-structure fire spread. Most testing on this topic has only been investigated in detail with 6-foot separations (Maranghides and Johnsson, 2008); however, it is clear that spread occurs among larger spacing as well, whether due to fire or embers. Wood fences were also identified as key paths for fire spread between structures and vegetation following the Waldo Canyon fire investigation (Maranghides et al., 2015).

Two primary mitigation methods are therefore available to reduce structure losses in the future. First, reducing exposure to structures, either through fuel modification in the defensible space directly surrounding structures or in the wider area surrounding communities will reduce radiant and convective heating exposure to structures. Second, hardening structure exteriors so that they

cannot be ignited by embers which land on them will reduce ignition by this final mode (Maranghides and Mell, 2012). Hardening structures can incorporate a wide variety of means, including fire resistant design, the incorporation of ignition/fire spread resistant materials, active suppression methods, and community design (spacing, etc.). Much of the existing guidance for communities is focused on vegetation treatment within the defensible space surrounding structures. This advice remains useful when paired with home hardening in low density communities (where home-to-home spread is unlikely) and can still be effective when displacing fuels (e.g. moving a wood shed 100 ft away from a structure). In higher density communities, where spacing between structures is often less than 30 ft and home-to-home spread is likely, this is no longer an option and fuel removal is necessary. In these cases, a community-wide mitigation approach is critical. Second, fuel treatment or removal in the area surrounding a community can reduce exposure to structures. This can be achieved via mechanical means, burning, or other measures depending on the specific area and application.

At-Risk Communities

Several burst talks were presented on *The State of Things: The Problem, its History and Projections for the Future*. Ren Larson, from the Arizona Republic (now the Texas Tribune) presented an assessment of at-risk communities across California (Wagner and Larson, 2019). This data-driven approach to reporting showed how humans impact geography and geography impacts us. Similar risk exposures calculated incorporating factors on both the natural environment and people within communities were found across the Western US, highlighting how the events in Santa Rosa and Paradise, California were not isolated events are destined to occur again. Examples were highlighted of communities such as Pine, AZ and Ruidoso, NM where actions could be taken to reduce exposures to communities. One important factor that was included in the analysis was the average age of community members, which could influence response to evacuations and ultimately life safety. Notifications were also highlighted as a key issue.

Evacuation and Notification

Erica Kuligowski (formerly of the National Institute of Standards and Technology, now RMIT University) presented on Evacuation and Notification Challenges for WUI Communities. WUI fire disasters tend to occur during extreme fire conditions, which includes unpredictable behavior and rapid fire spread, posing challenges for evacuation and notification. Households are also vulnerable to injuries or death, exacerbated by competing responsibilities, varying perceptions of risk during and after a fire event and uncertainties regarding emergency procedures before a fire. Finally, evacuation and notification can be challenging due to limitations in both physical infrastructure (e.g., limited egress routes, insufficient transportation options or power losses) and social infrastructure (e.g., a lack of means to identify trigger buffers, uncertainty in triggering warnings, an overreliance on opt-in systems, etc.). As a consequence, decisions to evacuate from homes, schools or hospitals can often be delayed, resulting in injuries and death. Moving forward, many issues must be explored including improved data collection of household response to WUI fires (especially after an evacuation decision is made), the development of practical evacuation models and tools, improved warnings and dissemination strategies, and innovative evacuation training/education methods. The use of temporary shelters or refuge areas should also be explored in the future. Many areas related to evacuation are in need of improvement and can be addressed via multidisciplinary expertise and collaboration.

Discussion Summary

A broad theme arose during discussions following the opening presentations - what makes people behave the way they do? *While a series of mitigative actions is available and is known to reduce losses from WUI fires, it is clear there are still major barriers to implementation*. An example brought up during the discussion was post-fire building in Santa Rosa, California. In the 2017 Tubbs fire almost the entire community of Coffey Park was destroyed. While a model code (California Building Code, 2013) was available, the community ultimately decided to waive these requirements in favor of perceived quicker, cheaper construction to get the community afloat again as fast as possible (Kasler and Sabalow, 2019). Sadly, this results in less fire-safe design for an area already devastated by wildfire. A variety of questions therefore arise – economic/insurance questions on funding fire-resilient rebuilding, the social science questions of risk perception, and whether reliable information on fire risk has been provided to community members and policy makers.

Risk perception and an interest in short term or local issues was discussed as a common hindrance to action. Quantifying and then communicating this risk is key. Finding ways to engage policy makers and educate communities, starting early in school, perhaps, was a key path forward. Most of the infrastructure needing protection is already built, so new building codes alone cannot be relied upon. A debate between personal freedom and protection, made harder by the fact that risk is shared amongst a community, will always arise here. Long-term solutions ultimately will require economic incentives, a public will, and regulation that enforces mitigative measures.

The question was also posed: *What will success (resilience) with the right solutions look like in the future (20 years from now)?* The discussion was engaging, and included community awareness, education, engagement at all levels, and a focus on collaborative work. Financial incentives were cited rather than enforcement and, overall, how to develop a greater recognition of risk at all levels. This will take outreach, funding and continued engagement. In a perfect world, we want an educated, informed, engaged, resilient population (of households, officials, stakeholders) that receive information from trusted sources, which allows them to act and know whom to work with and be the influences towards the change process.

3.2 LAND USE AND WILDFIRE PROTECTION PLANNING

Theme overview

Land use planning is central to WUI resilience, as the location and density of developments is critically coupled with fire risk. Without appropriate mitigations, developing communities on or adjacent to fire-prone landscapes can increase fire risk to structures, infrastructure, and other aspects of the built environment. Higher-density developments—areas with structures closer to one another—also present unique challenges due to the shared implications of fire risk and mitigation activities. As presenters demonstrated at the workshop, land use planning can play a role in fire mitigation strategies and chart long-term changes for new and existing developments.

Prior to the workshop, insights covering land use and wildfire protection planning were collected through a survey sent to workshop invitees. The relevant prompts are copied below, and the responses are incorporated into findings discussed in this section. (Refer to Appendix B for a full text of survey responses.)

- What challenges exist that hinder communities' ability to generate or maintain wildfire protection plans?
- How can land-use planning practices become a more effective tool to enhance community wildfire resilience?

On Day 1 of the workshop, there were three presentations on the topic of land use and wildfire protection planning: Miranda Mockrin (USDA Forest Service) presented on *Adaptation through recovery: past experience from CA*; Molly Mowery (Wildfire Planning International) presented on *Community Wildfire Protection Plans and land use planning tools*, and Greg Dillon (USDA Forest Service) presented on the challenges of modeling and mapping hazard and risk at the boundary of wildlands and communities. Workshop participants had the opportunity to engage with the speakers during a panel session that followed the three presentations. Discussions on the topic continued amongst each of the participants during a small group breakout session.

Planning tools such as Local Hazard Mitigation Plans (FEMA) or Community Wildfire Protection Plans (CWPP), which were a result of the Healthy Forest Restoration Act, can help communities collaboratively prioritize fuel reduction, address structural ignition vulnerabilities, and plan other fire mitigation measures. There are many additional land use planning tools that can also integrate wildfire mitigation and risk reduction concepts, including development and zoning codes, subdivision regulations, and comprehensive plans. The implementation of such tools can be tied to hazard assessments. For example, WUI building code and Fire Safe Regulations are tied to California's statewide Fire Hazard Severity Zone maps. Ultimately, there are many tools available that can help communities mitigate fire risk through planning, stakeholder engagement and collaboration. There are also many improvements that can advance implementation of these land use planning, recovery, and assessment opportunities across various scales and built environments.

Research questions remain related to maximizing the effectiveness of different land use planning tools and decisions. For example: in terms of the intermix versus interface, are we seeing consistent

patterns of structure loss that can be attributed to specific factors? How is housing density tied to losses, particularly denser communities where there is greater potential for urban conflagrations (Kramer et al., 2019)? Guidance on the best practices for community placement and design, backed up by data and modeling, would be useful to inform these practices. New tools, such as the Wildfire Risk to Communities (wildfirerisk.org) are providing a means for all stakeholders to better understand their local fire risk. This is a step in the right direction being led by the USDA Forest Service, which traditionally focuses on fire risk on federal lands, however the model still is focused on the hazard and exposure to communities without regard to structure response.

Highlighted issues and solutions

Although land use planning is actively used in the WUI, there is still a lack of an organized or uniform framework for applying this information. Some major efforts have been undertaken towards helping communities improve the effectiveness of CWPPs through the development of leadership guides, research, and outreach programs. Other state and local governments have been taking meaningful steps toward advancing land use planning tools to address wildfire risk; however, research also underscores that patchwork approach to implementation. Discussions from the presentations, workshop, and survey are summarized below in terms of 1) frameworks, 2) tools and data, 3) infrastructure and resources, and 4) community engagement.

Area 1: Frameworks

	Operational, research and market gaps	**Potential solutions**
1	Land use planning, building, and development codes • With some exceptions, a lack of building codes / associated referenced standards. • Where building codes / standards exist, some disagreement regarding severity (how restrictive) of code and related potential effectiveness. • Political backing for enforcement of smart building codes and standards • Ignitions follow people and building more structures in previously uninhabited areas may increase risk for everyone else.	• More research could minimize the extent of disagreements on code restrictiveness vs. effectiveness. • Build smart. Fire resistant construction, Covenants, Conditions & Restrictions (CC&Rs) that mandate mitigation based on science, siting of developments where they can survive, etc. • Land use planning practices can direct how, where, and under what conditions homes built in high wildfire hazard areas are constructed. Land use can also influence the pace, scale, and location of development. Examples include requiring firewood to be stored 100 ft from the home, home hardening materials, adequate width/access for emergency vehicles, defensible space, landscaping requirements, etc. • Increase (fire resilient) housing density in fire areas and limit development in high-fire (wind whipped) corridors. • Limiting sprawl into fire prone areas, restrictions on expansion which increases WUI area. • Potential solutions could include the prioritization of entitlements in low vs. high wildfire risk areas, wildfire setback regulations that reduce the attractiveness of small lot subdivisions in hazardous areas, or by requiring Home Owners Association (HOA) resources to create and

		maintain defensible space as a condition of entitlement.
2	Community Wildfire Protection Plans (CWPP) • Updating CWPPs regularly and having all stakeholders involved in, and having a say in, the process. • Long-term enforcement of actionable items that have to be included in a CWPP. Potentially developing an enforceable mechanism behind risk reduction and assessment of their implementation. • Addressing socio-economic and other societal factors (older adults, people with disabilities, transportation considerations, tech connectivity, employment, etc.) that limit resident's ability to participate in the CWPP process and act on proposed risk reduction methods. • Including local experience and knowledge in CWPP planning.	• Seeing land use planning as a continuum -- providing more information on initial steps (what do you do if you don't have a building code?) and on improvements you can still make once housing is largely developed • Creating a 'safer from the start' mentality and having a plan in place for long-term maintenance of landscaping and plantings in the community. • Ensuring CWPPs are reflective of the community, involve the community, and set a clear collective path for the community • Acknowledgement by planners, policy makers, local municipal budget managers, and code enforcers that current WUI structural and community loss is both unacceptable and the "Urban Conflagration" risk of the 21st century. • If possible, achieve a regional-level, cross-county boundary, and economically collaborative, land-use planning focus that had regional wildfire in mind, to better plan local development locations and risk/value assessments. • Make items in the CWPP actionable and enforceable over time by integrating partners and policy.
3	Guidance for cross- coordination • While many different tools and offices work on these plans, they do not always engage with one another. How can we integrate different silos together? • Offices with different but overlapping resilience goals need to be better integrated (e.g. double-pane windows provide both an energy reduction and fire prevention improvement.) • Maximize the CWPP by integrating as many stakeholders as possible • Improve communication across disciplines (e.g. Fire, Parks, Planning, Public Works, etc.)	• Merging of plans (plans referencing other plans) • Attention in the general plan process • Communication between all levels - fire department, planners, developers, builders, landscape architects, landscapers, homeowners, HOA's, etc.
4	• Improve disclosure laws around the country • Create a clear nexus between improvements and insurance costs/availability	• Make fire hazard/risk known for buying homes everywhere, including a general notification for risk among disclosure laws across individual states • Provide accurate, data-driven risk maps

Area 2: Tools and data

	Operational, research and market gaps	**Potential solutions**

1	Tools • The input/output of the tool needs to be relevant to the user /consumer (community, planner, insurance company, etc) • Unclear how to rank risk level on a hazard map / quantifying hazard and risk and exposure • Community risk assessments and hazard maps can be static and do not consistently capture changes on the ground.	• Simplify existing tools and work to validate/legitimize them • Improving the user experience (UI/UX) • Develop a framework for community-level risk and hazard assessment
2	Data for and identification of scenarios • Use datasets to simulate actual scenarios • The worst-case scenario today may not be the worst-case scenario in the future • e.g., Tubbs Fire – average vs. extreme weather "goal post" has changed. Worst-case scenarios today may not be the same in 10 years • How does climate change affect the application, long-term? • Barriers remain in getting the best available data.	• Develop tools which have a temporal framework to improve effectiveness • Develop dynamic hazard maps. • Develop best practices for risk analysis including selection of worst-case scenarios, variability in analyses, baseline data required, etc. • Develop a dataset for future climate-informed weather projections to be used in fire risk modeling
3	• Implementing economic and other non-fire behavior information to fire risk modeling • Currently, for a long-term solution, we don't forecast fire as well as we can. Ideally, we would have these models better predict fire behavior • Modeling at various scales is useful	• Develop a "fully-loaded" land use planning cost tool

Area 3: Infrastructure and resources

	Operational, research and market gaps	**Potential solutions**
1	Governance structure and resources • Lack of specific local government staff focused on problem of fire risk. • Specialized fire planning personnel/representatives in public agencies • Lack of capacity for code enforcement and plan review	• Creating federal funding or partnerships (e.g., university extension specialists) to fill this role and interact with local government • Providing training for more users to perform local fire risk assessments, • Provide training for code enforcement officials on wildfire mitigation
2	Economic resources • Tension between how far we can reasonably protect structures given economic realities - need to choose where to focus efforts • Funding for updating CWPPs seems inconsistent. Few communities pursue house-level mitigation through CWPPs • Funding to understand localized risks and potential responses	• Improve funding for CWPPs and mitigation efforts

3	• Small communities often lack the resources to design a serious wildfire protection plan, much less implement it.	• Create more funding structures that incentivize local risk mitigation planning such as the development of CWPP.

Area 4: Community engagement

	Operational, research and market gaps	Potential solutions
1	• Gaps in public communication and messaging barriers: o Denial of the issue o Misperceptions of costs for (re)constructing to a higher standard o Understanding what risk is – a lack of ability to define and quantify risks. • A major top to bottom renovation of how we deal with fire as a nation. • We need to stop "fighting" fire and learn how to prepare for and survive fire. A "fire adapted" mentality.	• Tools should produce outputs in units relevant to the audience • Make tools publicly available, so people can look up their house and community • Integrate tools into existing maps (like Zillow or Google Maps) or as a general estimate of insurance in the area • Improve labeling of risks/hazards throughout communities.
2	• Maintaining interest, support, and participation of communities in the risk reduction and planning process. Engaging participation of all stakeholders (fire, police, large private landowners, public landowners, government). • Communities are not necessarily involved in mapping local hazards, vulnerabilities and capacities. How can we encourage local authorities and councils to adopt methods of co-learning wildfire resilience with communities, in ways that democratize mapping and the creation of actionable data? • How can a community confront the risks that do exist and make changes that create safety?	• Meet communities where they are at and see what solutions will work with them on the ground. • Getting tools to the hands of people living in unincorporated areas.

Realistic actions to resolve research and market gaps

Summarized below are key actions to address the operational, research, and market gaps identified in previous subsections. These were developed following summary discussions with the entire group. Some of these actions are already being undertaken, to some extent, by various organizations and local/state governments across the country. For example, CWPP/hazard mitigation plan integration is becoming a more standard best practice; similarly, a lot of research has gone into developing guidance for integrating fire safe practices into land use planning (see Mowery et al., 2019). Again, we followed a format of topically themed recommendations followed by a designation of short, mid, and long-term timescales for research and development.

Development of Guidelines and Analyses

- Develop a methodology for holistic performance-based design (PBD) for WUI communities [mid-term]

- Develop guidance for resilient rebuilding that exceeds current code requirements [mid-term]
- Standardize methods for visualization and presentation of risk to various stakeholders [mid-term]
- Investigate the co-benefits of retrofits and actions alongside vegetation management (potentially conflicting strategies) [mid-term]
- Integrate fire-safe planning best practices into land use planning best practices and curricula as a whole [mid-term]
- Analyze the total life cycle cost of wildfires [mid-term]
- Quantify cost between incentivizing retrofit vs. post-fire damages [mid-term]
- Compare mitigation costs to potential savings through risk reduction [mid-term]
- Research effectiveness of sustained funding for outreach and mitigation programs [mid-term]
- Estimate climate change mitigation/adaptation and associated costs, as well as cost of inaction, cost of co-benefits [mid-term]
- Investigate economics and costs associated with real estate, banks and mortgage that may motivate risk reduction [mid-term]
- Perform cost-benefit analysis of individual and community actions [mid-term]

Land-Use Planning Improvements

- Integrate community wildfire protection plans (CWPP) into local hazard mitigation plans [mid-term]
- Standardize notification and warnings on a national scale [long-term]
- Streamline agency responsibilities [long-term]

Testing and Standards Development

- Compare international WUI building codes and outcomes [short-term]
    - Studies to quantify effectiveness of outreach and mitigation measures
- Quantify retrofit effectiveness [mid-term]
    - Features, exterior/interior sprinklers, home spacing, etc.
- Develop test methods and codes for construction materials and assemblies [mid-term]
- Incorporate more research on recovery and all-hazards research [mid-term]
- Improve understanding of firebrands (embers) [long-term]
- Improve and standardize community-wide design principals rather than parcel-level only [long-term]
- Further understand the impacts of wildfires on public health [long-term]
- Create a general and uniform model for mitigation [long-term]
- Pilot community where rebuilding has been done
- Engage with user groups early in development of solutions [long-term]

3.3 TECHNOLOGIES FOR RISK ASSESSMENT AND PLANNING

Theme overview

Promising advancements in WUI resilience have been made possible in part due to an emergence of new and improving technological solutions, which is why the topic is highlighted as a key workshop theme. Today, landscape and location-specific wildfire hazard and risk analyses are more widely being conducted thanks to existing tools that harness various technologies together with data science techniques. Although for years fire departments and emergency operations centers have used and relied on such tools, there is marked improvement in their fidelity and capability, which has both improved emergency response outcomes and prompted more widespread adaptation. Notably, community-scale wildfire hazard and risk assessments are now being required in some US states[4] as undoubtedly necessary to inform planning for mitigation efforts, construction development, and resource prioritization or allocation. Technology-based tools that are accessible to the public at no cost via web applications or open-source software have further spurred an increase in the use of wildfire risk assessments by industry practitioners, such as land-use and community planners, fire protection engineers, foresters, insurance underwriters, and policy makers. Similarly, advanced technologies and data solutions for fire risk and planning are increasingly becoming engrained in standard operations for electrical and gas utility providers and agency regulators[5].

Prior to the workshop, insights regarding technologies for risk assessment and planning were collected through a survey sent to workshop invitees. The relevant prompts are copied below, and the responses are incorporated into findings discussed in this section (see Appendix B for full text of survey responses.)

- What are the market gaps and challenges for conducting landscape-scale fire risk assessments? How might those gaps be addressed by new technologies and data solutions?
- What are the market gaps and challenges for WUI resilience planning? How might those gaps be addressed by new technologies and data solutions? This can be planning for construction/development, fire service operations, etc.

On Day 1 of the workshop, there were three presentations on the topic of technologies for risk assessment and planning: Chris Lautenberger of Reax Engineering Inc. discussed developments and applications in real-time fire spread and risk forecasting; David Sapsis with CALFIRE presented on California's improved statewide hazard mapping with downscaled fire climate data; and David Marvin and Chris Anderson, both at Salo Sciences, spoke on dynamic mapping of forest structure and fuels with nanosatellites and deep learning. Workshop participants had the opportunity to engage with the speakers during a panel session that followed the three presentations. Discussions on the topic of technologies continued amongst each of the participants during a small group breakout session.

[4] California has related statutes SB 1241; Government Code Sections 65302; and 65302.5.
[5] https://www.cpuc.ca.gov/wildfiresinfo/; https://www.oregon.gov/puc/safety/Pages/Wildfire-Mitigation.aspx

Highlighted issues and solutions

Although there have been significant improvements over recent years, there still exists critical gaps and challenges with technologies for wildfire risk assessments and planning. Findings from responses to the pre-workshop survey, speaker presentations, and discussions during the workshop are organized into four main areas of operational, research and market gaps: 1) frameworks (*i.e.,* plans, standards, and procedures), 2) tools and data, 3) infrastructure and resources (*i.e.,* utilities, computing power and resources), and 4) end-user engagement. The following tables outline the gaps and identify potential solutions under each of the four identified areas.

Area 1: Frameworks

	Operational, research and market gaps	**Potential solutions**
1	• There is a general lack of building codes and associated reference standards for land use planning and construction development in at-risk WUI areas. • There is no model code that provides a map of "WUI risk areas" such that state or local jurisdictions can refer to for guidance in establishing regulatory measures for wildfire risk reduction. • Even with today's definitions, the delineation of at-risk areas, and the level of present risk, would require consistent updating as wildfire risk is dynamic. • Where WUI building codes and standards do exist, there is some disagreement regarding severity or restrictiveness of code requirements and the related potential effectiveness in risk reduction. • There are also limitations and latencies in currently available maps of hazard in WUI-defined areas, e.g. Fire Hazard Severity Zones (FHSZ) in California.	• A nation-wide WUI risk map[6] was recently developed and launched by the USDA Forest Service. Such a tool that depicts risk is needed to be adopted by reference in model codes for improved wildfire safety in community planning processes and engineering design practices. The map would need to be updated with every code cycle so that it reflects the changes in risk. • Lower cost LiDAR with use of UAV's for fuel and hazard mapping, along with a national understanding of best practices in this area, utilizing worst case scenarios based on historical weather data, can be employed to create current and realistically defined WUI areas and associated geospatial data layers. • More data should be collected regarding effectiveness of WUI code requirements. The limited data that is available should be used to inform future code requirements as applicable.
2	• There are several wildfire modeling tools available in the US, however, there are no minimum standards or regulations as to how the models are developed and to what degree-of-certainty they are used to inform planning and engineering of buildings and communities. • There are no open source / actively maintained software tools available for this similar to FDS for the built environment.	• Regulatory guidance that addresses operational wildfire models and associated data should be created so as to ensure that scientifically robust tools are in use. • Standardizing the data formats of inputs and outputs for wildfire modeling, as well as the standardization of minimum scientific requirements for modeling and mapping tools, would allow for increased compatibility and efficiency in sharing information across agencies. In turn, this would help to streamline resources and reduce losses before, during, and after a wildfire event.
3	• Local governments and communities lack the tools to prioritize cost-effective investments: e.g., should they spend money on home	• New tools that can help arrive at prioritization of mitigation measures based on risk and cost are needed.

[6] https://wildfirerisk.org/wp-content/uploads/2020/04/WRC-US-Risk-to-Homes-202004.pdf

	hardening, defensible space, community level fire breaks, or what mix and where?	

Area 2: Tools and data

	Operational, research and market gaps	Potential solutions
1	Some existing gaps in technologies are due to limitations in physical sciences that inhibit the development of more advanced tools, *e.g.*: • A lack of understanding on how materials react under wildfire exposure (including material science and thermal engineering of WUI fuels) • No physical method exists to establish a fuel model for the built environment nor incorporate WUI fuels into fire models. • Physical underpinnings of fire spread are still unknown.	• Develop test standards for WUI materials and assemblies that reflect realistic exposure conditions (magnitude, mode and duration of heat transfer) • Develop a framework and model for fire spread from vegetation to the WUI built environment. • Continue to research physical mechanisms of spread to improve models in the future.
2	Social sciences also need greater attention and incorporation into wildfire technologies. Limitations in this area include: • More mapping of social aspects, not just physical aspects, and linking them together (consider the picture holistically). • Improved understanding of how the public interprets and responds to emergency information from apps, alerts, and other sources. • Methods to define uncertainties due to human factors (e.g., notification and evacuation response).	• Continued research on human factors in fire is needed so that data can be collected and used to improve the capability of wildfire models and other tools. Advocating for cross-disciplinary research funding in social sciences and wildfire can help to boost development.
3	Modeling tools gaps and needs: • Dynamic vs. static models (changing conditions create need for more dynamic models – even for planning purposes) are needed with the ability to update models on a regular, consistent basis. • Situational awareness of resources - people, firefighting resources, etc. is needed. • Structures need to be included as a fuel source. • Future scenarios with climate change and future development are not included in current models. • Most wildfire models do not run at a fine enough scale for WUI planning purposes (i.e. neighborhood/parcel). • To be effective for planning at the local level, risk assessments currently have to be verified via site-by-site parcel assessments, which are costly and time consuming.	Areas for potential improvement include: • Providing real-time location information on wildfires • Real-time detection • Data-sharing tools for use by authorities or the public • Evacuation modeling tools need to be developed and widely available • Effective guidelines for community risk assessment with modeling (assumptions and methods, best practices, etc.)

4	Data gaps and needs:
	• Data resolution
	  o Fire detection and mapping need higher spatial and temporal resolution
	  o Users have different resolution needs.
	  o More finite data and funding mechanisms to provide for this data acquisition
	• Timing of data collection
	  o Pre-fire data
	  o Need real-time data, provide to right people and help make decisions.
	• Data acquisition and quality, scale of resolution, process.
	• There is much static data available, but having dynamic real-time data tied in with other geospatial layers will help us with preplanning events and responding to events using a much more concise and safe approach.
	• Incomplete knowledge regarding local weather patterns, vegetation loading
	• Maintaining information regarding current conditions
	• Obtaining sufficient information regarding property-level vegetation and built-environment materials / installation details.
	• Drone technology (personal privacy issues)
		• A combination of satellite, airborne and ground-based sensors to improve fire detection and mapping
		• Improved systems for sharing geospatial information to targeted users
		• Improve timely updates to local weather, fuels, and fire data.
		• Generally, apply real-time data rather than static data (e.g. multi-year wait for LANDFIRE updates).
		• Include homes and communities (including local vegetation) in fire maps for risk analysis (fine scale)

Area 3: Infrastructure and resources

	Operational, research and market gaps	**Potential solutions**
1	• Technology needs and redundancy for public warning systems which depend on power, i.e. dealing with power losses.	• Investigate hard wired systems for warnings where cellular signals and power shutoffs may influence the ability for notification • Improve backup power for cell towers
2	• There is a high standard for models to work every time, but they also need to be usable by all fire departments.	• Differentiate information from models for different end users over different time scales (e.g., detailed morning overviews but brief updates of major fire behavior changes)
3	• Local governments need to understand how different investments of local and state dollars will impact safety, grid reliability, and insurability.	• Improve outreach and communication on available technology to government and first responders
4	• Wildfire modeling requires many data inputs that must be obtained from various sources. Data fidelity, latency, resolution, and access are several of the key considerations during model set-up, yet such metadata is not always well documented.	• A wildfire model-user data repository that hosts external links to sources of necessary data for wildfire modeling in the US, as well as a description of the data attributes, would help to streamline modeling processes, provide the user community with greater access to available resources, and allow for an understanding of the data gaps across the nation.

Area 4: End-user engagement

	Operational, research and market gaps	Potential solutions

1	• Ease of understanding the technology
	  o How is information going out to the first stage of the user groups?
	  o User-friendly models are needed for land use planning on a broad scale
	• Education and training for field engineers, fire departments & practitioners
	• For landscape-scale application, advances in usability and accessibility for local governments to use GIS and areal (drone) technology
		• Develop applications and online training for local fire departments (and residents, local NGOs, installer/contractors, insurance industry) to learn fire risk assessment techniques so a local department or group of volunteers, etc., can be empowered to do such work on their own at less program cost. Same technology for data review, risk identification, and comparative work.

2	• Transparency and security o Need to be clear what information can be released to the public and how it will be used (e.g., national security concerns related to arson). • Provide fire risk evaluation including things like weather conditions, to increase the transparency of information. • Need to better define, at the start of the project, at what level people interface with the tools/products	• Create guidelines for the use of fire modeling, risk, and other outputs by different users • Work with national security experts to assess risk of making fire hazard information data publicly available
3	• The issue is related to people and relationships, rather than technology. • It is a benefit if a technology can do the mapping more quickly and at a cheaper cost - the rest of the work is people intensive.	• Work to build relationships with different end users. • Create opportunities for scientists developing tools to interact and learn from decision makers who may use these tools.

Realistic actions to resolve research and market gaps

Summarized below are key actions to address the operational, research and market gaps identified in previous subsections. These were developed following summary discussions with the entire group. Again, we followed a format of topically themed recommendations followed by a designation of short, mid, and long-term timescales for research and development.

Technology Solutions

- Develop methods to collect real-time structure loss data [mid-term]
- Build a field sensor network to improve assessment of local conditions (e.g., weather, fuel moisture) and fire detection [mid-term]
- Develop real-time fire modeling tools which can be tied to evacuation and notification to inform decisions [mid-term]
- Increase utilization of existing satellite information [mid-term]
- Develop immersive technologies for training (e.g., gamification) [mid-term]
- Improve technology for warning systems, even including hard-wired systems where applicable [mid-term]
- Improve the spatial and temporal resolution of current fire detection from satellites [long-term]

Technology and Risk Mapping Solutions

- Develop risk maps that incorporate home ignition risks at both community and individual parcel scale [mid-term]
- Implement personalized and accessible risk evaluations [mid-term]
- Increase use of satellite and other real-time data for decision-making and post-event data collection [mid-term]
- Improve data collection, including pre-event data (such as defensible space inspections) to understand the impact of mitigation during post-event investigation (e.g., DINS data in CA). [mid-term]
- Improve spatial and temporal resolution of satellite-based fire detections [long-term]
- Add redundancies in communication systems including adoption of wired analog systems in some areas [long-term]

Data Needs

- Create a WUI data-sharing repository for pre- and post-event data [mid-term]
- Research how to collect and apply real-time loss data [mid-term]
- Improve post-fire data collection [mid-term]
    - Landslides, mudslides, erosion
    - WERT, BAER (federal level, rehab of burnt area)
    - Long-term data on community recovery post fire.

Modeling Needs

- Develop models capable of simulating fire spread into and within WUI communities [mid-term]
- Standardize quantification of risk and develop a framework for mapping risk to WUI communities [mid-term]
- Utilize fire models for real-time simulations to aid in evacuations and fire management [mid-term]
- Utilize fire models for next-day fire risk calculations that are highly localized (e.g., targeted community rather than county-level fire danger warnings). [mid-term]
    - Improve ember modeling science and simulation tools

3.4 OUTREACH AND ADVOCACY

Theme overview

By its very definition, the wildland-urban interface is where forests and rangelands meet subdivisions, ranches and other arrangements of the built environment and therefore where wildfire moves from vegetation to structures. Resilience for these areas includes reducing the likelihood that people will be injured or killed, and the likelihood that homes and businesses will be damaged or destroyed. Individuals' actions to prepare their homes and families for wildfire events is both necessary and effective; yet, to motivate action, people must be aware of the risks and understand what they can do to reduce them. There is also a contextual understanding that, in the U.S., nearly any actions on private property must be undertaken by the property owner or resident voluntarily, as there is a strong cultural perception defending property rights that limits the ability of regulators to force action. We can assume, then, that without educational outreach to people living with wildfire risks, there will be little to no risk reduction action at the individual property and neighborhood level. A caveat to this notion is that perhaps the individual has a heightened perception of risk due to previous experience with wildfire, for example, which can serve as an enabling factor for mitigative efforts whether the individual has received educational outreach or not. Still, individual wildfire risk is a function of neighborly (in)action; advocacy in one's own community, on social media, and/or other platforms to inform and motivate neighbors to protect themselves and each other through property hardening also plays an important role. Thus, the need for outreach and advocacy – communication and education of residents and property owners with the goal of getting them to take risk reduction actions – is identified as a critical component of a holistic approach toward WUI resilience.

The two prompts below on the topic of Outreach and Advocacy were included in the pre-event survey that was sent to workshop invitees. The responses received are incorporated into findings discussed in this section (see Appendix B for full text of survey responses).

- What are the gaps and challenges of current outreach programs that aim to improve WUI resilience?
- What are the needs and next steps to encourage adoption of mitigation measures?

On Day 2 of the workshop, two speakers presented their insight and experience in outreach and advocacy for WUI resilience. Michele Steinberg, Wildfire Division Director at the National Fire Protection Association (NFPA), shared about the work of NFPA's Firewise[7] program and how it has been successful in educating and empowering communities to take responsibility in reducing fire risks. Jerry McAdams, Senior Captain and Wildfire Mitigation Coordinator for the Boise Fire Department, gave a first-hand account of the role that local fire departments are encouraged and needed to fulfill in supporting their communities to become better prepared for wildfire. Following their talks, Steinberg and McAdams fielded questions from workshop attendees, then everyone split into breakout groups to continue discussion on challenges and solutions related to outreach and advocacy.

[7] National Fire Protection Association's Firewise USA® Recognition Program: https://www.firewise.org

Highlighted issues and solutions

A set of findings on the highlighted issues in outreach and advocacy efforts for WUI resilience was gathered from the pre-workshop survey responses, speaker presentations, and group discussions. It is important to note these findings do not provide the full context of important outreach and advocacy work already ongoing but instead reflect the discussions at the workshop. Many significant outreach efforts already take place across the United States, but most are focused in local areas. As highlighted in the recommendations below, metrics to assess program effectiveness would be very useful to compare the multitude of ongoing efforts. These findings are organized into four main areas of operational, research and market gaps: 1) frameworks (*i.e.,* plans, standards, and procedures), 2) tools and data, 3) infrastructure and resources, and 4) community engagement. The following tables outline the gaps and identify potential solutions under each of the four identified areas.

Area 1: Frameworks

	Operational, research and market gaps	**Potential solutions**
1	• Limited guidance is available on effective communication and messaging best practices for programs that support outreach and advocacy efforts. • There is often inconsistent or conflicting messaging coming from several different outreach programs. • Communication needs to consider the needs of urban vs. rural communities and possible cultural barriers.	• Develop and adopt a common messaging strategy based on science and tailored to communities. • Seek out and share information from valid sources across communities. • Involve cultural brokers in the conversation to ensure information is getting to all sectors of society. • Use windows of opportunity triggered by recent fires (the increased awareness and interest in wildfire issues and how to mitigate) • Messages that are positive and or funny to keep people following/listening and engaged
2	• Policy to inform of hazardous conditions - Flood, earthquake, fire - in/out. When information is disclosed is inconsistent, state and regional differences. • Guidance is also needed to address challenges of doing mitigation work in communities where residents are renters as opposed to homeowners	• Disclosure and gathering of relevant information (hazards, etc.) to those who need to know i.e., home buyers, homeowners, travelers, vacation rentals, tourists, etc.
3	• A framework that enables tracking and measuring the success of outreach efforts would be useful as a form of empowerment for individual outreach groups.	• Performance indicators - community specific comparisons, competitive comparison for driving additional motivation, outreach success. • Tie community outreach to incentives and pricing. • Wildfire certification programs for homes as a possible option, as well as incentive programs like Colorado Springs and Boulder[8] have in place.
4	• The focus of existing outreach programs often falls short of disseminating important information, for example: o Not enough attention on community-level infrastructure and development beyond neighborhood level.	• Demonstrate long-term financial benefits of mitigation investments and the costs of doing nothing in terms of time and money to recover from loss. • Educate key decision makers and elected officials.

[8] Boulder County Wildfire Partners program: https://wildfirepartners.org/

	○ Not enough focus on homes and ignition vulnerabilities, especially embers. • Outreach should also focus on addressing debilitating perspectives, such as: ○ Fire-safe homes are more expensive and not aesthetically pleasing. ○ Air quality vs. prescribed burns • Existing programs may also lack adequate focus on education of actual wildfire risks and mitigation cost-benefit, both critical to enable action.	• Change public perception of WUI home construction through positive examples of aesthetic, fire-safe homes. • Change public perception of WUI risk reduction responsibility by emphasis of the effectiveness of individual actions. WUI risk reduction needs to become the social norm.

Area 2: Tools and data

	Operational, research and market gaps	**Potential solutions**
1	• Science and data on effective strategies for outreach may not always be clearly communicated or readily shared with outreach groups. • Better communication of hazards to the public, preferably geo-positional shared with larger community	• Engaging the scientific communities and government agencies with the public - bridging the gap - in a careful way to include all. • Use WiRe model[9] to understand individuals' needs and how best to address them.
2	• Messaging materials/tools • Outreach limited to print mailers and brochures is ineffective • Getting messages out to people - Facebook algorithms have limitations to disseminate • Materials rarely available in languages other than English	• Improve messaging tools and access to them

Area 3: Infrastructure and resources

	Operational, research and market gaps	**Potential solutions**
1	• Obtaining funding for outreach programs is a challenge and there is a general lack of sufficient funding channeled for wildfire mitigation efforts. Community leaders often look forward to funding from government to act, which can be slow or non-existent. Leaders should understand they are protecting their own community and be proactive.	• Use volunteer-led model such as Firewise. • Encourage community volunteer training - example given was the CERT[10] (Community Emergency Response Team) concept. • Partnering with larger organizations or agencies • Leverage existing local, state, federal grants and programs that can help homeowners. • Cost-sharing programs like community chippers • Getting people to do the little things like weed and brush control.
2	• Resource prioritization is an issue as current programs do not target those at most risk. Instead, resources tend to flow to those who already have the means to organize and acquire resources.	• Consensus on priority of preparedness items • Evaluate populations for vulnerabilities and capacities, investigate their understanding, assess how to improve

[9] Wildfire Research Center "WiRe": https://wildfireresearchcenter.org/approach/
[10] https://www.ready.gov/cert

3	• There is a lack of dedicated, trained personnel to support outreach efforts and build relationships with residents. Such a role is needed as voluntary programs alone will not solve the problem.	• Hire people locally whose sole job is community education, funding/implementation of local risk reduction projects. • Fund field positions for wildfire safety advocates to work in neighborhoods, get to know people, write grants, facilitate mitigation • Educate fire and agency personnel about home ignitability - if they don't understand, how can homeowners be expected to understand?

Area 4: Community engagement

	Operational, research and market gaps	Potential solutions
1	• Not enough efforts are being done that involve outreach to children.	• Use child-centered preparedness and resilience strategies. • Increase education and outreach to children (middle school, high school), higher education, and multidisciplinary communities-part of long-term solutions and increased long term community engagement. Child->Parent motivation • For example: terminologies, wildfire drill, curriculum, Ready-set-go
2	• Outreach programs have their own agendas and often a one-size-fits all approach – they aren't always tailored to community needs. • Outreach programs are top-down, not set up to receive community inputs and knowledge • Need to work together with neighbors - within community. At a system level, not parcel by parcel.	• Outreach should incorporate relationship building on local level and with homeowners. • Peer-to-peer resident education to help with understanding of risk. • Educated/informed residents who can influence local policy development and enforcement. • Socialize mitigation - make it the norm • Reach out and learn from indigenous nations on successful stewardship of the land

Realistic actions to resolve research and market gaps

Summarized below are key actions to address the operational, research and market gaps identified in previous subsections. These were developed following summary discussions with the entire group. Again, we followed a format of topically themed recommendations followed by a designation of short, mid, and long-term timescales for research and development.

Education Solutions

- Continue to improve and expand education and outreach to new stakeholders
    - Children and schools [mid-term]
    - Insurance customers [mid-term]
    - Government officials and legislature (California is a model in some ways) [mid-term]
- Connect WUI fire resilience to sustainability – e.g., carbon cost of rebuilding [mid-term]
- Create curricula to train architecture, landscape design, planners, etc. on WUI design principles [mid-term]

- Inform journalists so they are educated about the "full picture" of wildfire with thoughtful reporting. Documentaries as well. [mid-term]
- Integrating these concepts into curricula for fire service "marketing" based on existing understanding of social sciences [mid-term]
- Teaching to prevent human-caused ignition [mid-term]
- Share cost-effective retrofit guidance [mid-term]
- Improve overall communication of responsibility and risk [mid-term]
- Communicating hazards associated with post-fire [mid-term]
- Use lessons learned globally to communicate strategies. [mid-term]
- Increase the number of community experts for outreach and education [long-term]
- Improve methods to translate risk and research to citizens [long-term]

Engagement Actions

- Improve overall communication and collaboration between stakeholders through new partnerships: [short-term]
    - Partner with real estate agents, home builders, and insurance agents. (especially in communicating risk).
    - Commercial partnerships (e.g., incentives with home improvement stores)
    - Engage with construction industry to develop "safer" products
    - Engage with insurance industry and regulators to "price for risk"
    - Engage with critical infrastructure and utility operators for planning and mitigation
    - Partner with the Occupational Safety and Health Administration (OSHA) for personal protective equipment (PPE) regulations
- Increase fire service involvement in mitigation and communication of risk [mid-term]
- Increase involvement of tribal and indigenous partners - cultural burning and also risk and mitigation awareness [mid-term]

Research and Development Needs

- Develop metrics to assess outreach programs [mid-term]
- Improve understanding of risk perception and mitigation measure adoption [mid-term]

3.5 NOTIFICATION AND EVACUATION

Theme overview

Passive mitigation measures such as home hardening and vegetation management, as discussed previously, are crucial to WUI resilience yet cannot be solely relied upon to protect lives and property during a severe wildfire event. While we have evidence and data that passive strategies do increase the chance of structure survival in a wildfire (Maranghides et al., 2013), there is no absolute assurance in building performance under such uncertain fire threat. Besides, if a resident chooses to shelter-in-place in their home, there is no guarantee that fire service personnel will be able to reach them if help is needed. Thus, a community threatened by wildfire must be able to execute a timely and efficient evacuation so that residents can reach an area that is safe from radiant heat and smoke before onset of onerous conditions. This requires pre-planning, multi-agency coordination, situational awareness, and adequate resources. Additionally, both responding agencies and residents must receive timely notification of fire hazards and actions to be taken before, during, and after an evacuation event. Communication systems must be in place capable of withstanding severe weather; or evacuation warnings may be hampered. The topics of notification and evacuation are essential in enhancing resilience and reducing casualties in the face of wildfire threats.

Workshop participants examined key issues related to WUI notifications and evacuation through a pre-workshop survey, three workshop presentations (Cova 2020, Hawks 2020, Kuligowski 2020), two panel discussions, and breakout group discussions. The two questions related to notifications and evacuation that were included in the pre-workshop survey are copied below. Full survey responses are provided in Appendix B and key insights are incorporated into findings discussed in this section.

- What are the current gaps in notification and evacuation plans?
- What can be done to improve the process in the near and long term?

On Day 1 of the workshop, Erica Kuligowski (2020) summarized key challenges and identified some opportunities at the interface of three systems: fire/ environment, households/people, and infrastructure (both physical and social). On Day 2, Tom Cova (2020) summarized an evacuation planning framework for worst-case/ dire scenarios, and Steve Hawks (2020) presented key lessons learned on evacuation preparedness from the Camp Fire (2018) in Paradise, California. In follow up to the three presentations, further insights were contributed through audience questions and panel discussions.

Highlighted issues and solutions

The pre-workshop survey, presentations and discussions highlighted four areas of operational, research and market gaps in current wildfire notifications and evacuation planning: 1) frameworks (*i.e.,* plans, standards and procedures), 2) tools and data, 3) infrastructure and resources (*i.e.,* utilities, shelters and evacuation routes), and 4) community engagement. The following tables outline the gaps and identify potential solutions under each of the four identified areas.

Area 1: Frameworks

	Operational, research and market gaps	Potential solutions
1	• Inter-agency coordination of evacuation planning, preparedness and response operations can be improved. ○ For example, in California, the Firewise communities, Fire Safe Councils, CALFIRE, and CERTs coordinate different aspects of evacuation preparedness and planning before a fire event, while law enforcement agencies coordinate notifications and evacuation procedures as a fire situation develops. Messages to communities can be confusing and conflicting. • Local interoperable procedures on messaging and alerts need to be clearly defined. Delays or miscommunication can cause losses, as have been seen in a number of recent fires. • Inter-agency coordination procedures are not regularly practiced with participating communities. • There is no consistent standard to ensure interoperability of inter-agency communications infrastructure, which can cause delays in messaging and hinder coordination efforts during a fire.	• Inter-agency coordination, particularly in the form of interoperable procedures and communication standards, should be clearly integrated into local evacuation planning and community preparedness activities. • Adopt nation/ state-wide standards and procedures for creating and disseminating notifications to diverse members of the community. Standardized alerts and warning messages (e.g., in the way of templates) and standardized notification procedures can help ensure that visitors and tourists from other cities/ states understand the hazard, who is being warned, when they need to act, and the guidance they should follow to protect themselves from harm. • Conduct regular evacuation drills to test inter-agency plans and coordination of notifications, evacuation and return procedures with participating communities. Drills will be important to ensure clear messaging, better coordination and clarify institutional responsibilities.
2	• Plans and operating procedures do not sufficiently address worst-case/ dire scenarios. ○ For example, how can evacuation plans include redundancies in the event of fallen power lines blocking evacuation routes, notifications not reaching enough people in time, abandoned vehicles and traffic gridlock? • There is largely a reliance on historical environmental and fire data to inform plausible future fire scenarios, which are then used as a basis for developing evacuation plans and operating procedures. However, with rapidly changing environmental conditions, this approach leads to exclusion of the current and impending worst-case/dire scenarios that pose risk to communities.	• Plan for a range of dynamic, uncertain and worst-case scenarios. For example, apply lessons learned[11] from the 2018 Camp Fire's rate of spread in Paradise, California, where the pace of evacuation was dictated by the rate of the fire's spread, not the evacuation plan. Plans should include back-up options for cases with limited available time, adverse events, and warning system failures.
3	• Evacuation plans may not address the high probability of multiple and compound disasters that can affect WUI communities. For example, earthquake, landslide, flood, pandemic.	• Incorporate all-hazards planning within WUI evacuation plans, with an emphasis on all-of-community preparedness. • Integrate pandemic related requirements and procedures across all evacuation and shelter plans, including for health and assisted care facilities.

[11] https://www.buttecounty.net/oem

4	• Evacuation plans, standards and procedures are for the most part 'top-down' and may not be responsive to local needs and community preferences. • There remain research gaps in understanding the factors that limit residents' ability to participate in wildfire evacuation planning and implementation.	• Develop community-centered evacuation plans. Holistically examine vulnerabilities and capacities of all residents. Perform periodic review of the plan to assess changes within the community over time and to update the plan accordingly. • Consider how people may be impacted by the same risk in different ways (i.e., elderly, migrants, children, disabled, unemployed, and people with low mobility, fewer transportation options, and lower tech connectivity).
5	• Early notifications and warnings regarding safe routes and emerging hazards are often not issued or issued too late.	• Develop communication procedures whereby alert notifications of a nearby fire ignition are disseminated to all households, small businesses and critical services located within a specified radius of the ignition point, irrespective of when or if subsequent evacuation orders might follow. • Notification standards and procedures need to be clear and actionable.

Area 2: Tools and data

	Operational, research and market gaps	**Potential solutions**
1	• Early detection of ignition points and accurate prediction of fire spread remains a challenge with current approaches and limitations of available technologies.	• Develop and test networks of sensors (satellite, visual, lidar and thermal) to collect accurate, real-time, actionable data on fire spread, at-risk communities, landscapes and structures under highly dynamic conditions.
2	• Developing trigger points is difficult in the absence of early detection of ignition points, real-time traffic data and insights into social-behavioral trends.	• In addition to fire spread and traffic data, consistently incorporate social-behavioral factors, including their influence on decision-making, in wildfire evacuation modeling. • The factors that influence the following decisions should be identified and incorporated into trigger models: 1) if households will evacuate and when will they leave the house, 2) mode choice, 3) route choice and 4) destination choice, among other decisions.
3	• Real time, accurate data exist, but are not necessarily incorporated into mapping platforms that people (both community leaders and the public) can use for real-time updates on routes, traffic, shelters, and other important evacuation-related topics. • Data is owned by private telecom companies or on social media – how do we get real-time accurate data on people's movement and safety? • It is not just about mapping where a fire will spread, it is also important to know where people are likely to go, based on their past experiences and access factors.	• There is an urgent need for real-time data on routes, traffic and shelters. Communities need real-time data on blocked/ hazardous routes and traffic congestion, so people know where to go even as conditions rapidly change on the ground. • Enable real-time mapping of evacuation routes and hazards through apps. • It could be useful to map historic evacuation routes with community leaders to understand what has worked and what has not worked in the past. Tap into community knowledge and make it a part of the data that feeds into simulations and mapping evacuation routes. • In particular, evacuation route mapping should consider those with access, functional and special needs - homeless, economically disadvantaged, migrant households with language considerations,

		gendered dimensions (understanding who is more likely to use the maps among certain demographics), elderly, people with disabilities, animals and pets.
4	• Robust modeling tools that can simulate community evacuations are not yet available. Thus, current approaches to planning for evacuations typically rely on best judgement, or empirical or qualitative data.	• Development and use of evacuation models that provide quantitative, validated data could significantly improve planning of evacuation response for existing and new communities.

Area 3: Infrastructure and resources

	Operational, research and market gaps	**Potential solutions**
1	• Broken, fallen and sparking power lines and power shut offs contribute to heightened WUI risk from a range of utility infrastructure.	• Require mandatory hardening of power and communication infrastructure. Hardening efforts can be prioritized using risk evaluation that weighs capability of community egress. • Explore innovations in retardant/ suppressant technologies for pre-treating vegetation and defending critical infrastructure and evacuation routes.
2	• Temporary Refuge Areas (TRAs) are not pre-designated thereby increasing the likelihood of people not knowing where to go. Also, TRAs are not used preemptively, but as places of last resort, by which time TRAs could be impossible to get to, due to blocked routes. • Further, not all TRAs have animal and pet facilities. • Critical facilities such as schools and hospitals are currently not required to have an evacuation plan and practice regular evacuation drills. This leaves a large portion of vulnerable people unprepared.	• Develop plans that pre-designate TRAs for use by populations who are unable to evacuate safely during fire events. Additionally, critical facilities could develop wildfire plans that outline evacuation procedures and practice regular drills. • The ongoing COVID-19 pandemic shows why it will be important for evacuation plans to pre-designate medical shelters and make early evacuation mandatory to counter smoke impacts for a growing population with severe lung conditions. Schools, for example, can be used as surge shelters. • Notifications need to provide systematic guidance to households evacuating with animals and pets/ sheltering in place with animals and pets. For example, clearly list guidance on which TRAs are responsive to access and functional needs and can provide shelter to pets.
3	• Insufficient capacity of routes or transit options, especially in dire scenarios, thereby making evacuation an unsafe option.	• In terms of future evacuation planning needs, dire scenario planning may include incorporating robot rescues and building underground shelters. • Communities that have limited egress routes could look at public (places of refuge) and private (bunkers) in terms of fire shelter for scenarios where evacuation is not feasible. • Explore alternatives to evacuation (see McCaffrey et al. 2015).
4	• Online and cell notifications are not reliable in the event of a power failure or shutdown. Communities are currently over-reliant on opt-in and wifi-based technology and push-notifications from local authorities. What happens when these modes fail?	• Invest in alternative means of communicating real-time alerts, such as WEA, TV, and local radio channels, and identify those communication modes that could still be used in longer-term power outages, e.g., community warning sirens or Ham radios.

Area 4: Community engagement

	Operational, research and market gaps	Potential solutions
1	• Community outreach and engagement is currently one-way/ top-down. • There is an urgent need to adopt two-way communications with a greater reliance on real-time information shared by community • Adopting two-way communication modes can help field actionable information and early detection of hazards and emerging issues on the ground.	• Local councils need to ensure text based alert systems actually get tested on a regular basis, such as for traffic or similar safety alerts. If people don't regularly receive alerts, they will not necessarily know how to read them and act on them. • People can better understand how to interpret and act on wildfire alerts if they are engaged on an ongoing basis. Firewise, CERTs and schools can be a great way to regularly engage the community. • Building on the success of the CERT model, community volunteer training can also be incorporated in regional WUI resilience planning. This could serve as an efficient way to empower citizen corps who can be mobilized for community evacuation, communications and recovery operations. • Fire Adapted Communities, Firewise, California's FireSafe Councils and Prescribed Burn Associations serve as excellent working models and can be scaled down to reach more communities at risk in the WUI.
2	• While social media is increasingly used to communicate with diverse populations, people with a range of language, access and functional needs are too often left out. o People don't always sign up for third party notifications due to lower levels of perceived risk.	• Notifications and plans need to be more responsive to a range of language, access and functional needs. • Conduct regular multilingual surveys and public consultations to understand community needs and preferences. • A user survey could help explain how community members interact with safety messages/ alert apps to identify effectiveness and remaining needs. • It will be valuable to work through the County's Office of Emergency Services, local police and fire but also social services and American Red Cross. They will know how to get the message of evacuation planning across to those who need it most i.e., those with access and functional needs.
3	• There remain research gaps in understanding social-behavioral preferences. o One example is that oftentimes, people's preference is to wait until they receive confirmation about the fire (they want to wait to see the fire) before evacuating or deciding not to evacuate at all. Those who wait until the last minute or do not evacuate at all run the risk of injury or death during evacuation.	• Engage community members in discussions on how intense or destructive fires can be if you stay at home. Immersive technologies, for example, can help people to understand the danger associated with preferences to stay in place or wait until it is too late to begin evacuation.
4	• Need more systematic outreach to help homeowners understand evacuation notifications, procedures, and when to evacuate.	• Develop sustained engagement models with people who have access and functional needs, including, people living in vehicles and on the streets, economically disadvantaged, migrant households,

		elderly, and people with disabilities, service animals and pets. • It will be important to not only work with the County's Office of Emergency Services, local police and fire but also social services and American Red Cross. They will know how to get the message of evacuation planning across to those who need it most, e.g., those with access and functional needs. • Neighborhood education plans should be developed in consultation with residents and be specific and relevant to neighborhood needs.
5	• Child-centered wildfire preparedness and evacuation planning present a huge untapped opportunity.	• Social science research from around the world shows the value of adopting child-centered preparedness and planning strategies. Children can bring home important safety and preparedness messages from school. School-going children can be an especially important source of local risk and preparedness information for particular sections of the community, such as newly arrived people from refugee and migrant backgrounds. • Building on the success of child-centered learning strategies such as fire drills and 'drop, cover, hold' earthquake safety drills in California, it could be useful to integrate home safety, preparedness and evacuation drills in school districts across the WUI. • It can be useful to get students to participate in summer mapping classes where they can be trained in how to make and read maps of their county. Household preparedness will likely follow.

Realistic actions to resolve research and market gaps

With the relative lack of knowledge and guidance available for evacuation and notification, the group also took the additional step to develop a prioritized list of key actions specific for these topics following their discussion and review. Summarized below are key actions to address the operational, research and market gaps identified in previous subsections. A critical and overarching action will be to identify and allocate funding for convergence research efforts to bring together diverse stakeholders across disciplines and sectors of work. Greater details on the action items are provided in the table following.

Key Actions:

1. Form a Task Force: The group recommended that NFPA form and administer a Notification and Evacuation Task Force to oversee the development and coordination of a multi-stakeholder Notification and Evacuation Action Plan for wildfire resilience. The goal of the Notification and Evacuation Task Force will be to address the gaps identified here, through realistic actions to improve community notification and evacuation practices. Task Force members may include representatives from industry (city planners, engineers, technology developers), academia (researchers of social sciences and human behavior, emergency management and evacuation), public service agencies (Emergency management and emergency services personnel), government (city code officials, policy and law makers), community leaders, utility and

communications service providers, and other existing groups that share similar goals (Firewise, Fire Safe Councils, Fire Adapted Communities).

2. Develop an action plan: The Task Force will be responsible for developing and coordinating a detailed action plan through multi-stakeholder engagement. The action plan may include, but will not be limited to the following areas:
   a) Research on social-behavioral factors, community perceptions and practices of wildfire safety.
   b) Standard on emergency notifications and community evacuation planning
   c) Standard on community engagement for wildfire evacuation planning and preparedness
   d) Standard on inter-agency communications and evacuation coordination
   e) Standard on fire protection and life safety infrastructure for community notification and evacuation
   f) Real-time data sensor networks for evacuation response, mapping and modeling
   g) Evacuation models for planning purposes.

   Additional details for these action items are provided in the below table.

2) Prioritize implementation: The Task Force should be formed as soon as possible. The actions above will take time - some months or years - to implement. Therefore, a benefit-cost study can be a helpful method for prioritization and decision-making of action items. Categorizing those actions in terms of necessity (e.g., immediate, near-term, or long-term), effort of implementation, monetary costs associated with implementation, and/or other key factors, will provide clarity for developing an action plan timeline.

Action Item	What (description of outcome)	How (high-level steps to implementation)	Gaps addressed	Potential key challenges
2.a	Topical research into social-behavioral factors and preferences will enable more responsive and relevant community-centered evacuation planning and response procedures. Research findings can be integrated within new or existing evacuation tools for improved identification of trigger points, evacuation mapping, and predictive modeling. Experts in the field of social sciences and human behavior are needed for interpretation of the collected social-behavioral data to subsequently inform evacuation mapping and modeling. The data are complex, and the findings are likely not	Research and local data collection will require Task Force members to work with community representatives. It will be important to prioritize citizen engagement, collaboration and partnerships. 1. Leverage available community demographics data and research on social behavioral factors for evacuation response, including development of trigger points, highway and shelter capacity mapping, and improvement of predictive evacuation modeling. 2. Develop guidelines for conducting participatory and community-based research with	Area 1; Item 4 Area 2; Items 2, 3 Area 4; Item 3	1. Data privacy 2. Accuracy, currency, and consistency of data 3. Funding

	straightforward, thus it is critical to have appropriate experts leading this action step. Development of data interpretation guidelines can help to standardize and expedite this step for widespread application. Related to: Outreach, Technology	people who have access, functional and special needs, including considerations of age, gender, race and ethnicity, language, access and mobilities, housing and income. 3. Provide a means for residents to "check-in" with local first responders before, during, and after a wildfire. "Check-in" could include updates on changes in mobility resources, number of people in the household, and other information that would improve evacuation response.		
2.b	*Standard on emergency notifications and community evacuation planning* is proposed to be a national standard that includes procedures, guidelines and templates on: developing and incorporating multi-hazard and worst-case evacuation scenarios; community engagement and demographic-specific considerations; evacuation drills, including in schools and aged care facilities; and public emergency notification and communication procedures. The standard should include appendices with evacuation plan templates that can be adapted across a variety of communities and regions so that appropriate agencies can develop localized emergency communications and evacuation plans based on present risks and available resources. Related to: Outreach, Land Use and Planning	1. Conduct research and collate data that identifies and supports improvements to notification and evacuation standards. 2. Develop improved standards that address identified gaps. 3. Solicit stakeholder feedback through a review process. 4. Engage with local and state policy/law makers to adopt science-based guidelines that will improve community notification and evacuation practices. Grassroots efforts can be encouraged through participation in local city code hearings, communicating with senators and representatives, and sharing knowledge with community leaders.	Area 1; Items 2, 3, 4, 5 Area 3; Item 2 Area 4; Items 4 and 5	1. Volunteer-based time commitment 2. Enforcement
2.c	*Standard on community engagement for wildfire evacuation planning and preparedness* is proposed to improve outreach and engagement efforts on	1. Conduct research and collate data that identifies and supports best practices for community engagement on wildfire evacuation and preparedness.	Area 1; Item 4 Area 4; Items 1, 2, 4, 5	1. Volunteer-based time commitment 2. Enforcement

	emergency notification and evacuation for wildfire resilience. The standards should include guidelines on: empowering communities through two-way planning and transparent communication; systematic outreach to educate homeowners on evacuation procedures; engagement and inclusion of diverse populations; and involving local schools to increase child-centered evacuation preparedness. Related to: Outreach	2. Develop improved standards that address identified gaps. 3. Solicit stakeholder feedback through a review process. 4. Engage with local and state policy/law makers to adopt science-based guidelines that will improve community engagement practices. Grassroots efforts can be encouraged through participation in local city code hearings, communicating with senators and representatives, and sharing knowledge with community leaders. 5. Community leaders and city planners should involve and engage the community through these standards via identified methods, which may include survey, town hall meetings, door-to-door outreach, etc.		
2.d	*Standard on inter-agency communications and evacuation coordination* will enhance inter-agency planning and execution for pre-fire planning and during-fire response. Development of this standard will address compatibility and redundancy of communications (both taxonomy and physical infrastructure), as well as providing a streamlined approach to evacuation procedures across various emergency response agencies. Related to: Technology	1. Conduct research and collate data that identifies and supports best practices for inter-agency communications and coordination. 2. Develop improved standards that address identified gaps. 3. Solicit stakeholder feedback through a review process. 4. Engage with local and state policy/law makers to adopt science-based guidelines that will improve inter-agency coordination. Grassroots efforts can be encouraged through participation in local city code hearings, communicating with senators and representatives, and sharing knowledge with community leaders.	Area 1; Item 1	1. Volunteer-based time commitment 2. Enforcement 3. Cross-jurisdictional coordination 4. Funding for retrofitting of existing infrastructure 5.Agencies reluctant to change
2.e	*Standard on fire protection and life safety infrastructure for community notification and evacuation* will address capacity,	1. Conduct research and collate data that identifies and supports best practices for fire protection and life safety infrastructure,	Area 3; Items 1, 2, 3, 4	1. Volunteer-based time commitment

	maintenance, and resilience of physical infrastructure, including highways/evacuation routes, emergency shelters, and electrical/communications infrastructure. The standard will include guidelines on implementing redundant means of communicating real-time alerts, minimum maintenance requirements of electrical infrastructure and evacuation routes, considerations for establishing TRAs and potential alternatives to evacuation. Related to: Land Use and Planning, Technology	including capacity and maintenance of roadways, emergency shelters, and communications infrastructure. 2. Develop improved standards that address identified gaps. 3. Solicit stakeholder feedback through a review process. 4. Engage with local and state policy/law makers to adopt science-based guidelines that will improve fire life safety during community evacuations. Grassroots efforts can be encouraged through participation in local city code hearings, communicating with senators and representatives, and sharing knowledge with community leaders.		2. Enforcement 3. Cross-jurisdictional coordination and evacuee capacity planning 4. Limited available data to support evacuation alternatives
2.f	Development of a community data sensor network will allow collection and integration of real-time, localized data to inform evacuation response, mapping, and modelling. Community-specific data needs include social-behavioral factors and preferences, roadway traffic, fire ignition location and spread forecasting, and fire weather conditions. This data is proposed to be integrated with a mapping application service provider to augment communities' capability in accessing critical information for situational awareness during an emergency evacuation. Related to: Technology, Outreach	Technology developers and mapping application service providers are needed to lead this action together with coordination from public services agencies, community leaders, and fire safety experts. Potential action steps include: 1. Task Force engagement with appropriate tech companies and mapping application providers. 2. Engagement with public service agencies and community leaders for awareness, knowledge, and feedback. 3. Development of affordable sensor networks and strategic placement of sensors throughout the community. 4. Integration of real-time data into the back-end of the mapping application. Testing and validation of the collected data is of course required. 5. A user-friendly interface should be created to be	Area 2; Items 1, 2, 3	1. Accuracy, currency, and consistency of data 2. Funding

		accessible by emergency management personnel as well as diverse members of the public. 6. Community leaders should be given responsibility to ensure that community members are aware of the mapping application, have access to the mapping application in an emergency situation, and know how to use the mapping application.		
2.g	Evacuation modeling for planning purposes can be a useful tool during the schematic development stages of a new community, and/or during evacuation planning for existing communities. The models should be able to simulate social-behavioral factors and traffic, at minimum. More advanced community evacuation models that incorporate fire conditions would allow for improved insight to planning for probable blocked routes, limited visibility, and available time to evacuate. The models should be able to be used by city planners, engineers, and emergency services personnel. Related to: Land Use and Planning, Technology	1. Engage with researchers who are developing such models to understand the development timeline towards commercial availability. 2. Identify funding sources to accelerate development of the models.	Area 2; Item 4	1. Funding

3.6 LONG-TERM TRENDS AND MARKET CHALLENGES

Theme overview

The workshop closed with a section highlighting long-term trends in WUI risk and market challenges to adopting mitigative measures. Most of this discussion focused on the role of insurance and land management. The two prompts below on the topic of long-term trends and market challenges were included in the pre-event survey that was sent to workshop invitees. The responses received are incorporated into findings discussed in this section. (Refer to Appendix B for full text of survey responses.)

- What role should insurers be responsible for as related to WUI fire mitigation and recovery?
- What needs to be done to improve WUI policy and regulation for increased fire resilience of new and existing communities/utilities/resources? This can be pre-disaster and post-disaster.

On Day 2 of the workshop, two speakers presented their insight and experience in insurance and land management. Roy Wright of the Insurance Institute for Business & Home Safety (IBHS) first presented on the role of insurance in WUI fire mitigation. While insurers have always cared about wildfire as a traditional peril, the 2017-2018 fires which raged through suburban communities highlighted gaps in risk perception, where insurers did not price for these events. For the first time these costs mirrored those of more traditional large-scale perils such as hurricanes. Insurance, however, is highly regulated and pricing is based on risk. Much of the current work by IBHS, NIST and others is focused on structure-level mitigation of risk. This incorporates building features as well as maintenance but must be taken for a whole neighborhood to reduce risk.

Edith Hannigan (California Board of Forestry and Fire Protection) next spoke about where we are and where we're going in terms of land use planning in California. These decisions are heavily directed by the legislature and, after recent fires, there has been increased interest in doing better planning to reduce fire risk. One important issue is that existing communities (98%) are already built. For these communities, developing a set of prioritized retrofits and means to incentivize these are key. Next, finding ways to emphasize both individual and community roles in reducing risk. Finally, finding ways of improving the level of service to homeowners. Following their talks, Wright and Hannigan fielded questions from workshop attendees, then everyone split into breakout groups to continue discussion on challenges and solutions related to insurance, land-use planning, and other long-term market challenges.

Highlighted issues and solutions

A set of findings on the highlighted issues in long-term trends and market challenges was gathered from the pre-workshop survey responses, speaker presentations, and group discussions. These findings are organized into three main areas: 1) Existing communities, 2) insurance and risk, and 3) community engagement. The following tables outline the gaps and identify potential solutions under each of the three identified areas.

Highlighted issues and solutions

Area 1: Existing communities

	Operational, research and market gaps	Potential solutions
1	• Increasing focus on how to protect existing communities (98% of current housing stock) • Many recently devastated communities were built in the 1980's, before current WUI codes and standards • Building new roads to improve evacuation is important, however doing so is costly and the topography makes construction difficult or impossible in some areas.	• Developing a list of low-cost retrofits – closing eaves, vent screens • Have building permits incorporate more extensive retrofits (for large enough changes – additions, etc.) • Evacuation in existing communities – identify groups of communities that have one way in and out – develop recommendations • Using signage – reflective for evacuation routes and addresses • Identify where power lines or obstructions may impede progress
2	• Emphasizing individual and community scale role in reducing risk along with state role • How can we work together on the local level?	• Improve regulation of defensible space • Consider requirements from other agencies (water, etc.) with regard to regulations – working together • Build on the growth of Firewise communities in California and elsewhere • Produce statewide reports on vegetation management – high level analysis
3	• Improving the level of service to stakeholders/clients (homeowners)	• Ensuring consistent applicability of state laws • Getting better educated to better support local governments • Investing in better defensible space training • Balancing government regulations and local property rights – supporting with better knowledge and skills

Area 2: Insurance and Risk

	Operational, research and market gaps	Potential solutions

1	• Re-insurers role – they take on broader risk around the world and can ensure that the claims get paid. There is a price for that
	• Refusal of insuring high risk?
	  o At this point everyone can get insurance in CA (coverage and price can be impacted)
	  o FAIR Plan in CA – only insures a small percentage
	  o If insured experiences a loss? State law (CA) requires insurer to renew for two years
	  o Price can be increased beyond what some people can pay
		• Work with insurance companies to understand what is needed for them to feel comfortable insuring homes in high-risk areas. Perhaps a checklist or other approach for homeowners/communities to abide by.
		• Work with insurance regulators to incentivize risk mitigation that will encourage insurers to cover more homes in at-risk communities.

2	• How to incentivize mitigation through insurance? • How do we handle retirement communities or those who have paid off homes who are not insured?	• Firewise discounts • USAA example of incentivizing risk reduction in WUI, working with NFPA • Generally, if it reduces risk, it impacts price of insurance
3	• Pricing for risk	• Make it "financially infeasible" to build without appropriate WUI design instead of prohibiting development into the WUI
4	• Economic costs of wildfire including WUI losses and retrofit/mitigation costs are not available	• Include wildland fire and more specifically WUI in NFPA's "cost of fire"

Area 3: Community engagement

	Operational, research and market gaps	**Potential solutions**
1	• Homeowners are not aware of their insurance coverage - consumer education • Homeowners and renters are not aware of the risks and hazards when purchasing/moving	• Consider semi-transient populations (college towns, short-term renters, etc.) in outreach efforts

Realistic actions to resolve research and market gaps

In the summary discussions that followed the session the themes broadened beyond insurance and land-use planning to the full scope of long-term solutions. Most of this focused on sustained support for programs and overall coordination between public and private partners. Summarized below are key actions to address the operational, research and market gaps identified in previous subsections.

Sustained Support

- Programs for mitigation, outreach, etc. should be continually supported to remain effective [short-term]
- Can other sources of funding (private foundations, etc.) be found to support mitigation and outreach efforts while government support is secured? [short-term]
- Include staffing for outreach and mitigation as well as funds to support individual parcel and community-wide mitigation measures [mid-term]
- Financial models should be created that provide sustained maintenance (e.g., vegetation mgt.) as well as retrofits for vulnerable communities [long-term]

Mitigation

- Increase protection of critical infrastructure and system hardening (e.g., utilities - both ignitions from utilities & grid resilience) [mid to long-term]
- Develop a voluntary homeowner wildfire rating (i.e., LEED) [long-term]
- Expand Firewise to the community-level: enlarge footprint [long-term]
- More Certified forestry professionals for vegetation management [long-term]

- State and federal agency streamlining approval for vegetation management (NEPA) [long-term]

Research Infrastructure

- A dedicated funding system is needed for WUI fires:
    - For development of test and design standards (e.g., NIST) [short-term]
    - For teams to dispatch for post-event analyses and to maintain data [mid-term]
    - For continual support of fundamental and applied research [long-term]
    - Consistency is key to respond to crises and train a skilled workforce [long-term]
- Establish public-private partnerships such as hubs/ecosystems for testing and research [mid-term]
- Core research and testing facilities are needed that are geared to WUI fires in the United States, such as fire wind tunnels, ember facilities, and associated fire testing laboratories, especially in the Western US. [long-term]

4.0 CONCLUSIONS

Following the workshop and over a year of preparation, this report presents a compendium of actionable recommendations and research directions that can be taken to move WUI communities towards fire resilience. As mentioned at the start of the workshop, fire has spread across our landscapes long before western settlers arrived. Following decades of fire exclusion, land-use change, and climate change, fires are impacting communities more than ever. Solutions must recognize that fire is a natural aspect of our landscape, and communities must be built and landscapes managed to "live with fire", safeguarding people, property, and the surrounding environment.

What is clear from well over 100 specific recommendations outlined in this report is that a multidisciplinary approach is essential to making WUI communities more resilient to fire. The fire problem has numerous stakeholders: residents, government, emergency responders, and land managers, and requires a broad set of expertise, e.g., land use planning, engineering, construction, forestry, etc. which must work together to make decisions and design mitigation measures to reduce risk in WUI communities. Given the demographics of the workshop participants, the majority of the solutions proposed focus on changes that can be implemented within the built environment of WUI communities or in coordination with organizations. The actions proposed here mostly focus on changes within the built environment to reduce destruction following fire and improve evacuation and response, but they align with broader recommendations from fire ecologists that more prescribed fire and landscape management be taken to reduce the severity of fires across the landscape.

Despite identifying key challenges and outlining a litany of recommendations for action, it remains unclear who will actually implement many of these recommendations to achieve resilience. Some of this work suggested in the report is already being done by a variety of non-profit, local government, and/or academic groups working to achieve WUI resilience, but there may be capacity or resource limitations. In other instances, some recommendations are novel, and it would be helpful to further vet their potential impact, required resources, etc.

The organizers of this workshop view this document as a template for organizations at all levels: local community groups, organizations, governments, commercial enterprises, etc., to draw upon as they consider future measures to mitigate wildfire losses and improve resiliency in the WUI. For example, several broad research programs are proposed that involve significant resources in social science, evacuation, and firebrand physical processes. Progress in such large areas may require state or federal support to build infrastructure and fund research efforts. Other specific actions, such as increasing local outreach efforts may be easily implementable in individual efforts. Most efforts, however, will have multidisciplinary challenges that require coordination between residents, private enterprise and local, state, and federal officials. For instance, building regulations are adopted at the local level but can be mandated by state legislatures. In California, CBC Chapter 7A requirements only apply in Fire Hazard Severity Zones that are under state jurisdiction, despite fire risk crossing all boundaries. To cover all areas, both local and state governments must adopt these regulations. Federal officials may have no role in the approval of such policies, but they can fund research efforts, the development of model standards, and programs for retrofitting homes . Even with the implementation of regulations for new construction, most structures are already built

and require both incentives and regulation to implement risk reduction efforts. Cooperation between insurance, construction, and other industry representatives may help with this problem and also solve the wildfire insurance crisis, providing homeowners with better options for retrofits and risk reduction. A key here is building templates for these efforts and mechanisms to support their implementation.

Evacuation, notification, and the associated social factors were highlighted as key areas in need of coordination and future research. A detailed set of recommendations were proposed in Section 3.5 which included the formation of a task force, development of an action plan, and prioritized implementation of evacuation and notification standards. Such a group could be formed within a non-profit organization, such as the NFPA, or under the auspices of a government-led effort.

Technology will play a key role in optimizing the solutions that are implemented to mitigate risk, however the solution for resilience in the WUI ultimately revolves around the people who must use this technology and depend upon its results. Residents must recognize the risk to their property and take action, first responders must adequately plan for all eventualities, governments must develop incentives to mitigate risk and recover from eventual wildfire events, and organizations across the spectrum must work together to implement these solutions. Whether action is driven from a top-down or bottom-up approach, eventually these efforts will meet in the middle and bring about real change.

Another central theme has been the need for continued support and focus on WUI resilience. This issue is not unique to fire but rather exists across all fields responding to natural hazards. Nevertheless, proper fire mitigation efforts take time. Planning is essential to prepare a swift response and safe evacuation, while retrofits and land management around WUI areas can take years to implement and often require continued maintenance. Support for these efforts requires people engaged in the local, county, state, and federal levels. More efforts to build on the success of local efforts such as employing university cooperative extension specialists, supporting local fire safe councils, etc. will help to build continuity and keep fire highlighted as a continuing hazard in need of mitigation. Researchers have suffered from the same intermittent approach to funding needed to work in the field. Continuity and coordination, ideally at the state and federal levels, could dramatically improve the conduction, implementation and dissemination of work needed to improve WUI resilience.

Finally, we must remember that despite efforts to include a broad audience, this workshop included a focused audience that could not possibly address all topics. Coverage of evacuation, notification, and social factors was strong during this workshop and highlighted as a major need to improve life safety during WUI fire events. Our coverage of outreach and advocacy groups could have been improved; however, we were able to provide some recommendations, most importantly the need for assessment measures on outreach efforts and ways to further coordinate and support many disparate efforts. Following the intense 2020 smoke events in Northern California, we would be remiss by not mentioning the lack of air quality, public health, and atmospheric science experts who have broad challenges to address air quality and health concerns following fires. Prescribed burning, both near WUI communities to reduce fire severity and for broader ecological landscape management requires a community of fire, ecology, and land management experts. Climate experts surely will be needed to report on changes that are yet to come to the landscape that ultimately will impact resilience of WUI communities.

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APPENDIX A: PRE-WORKSHOP SURVEY QUESTIONS AND GROUP SESSION PROMPTS

1. **General - Framing Key Issues**

   Pre-workshop survey questions:

   - What are the biggest challenges or barriers that communities face in becoming more resilient against wildfire disasters?
   - What are the biggest opportunities that communities can harness to become more resilient against wildfire disasters?
   - Please describe any solutions or issues related to WUI resilience that you feel deserve more attention, as well as who are the responsible parties.

   Breakout group discussion prompts:

   - Outline current challenges and barriers to (positive) change. Look for agreement on the definition of the problem and what success (resilience) looks like.
   - Form statements like "in a perfect world, it would look like this," or "with the right solutions, in 20 years this would be the change we would see."

2. **Land Use and Wildfire Protection Planning**

   Pre-workshop survey questions:

   - What challenges exist that hinder communities' ability to generate or maintain wildfire protection plans?
   - How can land-use planning practices become a more effective tool to enhance community wildfire resilience?

   Breakout group discussion prompts:

   - How can we maximize the application of land use and wildfire planning tools to address the WUI?
   - What barriers exist to developing and implementing these tools?
   - What are key actions in the short, near, and long-term that may improve the effectiveness of these tools?

3. **Technologies for Risk Assessment and Planning**

   Pre-workshop survey questions:

   - What are the market gaps and challenges for conducting landscape-scale fire risk assessments? How might those gaps be addressed by new technologies and data solutions?
   - What are the market gaps and challenges for WUI resilience planning? How might those gaps be addressed by new technologies and data solutions? This can be planning for construction/development, fire service operations, etc.

   Breakout group discussion prompts:

   - What research and market gaps exist?
   - Do we know if there are already solutions or promising work being done?

4. **Outreach and Community Action**

Pre-workshop survey questions:

- What are the gaps and challenges of current outreach programs that aim to improve WUI resilience?
- What are the needs and next steps to encourage adoption of mitigation measures?

Breakout group discussion prompts:

- What are the gaps in current outreach programs?
- What are the needs and next steps to reduce destruction and encourage adoption of mitigation measures?

5. **Notification and Evacuation**

Pre-workshop survey questions:

- What are the current gaps in notification and evacuation plans?
- What can be done to improve the process in the near and long term?

Breakout group discussion prompts:

- What are the current gaps in our notification and evacuation plans?
- What can be done to improve the process in the near and long term?

6. **Long-Term Trends and Market Challenges**

Pre-workshop survey questions:

- What role should insurers be responsible for as related to WUI fire mitigation and recovery?
- What needs to be done to improve WUI policy and regulation for increased fire resilience of new and existing communities/utilities/resources? This can be pre-disaster and post-disaster.

Breakout group discussion prompts:

- Please reflect on the panel session we just heard. Now think with foresight and discuss: How will long term trends influence your role(s) in the bigger picture of WUI resilience? Are there groups that need to work more closely together in the future? Other insights?
- Rank (number) top needed actions/solutions and research needs. We will compile these as a group to come up with a list to be provided in the final report

APPENDIX B: PRE-WORKSHOP SURVEY COLLATED RESPONSES

WUI Resiliency Workshop

Pre-Workshop Survey Results

Q1. What are the biggest challenges or barriers that communities face in becoming more resilient against wildfire disasters?

1. Prioritizing against desired aesthetics and densification of homes.
2. Inconsistent messaging regarding mitigation strategies. This applies to mitigation strategies for the built environment and regulation / guidance for vegetation management on individual properties. Confusion / conflicting information on items as basic as plant lists / whether or not to have a plant list... - Insufficient funding, particularly at the property level - Lack of interest / awareness
3. Access to reliable information, education on wildfire risks, behavior etc, access to information in their language
4. Awareness that spurs people to take action. Most folks in WUI are aware, but they might not do anything. Also, adjacent landowners that do not prepare and thereby negate/minimize resiliency.
5. In order to cost-effectively deploy mitigation measures it is necessary to quantify and understand risk levels considering fuels, weather, and topography.
6. funding availability, grants that actually match the need - costs of retrofitting homes and removing vegetation for defensible space - feeling like fire won't actually affect them personally (even when it has and does) - people who have part-time homes, rather than full-time residents in the WUI - individuals who don't participate even when the community as a whole participates
7. Fire Safety Education, intended here as the combination of information needed to prepare for an event and act during an event
8. Lack of funding, long-term implementation and monitoring, political will
9. Big barriers include risk perception by community members, funding, the challenges associated with altering already built infrastructure or its uses, and the need to act as a community (not individually) to achieve optimal results.
10. Complacency and resistance to necessary change in order to adapt to inevitable fire.
11. The climate is changing and there are too many existing fire-prone structures in the WUI (intermixed and interfaced) with vegetative fuels.
12. Staff capacity, competing policy priorities, and need for more models of resiliency
13. Apathetic homeowners. Agency capacity for engagement.
14. Denial of the problem
15. Available economic resources.
16. 1) public's understanding of the risk and the the role they can play in its reduction around structures. 2) socio-economic and other societal factors that limit resident ability to act and/or have a place at the table when the risk is assessed, development made, etc. 3) The housing landscape they find themselves in: development standards

either at time of new construction, existing composition, or municipal expectations of re-builds after a wildfire.

17. 1. One of the most significant challenges for communities is gaining access to real-time wildfire hazard and risk information. Communities need better access to wildfire risk information in the form of maps, apps, social media and public messages. A market survey of existing apps and alerts could help identify usability and interface challenges and opportunities for improvement/ further developments. 2. A second challenge is in sustaining engagement with local authorities in developing, implementing and regularly updating WUI resilience plans in the absence of strong community leadership or safety 'champions' who can represent neighborhood issues to the city council. Cases of successful community-centred WUI resilience planning from around the world demonstrate the need for strong local governance, responsive services and sustained community engagement and leadership. A best practice review of how some Firewise communities and FireSafe Councils have successfully organized and coordinated mitigation and preparedness actions with local councils could help communities in other places to identify similar entry points for incentivizing sustained community engagement and leadership. 3. It can be challenging to work with a range of disparate / silo-ed public and private initiatives that may not always be well coordinated within a local planning and budgetary framework. It could be useful to see a best practice review that documents how local planning frameworks / agencies have effectively coordinated multiple and parallel efforts for WUI resilience.

Q2. What are the biggest opportunities that communities can harness to become more resilient against wildfire disasters?

1. Property maintenance and judicious landscape choices.
2. Increased interest & awareness in wildfire issues as a result of recent large wildfires / bushfires. This applies to both fuels treatments (particularly community-level) and "home-hardening" activities.
3. Seeking information from established wildfire emergency response/prevention sources and sharing of such information (prevention, emergency procedures, etc) in community spaces.
4. Some opportunities are the level of federal investment in resilient landscapes. There is a myriad of local, state, federal grants and programs that savvy homeowners can take advantage of.
5. Not make the current problem worse by building in areas that we shouldn't be building in.
6. working together through Firewise communities or neighborhood/community groups - partnering with larger organizations or agencies
7. The Firewise programme seems to have a great potential to positevely impact communities
8. Act immediately following a large wildfire event to adopt mitigation measures, such a strategic placement of fuel treatments, WUI Code, and building codes.

9. Home hardening policies and grant funding. Capacity building to take advantage of opportunities to apply for newly available grant funding for fuels reduction. Better planning and building code to ensure that they aren't "digging the hole deeper."
10. Realize that it will happen, that there is a great deal that CAN be done to reduce loss. Understand that when losses occur it takes years to recover and recovery is expensive.
11. Ignoring political barriers, fuel reduction and removal. We can't control the weather, topography, and (it seems) the volume of people that want to live in fire areas.
12. I think wildfire experience is a good opportunity for some community-level actions. I think integrating fire department staff into land use planning is a potential opportunity.
13. Building relationships with homeowners. Building coalitions and/or collaborative partnerships.
14. Getting people and the establishment to do the little things, like weed and brush control
15. Active forest management. Not all fire is bad.
16. 1) community organizing through a social-equity lens that seeks to connect with the residents and them to the issues around them. 2) formal programs, like Firewise USA and its international iterations, that give ownership of the issue to the residents and develop a sustainable model for local-led future action. 3) peer-to-peer resident education the bridge risk understanding. 4) residents leveraging gained knowledge to influence local policy development and enforcement from the grass roots level up.
17. Much success in WUI resilience can depend on well-organized and engaged communities regularly contributing to a range of policy decisions regarding local land use planning, building regulations, land stewardship and habitat restoration. The Fire Adapted Communities, FireWise, California's FireSafe Councils and Prescribed Burn Associations serve as excellent working models and can be scaled down to reach more communities at risk in the WUI. In addition, considerable social science research from around the world has shown the value of adopting child-centered preparedness and resilience strategies. Children can bring home important safety and preparedness messages from school. School-going children can be an especially important source of local risk and preparedness information for particular sections of the community, such as newly arrived people from refugee and migrant backgrounds. Building on the success of child-centered learning strategies such as fire drills and 'drop, cover, hold' earthquake safety drills in California, it could be useful to integrate home safety, preparedness and evacuation drills in school districts across the WUI. Additionally, building on the success of the CERT model, community volunteer training can be incorporated in regional WUI resilience planning. This could serve as an efficient way to empower citizen corps who can be mobilized for community evacuation, communications and recovery operations.

Q3. Please describe any solutions or issues related to WUI resilience that you feel deserve more attention, as well as who are the responsible parties.

1. No response

2. Conflicting requirements between codes / guidance regarding different exposures / threats to buildings (e.g., energy conservation requirements versus wildfire (built environment) requirements, as an example). Other conflicts that planning folks need to deal with / reconcile.
3. Engagement of the scientific community and public agencies with the public in order to inform about wildfire risk, emergency procedures, etc. This requires the development of programs that aim to bridge the gap between the public and the scientific community. In addition it requires careful socio-cultural science communication planning as to fully engage all communities, including disadvantaged and minority communities as well as non-English speakers.
4. A group at the Rocky Mountain Research Station under Dr. Patty Champ was been doing some amazing micro-studies and work at the community level. This scale is allowing her team to actually understand individuals' needs and how to best address them. The WIRE program as it is called, is building solutions that work on the ground to deliver what people want and will support. From there, they can begin to extrapolate to larger scales. I like this approach.
5. Real-time forecasting of fire spread and risk has great potential to reduce losses.
6. No response
7. Evacuation planning (especially for very large evacuations) [communities, authorities] - Coordination of roles and leadership during emergencies [authorities]
8. How to construct a home to higher wildfire resistant standards (Headwaters Economics, Insurance Institute for Business & Home Safety); encourage larger role by insurance companies
9. I think the most important step would be to insure that there are one or two people in every jurisdiction whose sole job is to work with the community to educate, seek funding for projects, and facilitate implementation of projects aimed at risk reduction. This needs to happen at the house to house level - that's where trust and knowledge will be built. And it can't be a nights and weekends job for a firefighter or interested community member. But funding these positions is really hard.
10. We have to get residents to understand their responsibility for their own properties and socialize mitigation so that it becomes the norm, not the outlier.
11. Fuel removal and the responsible parties are citizens, along with local and state government.
12. I don't see many communities doing disaster recovery planning -- I know that's likely easiest to consider in places with additional hazard planning, but I think it's worth doing
13. Encouraging individual ownership of the problem and creating of solutions by homeowners, policy makers, agencies, and other stakeholders. Spreading truth and reality, not anecdotes.
14. Separation between build-up of combustibles and occupied areas
15. Restriction on building location and maintenance of clearances. Local government, owner.
16. The volunteer-led model of Firewise, both domestically and internationally. Successful and, importantly, sustainable, wildfire risk reduction is not achievable by smothering the issue with outside money.

17. WUI mitigation activities, particularly managing fuel loads, can be expensive, require trained capacities and equipment. Small, amenity poor and remote communities cannot go it alone, they will need to be supported through a regional approach to WUI resilience planning. In adopting a regional planning approach, it will be important to ask, which communities have the capacity and resources to mitigate risks, and prepare for response and recovery in equitable ways? Which households, in which communities, have access, functional and special needs? How can neighboring communities provide support through peer to peer training and knowledge/ equipment sharing events?

Q.3.A. Additional Comments

1. No response
2. No response
3. No matter how good a community's Emergency Services are, they cannot stand up to extreme wildfire. We must bring home ignition resistance to scale if we hope to keep pace at all.
4. I'm not sure if resilience in this survey refers to loss of property and/or life, as well as whether it refers to the ability to withstand and/or recover from fire events.
5. No response
6. No response
7. No response
8. No response
9. If fire department and agency personnel don't understand the real problem with home ignitability, how can we expect homeowners to understand. This message needs to spread.
10. Through 16 – No response
17. More convergence research around the social, behavioural, technological and institutional aspects of WUI resilience can be encouraged to contribute new insights from across a range of contexts. Specifically, we need more longitudinal research around the lived experiences of people in WUIs – how have communities worked with local agencies and services to prepare for fire? What did they do in response to the last fire? How did they learn from that experience? What will they do differently next time? This methodology could be developed as similar to institutional after-action reviews, but with a focus on understanding community learning, preparedness and resilience objectives. We don't know enough about community's lived experiences before, during and after wildfire disasters.

Q.4 What challenges exist that hinder communities' ability to generate or maintain wildfire protection plans?

1. No response
2. Maintaining interest / energy of community / neighborhood leaders - Community / public support for funding (via parcel tax, for example). - Participation of all stakeholders (fire, police, large private landowners, public landowners, government).

3. No response
4. Time and a champion that will maintain the plan despite the low probability of a devastating incident.
5. They are only required for new developments in San Diego County.
6. small communities may not have the resources to design a serious wildfire protection plan, much less implement it - consultants might actually write the plan, which then isn't implemented - other priorities may take precedence
7. Communication between interested parties
8. It's not just generating and maintaining- it's the long-term enforcement of actionable items that have to be included in a CWPP for it to be useful and not a standalone symbolic document. CWPPs are just an initial step, largely for outreach purposes and collaboration, than any enforceable mechanism behind risk reduction.
9. Attention in the General Plan process; funding to understand localized risks and potential responses; community will to confront the risks that do exist and make changes to community look and feel that create safety; a clear nexus between improvements and insurance costs/availability.
10. Other than the time and complexity of some plans, they do get done. Executing them with actionable tasks is the thing that rarely gets done.
11. Limiting sprawl into fire prone areas.
12. Funding for updating CWPPs seems inconsistent. I also see very few communities pursue house-level mitigation through CWPPs
13. From a development standpoint - communication between all levels - fire department, planners, developers, builders, landscape architects, landscapers, homeowners, HOA's, etc. From a CWPP standpoint, having the CWPP updated regularly and having all stakeholders involved in, and having a say in, the process.
14. Denial of the issue
15. Available economic resources.
16. 1) socio-economic and other societal factors that limit resident ability to act and/or have a place at the table when the risk is assessed, development made, etc. 2) Whether the developers of WPP (CWPP's, etc) holistically review all residents at risk and consider additional factors and groups that will be impacted by the same risk in different ways (ie: elderly, disabled, transportation considerations, tech connectivity, employment, etc.) 3) Whether or not the WPP and its development process reflects the local experience or is instead a plug-in-play contractor-purchased template. 4) buy-in at all levels of the "ecosystem" to the plan, its findings, and execution of next steps. Far too many CWPP's are well bound coffee coasters.
17. Community risk assessments and hazard maps can be static and do not consistently capture changes on the ground. Also, communities are not necessarily involved in mapping local hazards, vulnerabilities and capacities. How can we encourage local authorities and councils to adopt methods of co-learning wildfire resilience with communities, in ways that democratize mapping and the creation of actionable data?

Q.5 How can land-use planning practices become a more effective tool to enhance community wildfire resilience?

1. No response
2. I am hoping land-use planning folks will have some suggestions.
3. No response
4. Meet communities where they are at and see what solutions will work with them on the ground.
5. Ignitions follow people, and building more structures in previously uninhabited areas increases risk for everyone else.
6. No response
7. Enforcing them on the territory and check their implementation
8. Land use planning practices can direct how, where, and under what conditions home built in high wildfire hazard areas are constructed. Land use can also influence the pace, scale, and location of development. Examples include req'ing firewood be stored 100 ft. from the home, home hardening materials, adequate width/access for emergency vehicles, d-space, landscaping requirements, etc.
9. I think the best way forward on this is to entitle more in low risk areas as we entitle less in high risk areas. To allow atypical density in defensible places while reducing allowance for density in less defensible ones. One way to implement this is via wildfire setback regulations that reduce the attractiveness of small lot subdivisions in hazardous areas. Another is by requiring pretending of HOA resources to create and maintain defensible space as a condition of entitlement.
10. Build smart. Fire resistant construction, CCR's that mandate mitigation based on science, siting of developments where they can survive.
11. Increase (fire resilient) housing density in fire areas and limit development in high-fire (wind whipped) corridors.
12. Seeing land use planning as a continuum -- providing more information on initial steps (what do you do if you don't have a building code?) and on improvements you can still make once housing is largely developed
13. Creating a 'safer from the start' mentality and having a plan in place for long-term maintenance of landscaping and plantings in the community.
14. Separation of source and fuel
15. Restrictions on expansion which increases WUI area.
16. 1) Ensure they are reflective of the community, involve the community, and set a clear collective path for the community. 2) Acknowledgement by planners, policy makers, local municipal budget managers, and code enforcers that current WUI structural and community loss is both unacceptable and the "Urban Conflagration" risk of the 21st century. We've been here before. 3) If possible, achieve a regional-level, cross-county boundary, and economically collaborative, land-use planning focus that had regional wildfire in mind, to better plan local development locations and risk/value assessments.
17. No response

Q.5A – Additional comments

Respondent 8. See: Community Planning Assistance for Wildfire (CPAW) website for examples and reference

Respondent 10. As long as we have been at this, we still have major top to bottom renovation of how we deal with fire as a nation. We need to stop "fighting" fire and learn how to prepare and survive fire. At least in terms of extreme fire events. We successfully suppress about 97% of fires within initial attack. But about 3%, the extreme fires , we cannot suppress, we must learn to survive them with less losses.

Respondent 16. sustainable local planning and successful local economic development will need a reckoning. That will obviously not be easy.

Q.6 What are the market gaps and challenges for conducting landscape-scale fire risk assessments? How might those gaps be addressed by new technologies and data solutions?

1. No response
2. Incomplete knowledge regarding local weather patterns. - Changing vegetation loadings / maintaining information regarding current condition. - Obtaining sufficient information regarding property-level vegetation and built-environment materials / installation details. - Drone technology (personal privacy issues)
3. No response
4. The issue is a people problem--relationships, not a technology problem.
5. There are no open source / actively maintained software tools available for this similar to FDS for the built environment.
6. No response
7. Big data can be of help to assess the current status of a territory
8. I'm not familiar with any "market" gaps - challenges are related to data acquisition and quality, scale of resolution, not modeling houses as fuel sources, non-predictive (i.e. don't account for climate change scenarios or future development); and ability to update models on a regular, consistent basis.
9. I think there are huge gaps here. Local governments and communities within them have little to no idea how to identify cost-effective investments. Should they spend money on home hardening? Or defensible space? Or community level fire breaks? Or what mix? And where. Governments have essentially no information.
10. No response
11. No response
12. No response
13. Lower cost LiDAR with use of UAV's, along with a national understanding of best practices in this area, utilizing worst case scenarios based on historical weather data, to create realistically defined WUI areas and associated GIS layers.
14. We still do not know how to model spread
15. No response

16. 1) For landscape-scale application, advances in usability and accessibility for local governments to use GIS and areal (drone) technology. 2) Apps and online training for municipal employees to learn fire risk assessment techniques so a local area can be empowered to do such work on their own at less program cost. Same technology for data review, risk identification, and comparative work.
17. No response

Q.7 What are the market gaps and challenges for WUI resilience planning? How might those gaps be addressed by new technologies and data solutions? This can be planning for construction/development, fire service operations, etc.

1. No response
2. With some exceptions, lack of building codes / associated referenced standards. - Where building codes / standards exist, some disagreement regarding severity (how restrictive) of code and related potential effectiveness. More research could minimize the extent of these disagreements.
3. No response
4. If a technology can do the mapping quicker and cheaper great--the rest of the work is people intensive.
5. A nation-wide WUI risk map is needed so that it can be adopted by reference in the model codes.
6. No response
7. Modelling tools can help planning for emergencies
8. Most wildfire-risk models are not at the scale for planning purposes (i.e. neighborhood/parcel). To be effective for planning at the local level, risk assessments have to be verified via site-by-site parcel assessments, which are costly and time consuming.
9. I think we need to move towards a much more sophisticated understanding of where the 7a codes are mandated. I see astonishing construction occurring where I live within a few hundred feet of large timber stands but not technically mapped into the high threat zones because of inadequate mapping. I also think local Govs need to understand how different investments of local and state dollars will impact safety, grid reliability, and insurability.
10. No response
11. No response
12. No response
13. There is much static data available, but having dynamic real-time data tied in with other geospatial layers will help us with preplanning events and responding to events using a much more concise and safe approach.
14. No response
15. No response

16. Apps and online training for local fire departments (and residents, local NGOs, installer/contractors, insurance industry) to learn fire risk assessment techniques so a local department or group of volunteers, etc, can be empowered to do such work on their own at less program cost. Same technology for data review, risk identification, and comparative work.
17. Current fire defense systems urgently need innovations that make fire containment safer, more effective and cleaner - for fire fighters, affected communities and habitats. At Wonder Labs, we're supporting the development of an acoustic fire extinguisher that could enable cleaner and more effective fire containment outcomes. The acoustic fire extinguisher device is being developed as part of an integrated sense and response system that would provide end to end wildfire risk management. We look forward to speaking about this solution at the workshop and welcome your feedback on potential uses and applications.

Q.8 What are the gaps and challenges of current outreach programs that aim to improve WUI resilience?

1. No response
2. I think there is confusion with the general public regarding all of the outreach groups. Firesafe Councils, R-S-G!, Firewise, as examples. Why is there a need for so many? Are these different? Many people are left scratching their heads in wonder, potentially listening to no one... - Lack of coordination between outreach / education groups. Can lead to / result in inconsistent / conflicting messaging. Common messaging is good. Non-uniformity in messaging is not.
3. Bridging the communication gap between the public, the scientific community and public agencies is a significant challenge when it comes to outreach programs. This is specially the case for disadvantaged and minority communities who may be specially vulnerable to natural disasters. Access of information in various languages and dissemination of this information in community spaces
4. Coming into communities with a one size fits all or externally driven program. Meet people in communities where they are.
5. People don't understand what their risk from from wildfires actually is.
6. No response
7. Reaching out more communities and make them aware of the risks linked to WUI fires
8. Not enough focus on the home itself. Defensible space and the HIZ zones are emphasized but little attention, if any, is given on the design, layout, and building materials of the home. Embers cause up to 90% of home destruction, therefore messaging needs to focus on protection the home from ignition vulnerabilities.
9. Funding. We need people in the field building relationships with WUI residents. Not a nice postcard in the mail from the local FireWise group.
10. Voluntary programs alone will not give us the scale we need. Local government must engage, use codes, and enforce to help create the necessary social change for personal responsibility to prepare their homes.
11. No response

12. I don't see as much attention paid to community-level infrastructure and development over time - focusing beyond neighborhood level.
13. Capacity of fire departments and agencies to deliver adequate and consistent messaging.
14. People need to be convinced it could happen to them- at the city and owner level
15. No response
16. 1) Are the communities most at risk being connected with or are those with the means to identify their risks and who have the existing community coordination to connect with state forestry, etc, receiving the limited support available. 2) Public perceptions of WUI home construction.
17. Outreach programs can be fairly 'top-down' in that they provide one-way information to communities but are not set up to receive community inputs/ information/ alerts 'bottom up'. We need to get smarter about how to use community inputs for enabling early detection and facilitating immediate response, similar to, 'if you see something, say something'.

Q.9 What are the needs and next steps to encourage adoption of mitigation measures?

1. No response
2. Common messaging. - Greater understanding and agreement regarding how to prioritize preparedness items "generically".
3. Evaluate who are the vulnerable populations, investigate their understanding of mitigation measures and best practices, and assess how to best improve their understanding of best practices,
4. Relationship building on local level.
5. More aggressive inspections, weed abatement regulations, etc.
6. No response
7. Demonstrate the long term financial benefits of investing in mitigation measures
8. Educate the key decision makers and elected officials that fuel treatments alone will not solve this problem. We can't log our way out of the wildfire risks in the West.
9. I think we should be funding field positions for Wildfire Safety Advocates to walk the neighborhoods - get to know people - write grants - facilitate defensible space creation and maintenance.
10. It needs to become the social norm. We need to no longer foster the idea that everyone is a victim and the government will be there to save them, and if they can't, then to help them recover. Preventing these large scale losses in the first place if far less expensive than recovery.
11. No response
12. No response
13. Cost sharing programs, like community chippers and other incentive programs, such as locations like Colorado Springs and Boulder County have in place.
14. getting people to present and understand reasonable scenarios
15. No response

16. 1) Public perceptions of WUI home construction. 2) Public perceptions of who is responsible for wildfire prevention and the role residents can play in preparedness. 3) Local policy maker understanding of the WUI risk and steps they can take to both reduce that risk and engage residents in the solution. Acknowledgement by planners, policy makers, local municipal budget managers, and code enforcers that current WUI structural and community loss is both unacceptable and the "Urban Conflagration" risk of the 21st century. We've been here before.
17. No response

Q.9A Additional comments

Respondent 3: The need to involve cultural brokers in the conversation in order to ensure that the information is getting out to all sectors of society should be an important priority in outreach and community action.

Repondent 11: Outside my area

Q.10 What are the current gaps in notification and evacuation plans?

1. No response
2. Many available notification plans. None seem perfect. I don't know where the gaps are.
3. No response
4. Not qualified to respond to this one.
5. No response
6. social media could be better exploited BUT is not a perfect tool - specific vulnerable populations (e.g. undocumented immigrants, non-English speakers, people who have limited mobility) - do people already know where they are supposed to go?
7. Means of communication can be improved - Reach out a larger proportion of the community
8. No response
9. Biggest is lack of standardization in communications and language. There needs to be a real effort to get to a statewide standard approach. Then the issue becomes reliability of non-copper communications during a blackout.
10. Two many different systems that require sign up, so therefore miss some of the population. The Amber Alert system seems more comprehensive, yet they have not been willing to use that platform for notification for evacuation.
11. We need to alert everyone near a fire ignition, regardless of when/whether subsequent evacuation warnings/orders might follow.
12. No response
13. People don't tend to understand the levels of notification and what they mean, even within fire departments. These are very few places that have this dialed in, with a unified command scenario with Fire/Law. How can we expect homeowners to understand this if we don't understand it.

14. We really have no plans whatsoever
15. No response
16. For notification, gaps in both public understanding of the tools available and how to use them. Also, an over-reliance by the public on technology and pushed-notifications to understand fire behavior, weather conditions, and when they should act. For evacuation plans, gaps in engagement and understanding of socio-economic and other societal factors that limit resident ability to act and/or have a place at the table when the risk is assessed, development made, etc. Also, whether the evacuation plan developers holistically review all residents at risk and consider additional factors and groups that will be impacted by the same risk in different ways (ie: elderly, disabled, transportation considerations, tech connectivity, employment, etc. Finally, whether or not the evacuation plan and its development process reflects the local experience or is instead a plug-in-play contractor-purchased template.
17. Local councils need to ensure text based alert systems actually get tested on a regular basis, such as for traffic or similar safety alerts. If people don't regularly receive alerts, they will not know how to read them and act on them. People need to understand how to interpret and act on wildfire alerts - FireWise, CERTs and schools can be a great way to train the community. Perhaps a user survey could help explain how community's interact with safety messages/ alert apps to identify effectiveness and remaining needs. Also, local SOPs on communicating alerts need to be very clear. Delays or miscommunication can cause disaster, as we have seen in a number of recent fires. It can be useful to get students to participate in summer mapping classes where they can be trained in how to make and read maps of their county. Household preparedness will likely follow.

Q.11 What can be done to improve the process in the near and long term?

1. No response
2. A common / uniform way for local authorities to think about / develop effective notification and evacuation plans.
3. No response
4. No response
5. No response
6. No response
7. Use tools which would display to stakeholders how to perform effective evacuation procedures
8. No response
9. No response
10. Better systems for notification, much more planning and practice of evac. Planning developments with large scale evacuation in mind.
11. Communities that have very poor egress should look at public (places of refuge) and private (bunkers) in terms of fire shelter for scenarios where evacuation is not feasible.

12. No response
13. Create incentives for Counties and other jurisdictional authorities to work together and put plans together that address these issues. Outreach to help homeowners understand levels of evacuation and when to evacuate.
14. Neighborhood education plans specific to the neighborhood.
15. No response
16. Better education to, and local data use by, the evacuation plan developers. More community engagement to identify all at risk and how the plan can reflect them.
17. Its not just about mapping where a fire will spread, its also important to know where people are likely to go, based on their past experiences and access factors. It could be really useful to incorporate mapping historic evacuation routes with community leaders - in the past, what worked and what didn't. There's so much knowledge about local routes among residents who have lived in a place for decades. Would be useful to tap into community knowledge and make it a part of the data that feeds into simulations and mapping evacuation routes. It will be important to not only work with County's Office of Emergency Services, local police and fire but also social services and American Red Cross. They will know how to get the message of evacuation planning across to those who need it most i.e. those with access and functional needs. Evacuation mapping should always include those with access, functional and special needs - homeless, economically disadvantaged, migrant households with language considerations, gendered dimensions (understanding who is more likely to use the maps among certain demographics), elderly, people with disabilities, animals and pets.

Q.11A – Additional comments

Respondent 13: Messaging on self-evacuation is paramount. "Don't wait for the jurisdictional authority to tell you to leave." Leave early, especially if things are starting to feel worrisome.

Q.12 What role should insurers be responsible for as related to WUI fire mitigation and recovery?

1. No response
2. Given antitrust regulations, it will be difficult for "insurers" to speak and act with one voice, but the insurance industry could be one source of financial support for mitigation activities. - The insurance industry could work with community-wide (up to county?) organizations to help ease public discontent with the industry over non-renewals by participating in Wildfire Partner-like efforts (Boulder County, CO).
3. No response
4. Insurers can be a driver for people's decisions, but many people live in vulnerable places because they can't afford to live in other areas and insurance isn't affordable either.
5. No response

6. No response
7. Funding and supporting mitigation measures
8. Insurance companies are post-disaster response and not involved enough with pre-disaster mitigation.
9. I don't think insurers should be responsible for more than paying their claims. I do think insurers should have an obligation to sell policies that will allow for reconstruction to current code. That should not be an option.
10. I think we need to get much better parcel level data on mitigation status before the Insurers can be major players. If they see that losses are reduced due to direct action in the Home Ignition Zone, then you may see more insurers using those practices as requirements for insurance and renewal.
11. No response
12. It would be nice to have more insight into the ways insurers assess WUI risk - I know it's proprietary but there's a lack of transparency for homeowners.
13. Insurers should look at insuring combustible structures in the WUI at a level so if there were a loss the insurer would replace with ignition-resistant building materials, and then create incentives/reductions to encourage homeowners to harden homes, manage vegetation, and deal with other ignition vulnerabilities.
14. It is not their role
15. No response
16. The current WUI structural and community loss is both unacceptable and the "Urban Conflagration" risk of the 21st century. We've been here before. Insurance can play an influential role in requiring the WUI development standards, codes, enforcement, and local policy that is required to ensure we end the loss of communities to wildfire and ensure post-fire rebuilding is to codes that ensure it does not happen again.
17. No response

Q.13 What needs to be done to improve WUI policy and regulation for increased fire resilience of new and existing communities/utilities/resources? This can be pre-disaster and post-disaster.

1. No response
2. Continued improvements in understanding of vulnerabilities and effective mitigation strategies to the built environment in wildfire-prone areas, with associated improvements in codes and standards, and guidance (and incentives) for retrofit activities. - Continued post-fire assessments that can guide / influence future research. - Making modifications to existing codes and standards is difficult, but scientific evidence and support can facilitate change.
3. No response
4. No response
5. No response
6. No response
7. set up more strict regulations on requirements in terms of preparedness and mitigation measures.

8. I'm a bit confused by this question - "what needs to be done to improve WUI policy and regulation...?" Outside of CA and a few cities who have adopted a WUI code, there is no policy. So the first step would be to adopt WUI policy and regulations, before suggesting how it could be improved.
9. More emphasis on pre-disaster. We focus too much on the victims we have, not the victims to be. Governor needs to have a constructive dialogue with both the builders and the insurance industry to get to some accommodation on land use policy. We need to have some sort of funding mechanism to improve community-level and structure-level hardening.
10. There needs to be some, first off. We need to stop cutting the guts out of regulation. We need good laws and enforce them because there is a segment of the population that will only respond to a stick.
11. Communities that can't safely evacuate in a set time threshold (e.g. 1 hour) will have to develop a shelter-in-place plan (if scenarios that offer less than 1 hour are feasible).
12. Increased emphasis on assessing community-level compliance with regulations and guidelines (voluntary). We don't have a lot of data on efficacy of interventions. Increased examples of paths forward for communities that are already developed.
13. Policy makers don't tend to really understand how they can best help. We need to find opportunities to message to these individuals (e.g. Association of Idaho Cities, Western Governors Association, etc.)
14. First – 1. Enforce and inspect for current rules 2. Develop long term plan for removal of ignition sources, starting with the most severe risk.
15. No response
16. 1) Acknowledgement by planners, policy makers, local municipal budget managers, and code enforcers that current WUI structural and community loss is both unacceptable and the "Urban Conflagration" risk of the 21st century. 2) Achieve a regional-level, cross-county boundary, and economically collaborative, land-use planning focus that had regional wildfire in mind, to better plan local development locations and risk/value assessments. 3) Help all players in the "ecosystem" understand the role they can and should play in WUI risk reduction. 4) Help developing counties and existing areas not to get stuck in the "local economic development trap" and the need by municipalities to quickly rebuild lost tax-base post fire when they quickly allow substandard rebuilding.
17. No response

Q.13A - Additional comments:

Respondent 2: - The home mortgage industry could have more control over "home hardening" activities that they may want to have or think they have.

Respondent 11: Outside my area

Respondent 16: I look forward to the summit!

Respondent 17: We look forward to contributing further thoughts during the workshop and learning about all your efforts.

APPENDIX C: WORKSHOP SPEAKER PRESENTATIONS

Preparing for Disaster: Advancing WUI Resilience

Workshop Agenda

March 3-4, 2020

Arup 560 Mission Street, Suite 700, San Francisco, CA

Last updated: 25 February 2020

Objectives:

1) Identify immediate and realistic actions to resolve research and market gaps between wildfire risk and WUI disaster resilience; and
2) Outline the steps required to execute development of holistic, accessible and sustainable solutions.

Structure:

The workshop will consist of short, themed talks followed by panel discussions, breakout discussions, and report-back presentations from breakout groups. Each breakout discussion will focus on one topic that will be reported back after the discussion.

Breakout groups will be selected in advance of the workshop with diverse representation from different fields in each group. One facilitator will be selected for each group and a scribe will be assigned to take notes using Google Slides.

Tuesday March 3

8:00-8:30 Check-in/light breakfast & coffee

8:30 - 9:00 Opening from Organizers

- Amanda Kimball & Michelle Steinberg: Welcome from the FPRF & NFPA (15 minutes)
- Michael Gollner and Maria Theodori: Defining resilience, workshop goals & objectives, workshop format (15 minutes)

9:00 - 10:15 Framing our Problem: Case studies

- Crystal Kolden (U Idaho) - Mitigating the inevitable - a success story and lessons learned from Montecito during the Thomas Fire (30 minutes)
- Alex Maranghides (NIST) - A review of NIST accident investigations of WUI fires (30 minutes)
- Panel discussion (15 minutes)

10:15 - 10:35 Coffee Break

Preparing for Disaster: Advancing WUI Resilience

10:35 - 11:10 The State of Things: The problem, its history and projections for the future.
Presentation Bursts

- Ren Larson (AZ Republic) - Assessment of at-risk communities across California (10 minutes)
- Erica Kuligowski (NIST) - Stay or Go, When and Where to? Evacuation and Notification Challenges for WUI Communities (10 minutes)
- Panel discussion (15 minutes)

11:10-12:00 Breakout into working groups

- Outline current challenges and barriers to change.
- Look for agreement on the definition of the problem and what success (resilience) looks like.
- Form statements like "in a perfect world, it would look like this," or, "with the right solutions, in 20 years this would be the change we would see."

12:00 - 12:30 - Lunch

12:30 - 1:00 Reconvene in main room - report back

- 1 slide per group, quick report back from groups on *key issues and problems*

1:00- 1:45 - Land Use and Wildfire Planning Tools for the WUI

- Miranda Mockrin (USFS) - Adaptation through recovery: past experience from CA (10 minutes)
- Molly Mowery (Wildfire Planning) - Community Wildfire Protection Plans and land use planning tools (10 minutes)
- Greg Dillon (USFS) - Challenges of modeling and mapping hazard and risk at the boundary of wildlands and communities. (10 minutes)
- Panel Discussion (15 minutes)

1:45 - 2:30 Breakout Groups

- How can we maximize the application of land use and wildfire planning tools to address the WUI?
- What barriers exist to developing and implementing these tools?
- What are key actions in the short, near, and long-term that may improve the effectiveness of these tools?

2:30 - 2:45 Coffee Break

2:45 - 3:15 Reconvene in main room - report back

- 1 slide per group, quick report back from groups on *key issues and problems*

3:15 - 4:00 Technology for Planning and Risk Assessment for Communities

- Chris Lautenberger (Reax) - Real-Time Fire Spread and Risk Forecasting (10 minutes)
- Dave Sapsis (CALFIRE)- Improved Statewide Hazard Mapping with Downscaled Fire Climate Data (10 minutes)
- David Marvin and Chris Anderson (Salo Sciences) - Dynamically mapping forest structure & fuels with nanosatellites and deep learning (10 minutes)
- Panel (15 min)

4:00 - 4:45 Breakout Groups

- What research and market gaps exist?
- Do we know if there are already solutions or promising work being done?

4:45 - 5:30 Reconvene in main room - report back and discussion

- 1 slide per group, quick report back from groups
- Additional discussions from the day

5:30 Adjourn for evening

Wednesday March 4

8:00 - 8:30 Breakfast

8:30-9:00 Opening, daily kick-off

- Review of key points from previous day (Gollner/Theodori)
- Goals and outcomes for the second day

9:00-9:35 - Outreach and Community Action (10 minute presentations)

- Michele Steinberg (NFPA) - Firewise and community-centered programs
- Jerry McAdams (Boise FD) - Education & Outreach: Capacity and Reality
- Panel Discussion (15 min)

9:45 - 10:00 Coffee Break

10:00 - 10:45 Breakout Session

- What are the gaps in current outreach programs?
- What are the needs and next steps to reduce destruction and encourage adoption of mitigation measures?

10:45 - 11:15 Reconvene in main room - report back

- 1 slide per group, quick report back from groups

Preparing for Disaster: Advancing WUI Resilience

11:15 - 12:00 - Notification and Evacuation (10 minute presentations)

- Steve Hawks (CALFIRE) - Evacuation Preparedness and the Camp Fire
- Tom Cova (Utah) - Evacuation planning for dire scenarios
- Panel discussion (15 min)

12:00 - 12:30 Lunch Break

12:30 - 1:15 Breakout group discussion

- What are the current gaps in our notification and evacuation plans?
- What can be done to improve the process in the near and long term?

1:15 - 1:45 Reconvene in main room - report back

- 1 slide per group, quick report back from groups

1:45 -2:15 - Long-Term Trends and Market Challenges

- Roy Wright (IBHS) - Insurance role in WUI Fire mitigation
- Edith Hannigan (Board of Forestry and Fire Protection, CA) - where we are and where we're going in terms of land use planning in California
- Discussion (15 min)

2:15 - 2:45 Breakout Groups

2:45 - 3:00 - Coffee Break

3:00 - 3:30 Reconvene in main room - report back

- 1 slide per group, quick report back from groups

3:30 - 5:00 Group Discussion

- Major gaps and deficiencies in current practice: from research to market
- Solutions in different timescales
    - Immediate Actions
    - Long Term Development (Research, Tools, Planning, Codes, etc.)
    - Influencing Policy
    - Post-Disaster Recovery (Funding to those who need it)

5:00 Adjourn

Preparing for Disaster: Advancing WUI Resilience

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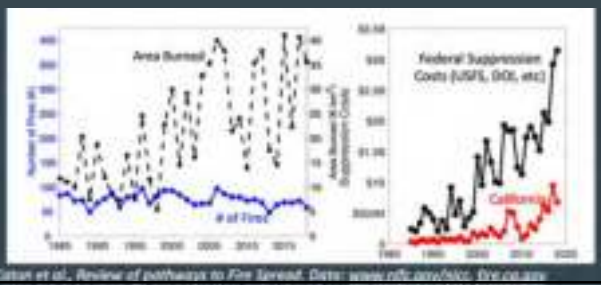
Tuesday, March 3, 2020

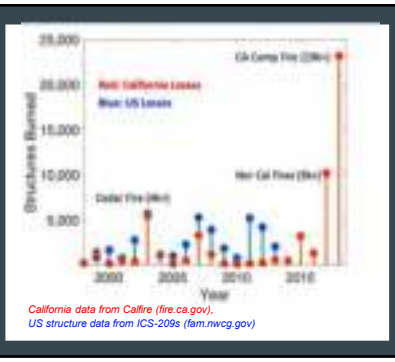
ARUP Berkeley REAX

Increasing Size and Cost of Fires



Calkin et al., Review of pathways to Fire Spread. Data: www.nifc.gov/stats, Dec release

Increasing Size and Cost of Fires



Pre-Workshop Survey Outcomes

- Shared with presenters and are incorporated into discussions to follow

Key Takeaways: Many Challenges

- Prioritizing actions and balancing other issues such as property rights, energy efficiency, politics, etc.
- Making actions cost-effective
- Long-term funding
- Public understanding of risk
- Engagement with the community
- Complacency and resistance to necessary change
- Climate change and changing risks
- Continued sprawl into WUI areas

Key Takeaways: Many Opportunities

- Can we develop risk-informed tools for planning?
  - Can we present financial trade offs to key stakeholders?
- Home hardening and community design
  - Sprinklers? How close is too close?
- Building codes and regulations
  - How can we push for more widespread adoption
- Land management and mitigation
  - How do we bring fire back onto the landscape?
- Community engagement
  - Best practices to enact long-term change
- Resident education and outreach
- Disaster recovery planning

Objectives of this Workshop

1) Identify immediate and realistic actions to resolve research and market gaps between wildfire risk and WUI disaster resilience

2) Outline the steps required to execute development of holistic, accessible and sustainable solutions.

Workshop Format

- Short, themed talks followed by panel discussions
- Breakout discussions
  - Each discussion will have a distinct theme
  - Groups selected with a diverse representation from each group
  - One facilitator and scribe selected for each group
- Report-back presentations
  - 5 minutes per group to report back on outcome of discussion
  - Presenters can be facilitators or anyone the group selects
- Post-workshop report
  - Presentations, slides and notes will be compiled by a small group after the workshop
  - A report will be prepared with outcomes of the workshop

Workshop Outline

- Framing our Problem: Case studies
- The State of Things: The problem, its history and projections for the future.
- Land Use and Wildfire Planning Tools for the WUI
- Technology for Planning and Risk Assessment for Communities
- Outreach and Community Action
- Notification and Evacuation
- Long-Term Trends and Market Challenges
- Major gaps and deficiencies in current practice: from research to market
  - Solutions in different timescales

Preparing for Disaster: Advancing WUI Resilience

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Wednesday, March 4, 2020

ARUP Berkeley REAX

Plan for Day 2

- Continue to discuss 3 topics
  - Outreach and Community Action
  - Notification and Evacuation
  - Long-Term Trends and Market Challenges
- Regroup and discuss major
- Major gaps and deficiencies in current practice: from research to market
  - Solutions in different timescales
  - We are going to list and rank
    - Solutions and clear actions
    - Research needs
  - As a group, come together and compile these into a top list based on timescale

Themes from day 1

- What is jumping out at you? Key Points?
- Should we focus any discussions today?
- What do practitioners need?
- What are modelers/data being developed
- How to connect with silos?
- Public health, smoke, other groups, recovery, social science,
- Evacuation
- policy/legislative link
- Connect with other disaster researchers

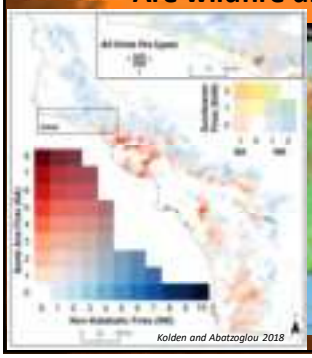
Crystal A. Kolden, Ph.D.
Associate Professor of Fire Science
University of Idaho
March 3, 2020

Mitigating the Inevitable:

A success story and lessons learned from Montecito during the 2017 Thomas Fire

Why try to mitigate the inevitable?

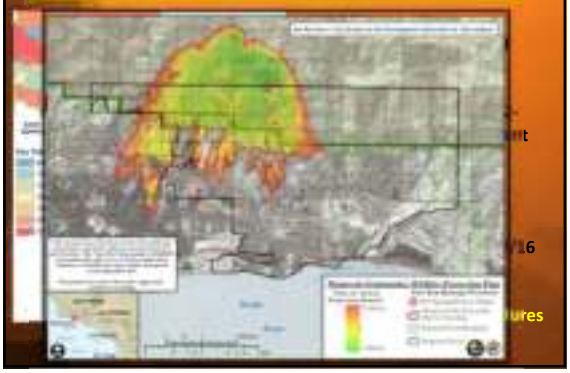
~~Is wildfire inevitable?~~ Are wildfire disasters inevitable?



Kolden and Abatzoglou 2018

Even in the most fire-prone place in the US wildfire disasters are NOT inevitable

A Defensible Community?



A Defensible Community?

What actually happened during the Thomas Fire?

The Numbers:

- 0 Fire fatalities
- 0 Entrapments
- 0 Injuries
- 7 primary residences lost
- 7 guest houses
- 37 parcels with some level of structure damage

Keith Callum/Santa Barbara Independent

1990 Painted Cave Fire: 500+ homes, 1 civilian life lost

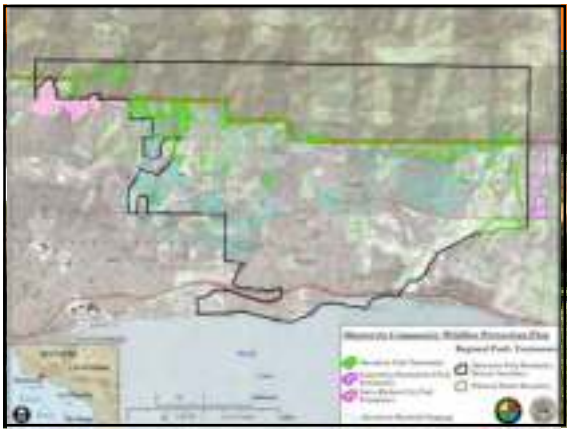
A Defensible Community?

A Defensible Community?

What did Montecito Fire Protection District do to prepare for wildfire?

A Defensible Community?

1) Defensible space surveys



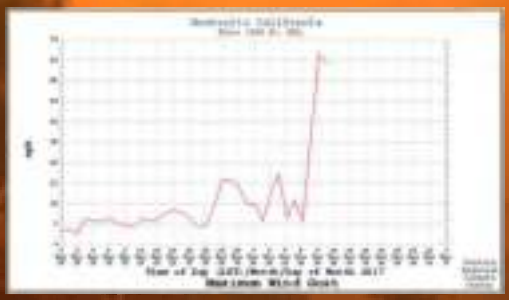
A Defensible Community?

1) Defensible space surveys
2) Fuel Treatment Network
3) Neighborhood Chipping Program

A Defensible Community?

A Defensible Community?

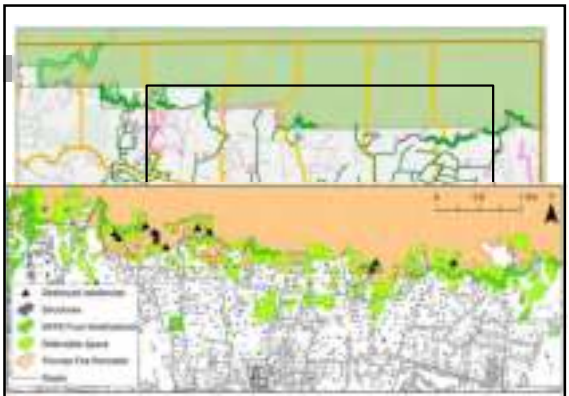
A Defensible Community?



A Defensible Community?

Socioecological approaches for mitigating wildfire disasters

Kolden and Henson, 2019, *Fire*



Kolden and Henson, 2019, *Fire*

A Defensible Community?

"They may not have done it for the greater good, but it served the greater good."

What did we learn?

Components of WUI defensibility?

Construction, landscaping, landscape, climate, and social all matter

Kolden et al., forthcoming

What does it mean to live with fire?

Bowman et al., forthcoming

A Review of NIST Accident Investigations of WUI Fires

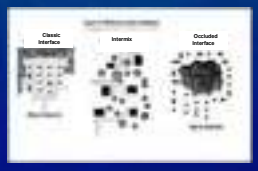
NFPA Research Foundation, March 2020

Alexander Maranghides
Wildland-Urban Interface Fire Group
NIST
USDOC, Gaithersburg, MD

William (Ruddy) Mell
Fire and Environmental Research Applications
USFS, Seattle, WA

"The Urban Wildland Interface community exists where humans and their development meet or intermix with wildland fuel."

Federal Register
https://www.gpo.gov/fdsys/pkg/FR-2001-01-04/html/01-52.htm



Outline

- NIST, Who We Are and What We Do
- NIST WUI Investigations
- WUI Fires are Different
- WUI Data Collection and Analysis
- Structure Ignition Pathways and the Exposure Gap
- Hazard Mitigation Paths Forward

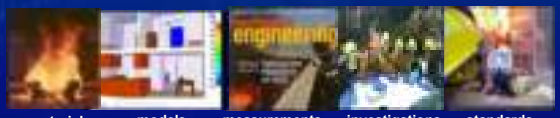
NIST's Role in Building, Infrastructure, and Fire Safety Regulations

- NIST is a non-regulatory agency in the U.S. Department of Commerce
- NIST does not set building codes, fire codes, or standards
- Codes and Standards not mandated by U.S. Federal Government
- Model Codes – consensus codes
  - Developed by Standards Development Organizations
  - International Code Council (ICC) - www.iccsafe.org/
  - National Fire Protection Association (NFPA)- www.nfpa.org/
- States, local government, cities
  - Adopt model codes - all or part of codes

NIST does Measurement Science

Measurement science supporting the technical basis for:

- Standard reference materials
- Models
- Investigations
- Standards
- Codes
- Best practice guidelines
- Software decision-tools
- Databases



materials models measurements investigations standards

Parcel level vulnerabilities identified from our NIST WUI Investigations



Camp Fire - Ongoing

WUI Structures not hardened against ignitions from embers or direct flame
Exposure Gap

WUI Fires Are Different

Urban Response	Urban Fire Extent of Damage	WUI Response	WUI Fire Extend of Damage	Wildfire Response	Wildland Fire Extent of Damage
One Fire Department Multiple Fire Stations	Room of origin ↓ *seconds to minutes*	Multiple Fire Departments and Jurisdictions *Mutual Aid*	Interface boundary ↓ *minutes to hours*	Multiple Land Owners and Jurisdictions *Mutual Aid*	100 acres ↓ *hours to days*
	Floor of origin		Neighborhood		1,000 acres
	Building of origin		Community		10,000 acres

Exposed structures often outnumber firefighting resources
Structures need to withstand exposure on their own

WUI Fire Exposure

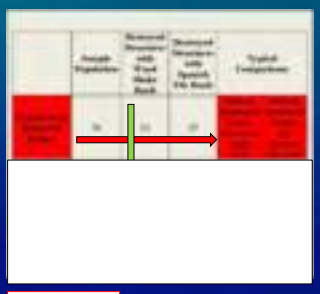
- Fire spread: radiation/convection and embers (firebrands)
- You can affect your neighbors and your neighbors can affect you*
- Reducing parcel level combustibles reduces likelihood of structure ignition(s)
- In *severe exposures* "80% of mitigation" → "80% ignition risk reduction"

* In medium density construction (like Paradise and high density like Coffey Park in Santa Rosa)

WUI Fire Exposures and Data

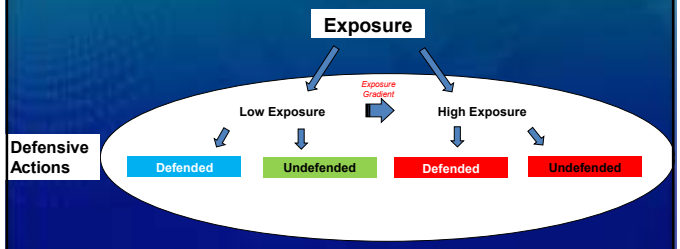
- Post Fire DINS data alone provide ***limited*** structure response information
- Post WUI Fire Damaged → Defended (90+% of the time)
- Post WUI Fire Undamaged → Low Exposure, and/or → Hardened Construction, and/or → Defended

Post-WUI Fire Data Collection and Analysis



NIST Witch/Guejito Report #2

WUI Post Fire Analysis - Exposures and Defensive Actions will Vary in Space and Time



Fire Spread and Structure Ignitions in the WUI

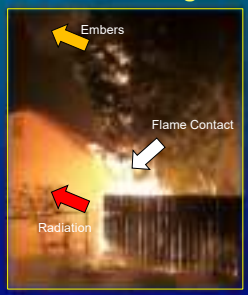
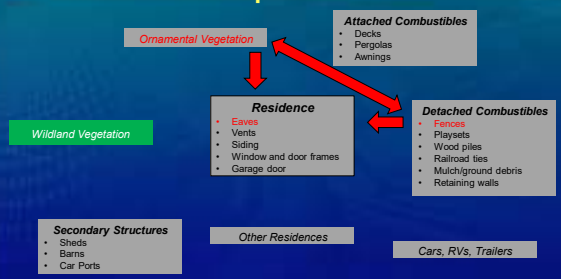
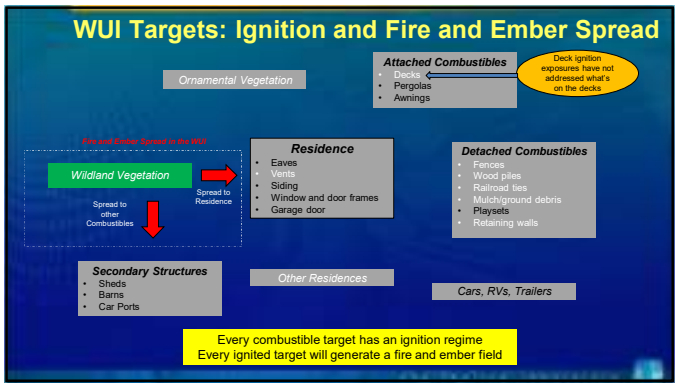


Photo courtesy of CALFIRE, used by permission

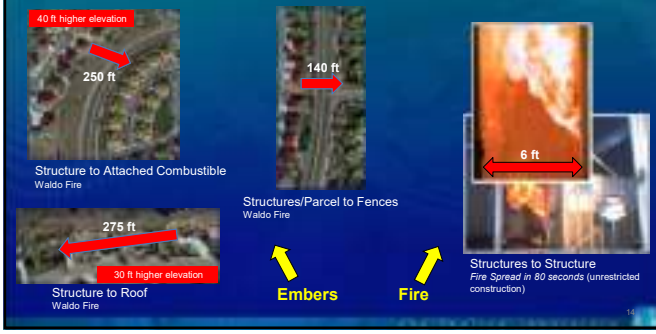
Fire and Ember Exposures to a WUI Residence



WUI Targets: Ignition and Fire and Ember Spread



Structural to Structure Fire Spread



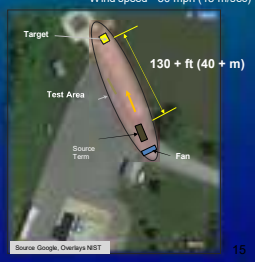
Spotting and Ignition Potential - Experimental Setup and Results

Source Terms:
- Double lattice redwood fence
- Shredded hardwood mulch
- Maple Firewood

Targets:
Shredded hardwood mulch (on the ground and elevated)

Spotting Distance:
130+ ft (40 + meters)

Times to spotting: 55 sec. to 5 min.



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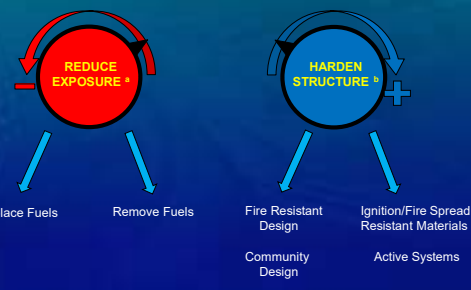
Frederick County Government Fire & Safety Training Center

Where do we go from here? Two Tools

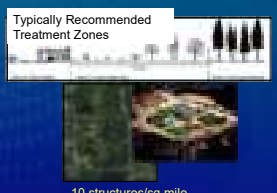


[a] Fire and Ember

[b] Hardening for embers and/or fire

Different Types of High Hazard WUI – Different Solutions

✔ *Low Density – FIREWISE*



10 structures/sq mile

Fuels Displacement works

High Density – FIREWISE HD (?)

300 structures/sq mile

Fuels Removal is necessary

What exposures require hardening the structures?

Three distinct problems:

1. Wildland exposures (Fuel treatments around a community – science needed) – *combination of fuel treatments and hardening*

1. Structure to Structure exposures Multiagency/organization effort

CAL FIRE/NIST/USFS/IBHS/CBIA/WFCA – *combination of spacing (placement of targets) and hardening*

3. Parcel Level Exposures (NIST Standard Parcel under development) – *combination of reduction in targets, placement of targets and hardening of structure*

WUI Fire Exposures

- Fire spread: radiation/convection and embers (firebrands)
- Post Fire DINS data alone provide limited structure response information
- You can affect your neighbors and your neighbors can affect you*
- Reducing parcel level combustibles reduces likelihood of structure ignition(s)
- In Severe Exposures "80% of mitigation" "80% ignition risk reduction"

* In medium density construction (like Paradise and high density like Coffey Park in Santa Rosa)

Contacts

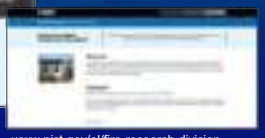
Alexander Maranghides, alexm@nist.gov
office (301) 975 4886
cell (202) 567 1634
NIST

William (Ruddy) Mell, ruddymell@gmail.com
cell (206) 430 2072
USFS

Thank You

NIST, Who We Are and What We Do

www.nist.gov

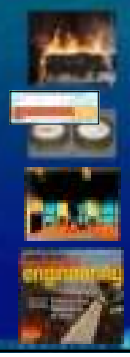


www.nist.gov/el/fire-research-division-73300/wildland-urban-interface-fire-73305

NIST is a Non-Regulatory Federal Agency

NIST Fire Research Success Stories

- **Reduced Mattress Flammability and Cigarette Ignition** – standard test methods for reduced-ignition-propensity cigarettes and mattress flammability, reducing smoking related fires and unsafe mattresses.
- **Fire Dynamics Models** – tools to predict the spread of fire, smoke, and toxic products, enabling a transformation from prescriptive to performance standards.
- **Fire Fighter Protective Equip** – performance metrics and standards for thermal imagers and personal alert safety systems, facilitating safer and more effective fire fighting.
- **Fire Fighting Tactics** – guidelines for wind driven fires and positive pressure ventilation firefighting tactics.
- **Heat Release Measurements** – improved standard test method, enabling fundamental heat release rate measurements worldwide.
- **Automatic Fire Sprinkler Standards** – installation & design standards for residential sprinkler systems, reducing fire losses.
- **Smoke Alarm Standards** – supported development of smoke alarm standards, enabling large reduction in fire deaths from the mid-1970's.
- **Material Flammability** – knowledge on the mechanisms and effectiveness of nanoparticle fire retardants, enabling a new generation of sustainable commercially available materials.

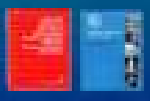


NIST's Role in Building, Infrastructure, and Fire Safety Regulations

- NIST works to reduce the total social cost of fire by:
  - Conducting research which provides the technical basis to support advances in best practices, standards, and codes
  - Disseminating research results to practicing professionals
  - Participating on technical and standards committees
  - Providing technical assistance to the building, infrastructure, and fire safety communities

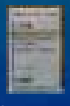
Key Outputs and Impacts to Improve Fire Protection

Standards



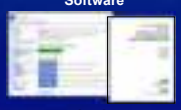
e.g., NFPA 1801, UL 217

Reference Materials



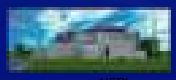
e.g., Standard cigarettes

Software



e.g., CFAST, FDS

Databases and Performance Metrics



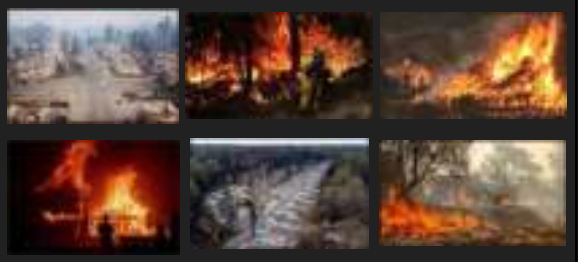
e.g., NFRL

California communities & wildfire, then & now

Ren Larson, The Arizona Republic/USA TODAY Network
Preparing for Disaster & Advancing WUI Resilience

@renLarson_
plarson@gannett.com

Justin Sullivan/Getty Images



Understanding the Hazards

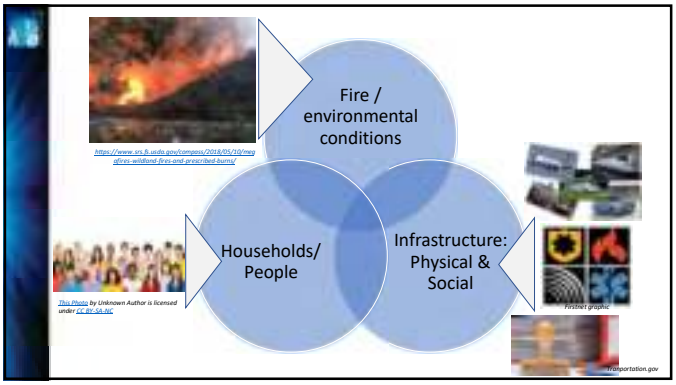
Natural environment

Built environment

Human communities

Stay or Go, When and Where to? Evacuation and Notification Challenges for WUI Communities

Erica Kuligowski
Sociologist, PhD; Fire Protection Engineer, MS and BS
Wildland-Urban Interface Fire Group, Engineering Laboratory
National Institute of Standards and Technology
ericakuligowski@gmail.com



Evacuation and Notification Challenges (1/3)

- **Severe fire/environmental conditions:**
  - Rapid fire spread *[Atlas 2017]*
  - Multiple ignitions over time *[Black forest 2013]*
  - Abrupt changes in wind direction/speed; high wind gusts *[Thomas, Tubbs 2017]*
  - Mega-fire behavior – jumps, fire whirls/tornadoes, localized weather systems *[Carr 2018]*
  - Complicated or rugged terrain *[Thomas, Nuns 2017; Chimney Tops 2 (CT2) 2016]*

Acknowledgements: IAFSS Large Outdoor Fire and the Built Environment Working Group, EME Subgroup's case studies: E. Ronchi et al., S. Wong, M. Theodori, and C. Ma

Evacuation and Notification Challenges (2/3)

- **Households/people**
  - Vulnerable to injuries/deaths *[Camp, Woolsey 2018]*
  - With competing responsibilities to family, home, or work [*Mendocino 2018]*
  - With opposing or unfavorable perspectives on evacuation, authorities
  - With lower perceptions of risk before [*Thomas, Tubbs 2017*] and during a fire event *[CT2 2016]*
  - Unaware or uncertain about emergency procedures
  - With tendencies to move to the familiar: e.g., routes and people *[Rye 2017]*
  - With previous experiences: (+) and (-) re: evacuation

Evacuation and Notification Challenges (3/3)

- **Infrastructure: Physical**
  - Limited egress routes *[British Columbia (BC) fires 2017; Hill, Woolsey 2018]*
  - Insufficient capacity of routes and/or transit options *[Creek, BC 2017]*
  - Power losses hindering communications *[CT2 2016; Thomas 2017; Camp 2018]*
- **Infrastructure: Social (emergency response, preparedness and planning)**
  - Lack of tools, models with data to identify trigger buffers (planning and real-time)
  - Warnings not issued or issued late *[CT2 2016; Tubbs 2017]*
    - Uncertainty on when to warn
    - Fear of panic, overwarning, or warning fatigue; distrust in push comms
  - Overreliance on opt-in systems
  - Difficulties with coordination when messaging → inconsistent messages *[Carr 2018]*
  - Differing evacuation warning strategies
  - Potential gaps in evacuation plans *[Waldo 2012; Camp 2018]*

Consequences: Pre-evacuation decision-making

- Delayed decision-making and evacuation or deciding not to evacuate → injuries and death
- Last minute evacuations of critical facilities (e.g., hospitals) → moving critical patients in smoky conditions *[Tubbs 2017; Camp 2018]*
- Significant numbers of emergency officials dedicated to door-to-door notifications limiting resources elsewhere *[Black forest 2013; CT2 2016; Carr 2018]*

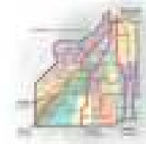
https://www.nfpa.org/News-and-Research/Publications-and-media/NFPA-Journal/2019/January-February-2019/POV/Perspectives Author(s): Scott Sutherland. Published on January 2, 2019

Consequences: Evacuation during Wildfires

- Traffic congestion; running out of gas; having to abandon their cars, causing additional congestion *[Carr, Woolsey 2018]*
- Evacuees slowed or overcome by fire or smoke on routes, trapped in vehicles or involved in accidents *[Fort McMurray 2016; Camp, Hill 2018]*
- Temporary refuge areas used as last resort *[Camp 2018]*
- Shelters:
  - Reaching capacity or overcrowding *[Tubbs 2017]*
  - Unable to accommodate people with health problems or disabilities *[Mendocino 2018]*

https://www.cdc.gov/disasters/wildfires/smoke.html

Multiple Challenges in 2018 Camp Fire with Consequences



- Town of Paradise – detailed phased evacuation plan
  - Residents were counseled on their zone and warning program
  - Emergency services conducted simulation evacuation exercises
- Delays in notifying residents
- 2 of the 4 routes inaccessible due to fire conditions
- Severe congestion
- People stranded took shelter in stores (Walgreens) with fire department continually wetting the structure
- Emergent plan to evacuate the hospital – planned transportation unavailable
- Surrounding community (Chico) also affected by fire – shelters, congestion, hospitals, pharmacies

Comfort, L. 2019. "Collective Action in Communities Exposed to Recurring Hazards: The Camp Fire, Butte County, California, November 8, 2018"; https://hazards.colorado.edu/quick-response-report/collective-action-in-communities-exposed-to-recurring-hazards

Future Projections…Ways forward (1/2)

- **Increase evacuation research efforts and collect data** on what people will do during evacuation
- **Develop practical evacuation models/tools** for evacuation planning and real-time decision-making on when to warn based on fire and realistic behavior
- **Improve evacuation warning strategies**:
  - Guidance, templates and tools on message creation and dissemination
  - National guidance/standard approach to communicating in wildfire events (messages/language/maps); places for local input
- **Use multiple evacuation warning dissemination methods**:
  - Especially opt-out systems, push communications
  - Benefits of social media
- **Focus evacuation training/education**; e.g., on risk to community members, routes

Examples of Research Efforts…

- Guidance and templates development:
  - Guidance on warnings/short message alerts[1]
  - Short message alerting templates[2]
  - Tools for WEA message creation in beta version[3]
  - Guidance on use of social media during disaster response[4]
- WUInity platform for simulating WUI fire evacuation (FPRF, funded by NIST)[5]
- Submodels on decision-making: CT2 fire work and Kincade fire study starting soon[6]
- NIST Burn Observation Bubble[7]
- VR training experiments: Massey University, NZ[8]

1. https://nvlpubs.nist.gov/nistpubs/TechnicalNotes/NIST.TN.1827.pdf; https://nvlpubs.nist.gov/nistpubs/TechnicalNotes/NIST.TN.2008.pdf
2. https://ascelibrary.org/doi/10.1061/%28ASCE%29NH.1527-6996.0000324
3. https://www.nfpa.org/-/media/Files/News-and-Research/Resources/Research-Foundation/Symposia/2019-SUPDET/Presentations/SUPDET19Doermann.ashx?la=en
4. https://nvlpubs.nist.gov/nistpubs/TechnicalNotes/NIST.TN.2086.pdf
5. https://www.nfpa.org/-/media/Files/News-and-Research/Resources/Research-Foundation/Current-projects/ProjectSummaryWUINITY.ashx?la=en
6. https://www.nist.gov/news-events/news/2019/03/official-nist-survey-support-data-collection-chimney-tops-2-fire-improve; https://hazards.colorado.edu/news/quick-response-news/upcoming-research-2019-california-wildfires
7. https://www.nist.gov/featured-stories/eye-fire
8. https://www.researchgate.net/publication/331001116_Virtual_and_augmented_reality_for_human_behaviour_in_disasters

Future Projections…Ways forward (2/2)

- Interdisciplinary mindset and varying expertise needed, e.g.,

Land-use planning

https://www.planning.org/publications/report/9174069/

Firefighting strategies/resources

This Photo by Unknown Author is licensed under CC BY-SA

Planning / traffic management

https://www.crcpress.com/Large-Scale-Evacuation-The-Analysis-Modeling-and-Management-of-Emergency/Murray-Tuite-Lindell-Wolshon-Baker/p/book/9781482259858

Infrastructure solutions

https://www.nist.gov/topics/community-resilience

Public outreach and communication planning

https://www.nfpa.org/-/media/Files/Public-Education/Resources/Educational-messaging/FMAC/EducationalMessagesDeskReference.pdf

Questions? Thank you!

Erica Kuligowski
ericakuligowski@gmail.com

Post-fire adaptation: Evidence from local policy and CA rebuilding

Miranda H. Mockrin[1], H. Anu Kramer[2], Hillary K. Fishler[3], Susan I. Stewart[4], David C. Helmers[2], Van Butsic[4], Volker C. Radeloff[2]

[1]USDA Forest Service, Northern Research Station, [2]University of Wisconsin, [3]Oregon State University, [4]University of California-Berkeley

March 3, 2020

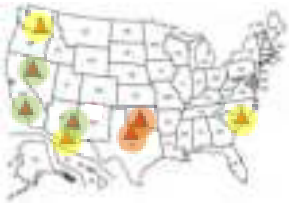
Does wildfire experience lead to community-level adaptation?

- Wildfire recovery could be an obvious time to see adaptation or change
- Focus on ***land use policy*** and ***built environment***
- Findings from two studies:
  1. Land use policy post-fire, 8 sites in U.S. (2009-2011)
  2. Building patterns post-fire in California (1970-1999)

2

1. Land use policy post-fire

- Eight study sites (2009-2011)
- Qualitative data (interviews) for local govt community leaders, analysis of codes and plans
- Variable land use planning for wildfire hazards



Research Questions: What changed—*and did not*—post-fire? Why?

3

Results

- Minimal change in regulations –building materials, zoning, defensible space
- Modest change in planning –CWPP, hazard mitigation
- Emphasis on suppression, evacuation, voluntary mitigation (Firewise)

4

Results

Challenges with land use planning and regulation:

1. lack of public support
2. resources and capacity
3. not necessary or effective
4. prioritizing housing growth
5. coordination and scale—internal, horizontal, vertical
6. adaptability over time

Many concerns present across sites—subdivisions vs dispersed homes, urban vs rural counties, previous investment in land use planning or none

5

Management implications

- Technical assistance and education
- Fire departments/hazard staff as partners
- Additional examples & approaches:
  - Rural places with housing stress
  - Large and diverse counties
  - How to update land use, regulations, and planning as wildfire hazard emerges? e.g., can you retrofit a subdivision?

6

2. Built environment in California

- Wildfires 1970-1999 (n=11)
- Followed long-term:
  - Rebuilding rates
  - Risk-specific to building locations

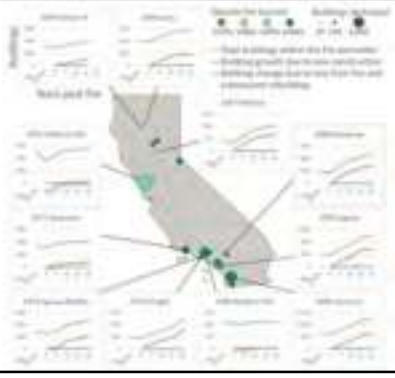
Kramer, H. A., V. Butsic, M. H. Mockrin, C. Ramirez-Reyes, P. M. Alexandre, V. C. Radeloff. In prep. California post-wildfire rebuilding and new building location reveals limited adaptation

1961 Bel Air fire (Steve Fontanini / Los Angeles Times)

7

Results- rebuilding and new development

8



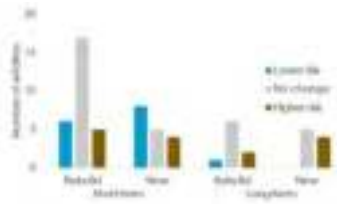
9

Results- building-level risk

No consistent trend of reduced risk:

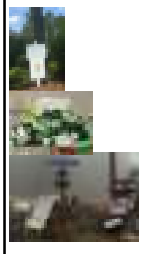
- Rebuilt
- New building
- Short- or long-term

Caveat - mitigation



10

Conclusions



- Wildfire experience does not lead to transformation in policy or built environment
- Development pressure and trends ongoing – both studies
- Caveats:
  - *Smaller scale than recent N. CA fires*

11

Thank you & questions

- Joint Fire Science Program
- USDA Forest Service (NRS and RMRS)
- Many people we interviewed
- Research assistants who created imagery
- Email: miranda.h.mockrin@usda.gov

12

13

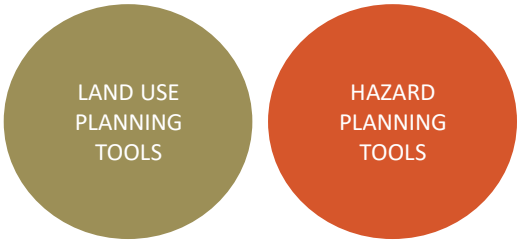

Retrofit buildings
New Buildings
A
B
C
D
Short-term
Long-term

14

Land Use & Wildfire Planning Tools

Molly Mowery, AICP
Wildfire Planning International

Overview of Tools



Overview of Tools

- Comprehensive (General) Plans
- Development Codes
- Zoning Codes
- Subdivision Regulations

Overview of Tools

- Community Wildfire Protection Plans (CWPPs)
- Local Hazard Mitigation Plans
- WUI Codes
- Fire Codes

Goal

Image Credit: Wildfire Planning International

Goal

Reality

FIRE CODE
Maintenance Agreements
Hazard Mitigation Plan
USE-SPECIFIC STANDARDS
Site Design Standards
Open Space Plan
Community Wildfire Protection Plan
Conservation Easement
Land Acquisition
Comprehensive Plan
SUBDIVISION REGULATIONS
Wildland-Urban Interface Regulations
Site-Specific Assessment
Building Code
Future Land Use Map
Nuisance Ordinance
Wildfire Overlay Zone District
Landscaping Requirements
Post-Disaster Building Moratorium
Development Fees

Land Use Planning | Hazard Assessments | Capacity Building | Research & Science




Stakeholder Engagement & Collaboration

Image Credits: Wildfire Planning International

Future Research Needs

Intermix

Interface

Image Credit: National Interagency Fire Center (left), Wildfire Planning International

Resources

- Community Planning Assistance for Wildfire (planningforwildfire.org)
- APA Hazards Planning Center
- NFPA / ICC WUI Codes and Standards
- Ecological Restoration Institute CWPP Assessment
- CA Governor's Office of Planning and Research Fire Hazard Planning General Plan Technical Advice Series (update)

www.planning.org/publications/report/9174069/

Contact Information

Molly Mowery, AICP
molly@wildfireplanning.com
303-358-9589

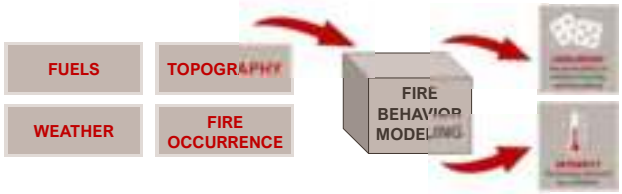
Challenges of modeling and mapping hazard and risk at the boundary of wildlands and communities

Greg Dillon and Eva Karau
USDA Forest Service, Rocky Mountain Research Station, Fire Modeling Institute
Missoula, Montana, USA

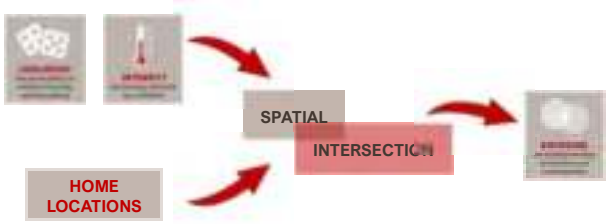
Preparing for Disaster: Advancing WUI Resilience
Fire Protection Research Foundation Workshop
San Francisco, California
March 3, 2020

UNDERSTANDING RISK

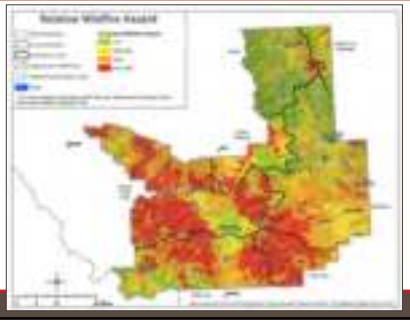
MAPPING HAZARD ACROSS A LANDSCAPE



MAPPING EXPOSURE TO HOMES



WHEN HOMES AND HAZARD DON'T INTERSECT



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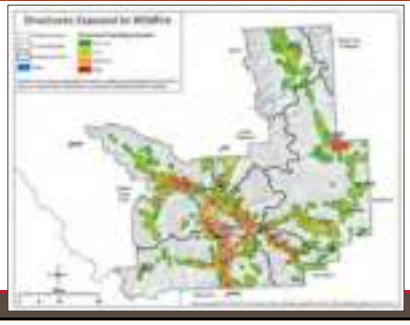

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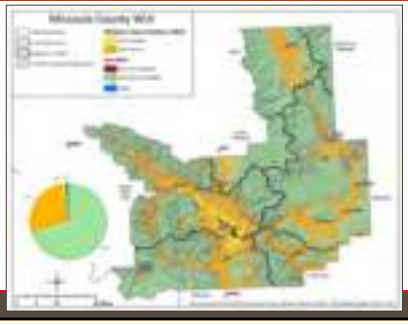
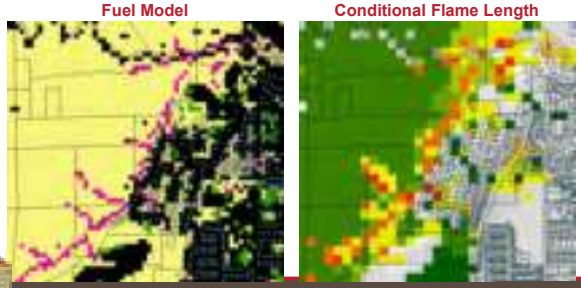


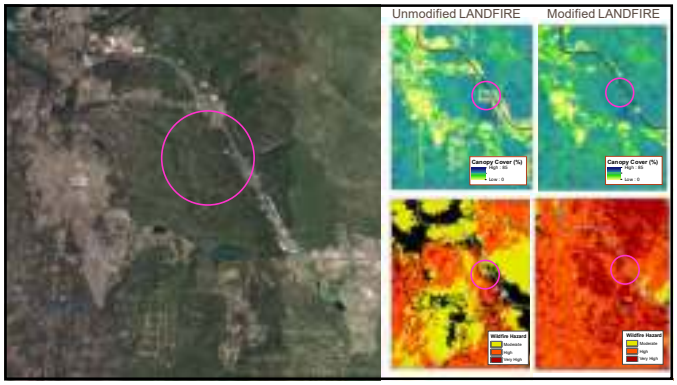
WHEN HOMES AND HAZARD DON'T INTERSECT

Fine-scale assessments: modify fuels

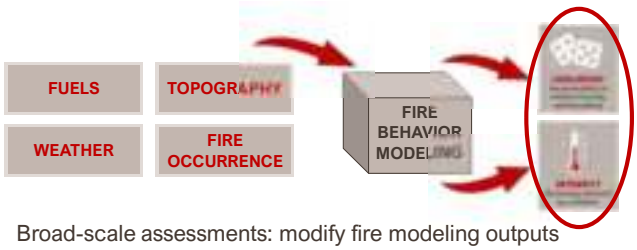
FINE-SCALE SOLUTIONS: MODIFY FUELS

FINE-SCALE SOLUTIONS: MODIFY FUELS





WHEN HOMES AND HAZARD DON'T INTERSECT



Broad-scale assessments: modify fire modeling outputs

WILDFIRE RISK TO COMMUNITIES

- Washington Office Fire & Aviation
- Rocky Mountain Research Station

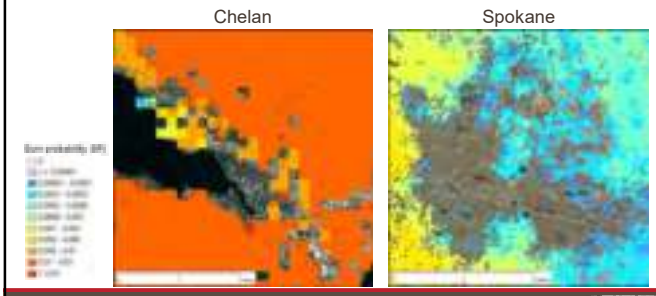
PYROLOGIX

HEADWATERS ECONOMICS

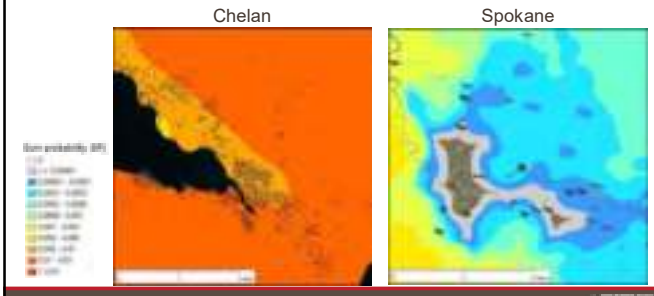
A website with interactive data and maps to help communities understand, explore, and reduce wildfire risk.

- Directed by Congress in 2018 Consolidated Appropriations Act
- Nationwide maps & data with consistent methods.
- Searchable by community, county, state.
- Products ready by April 2020 at www.wildfirerisk.org

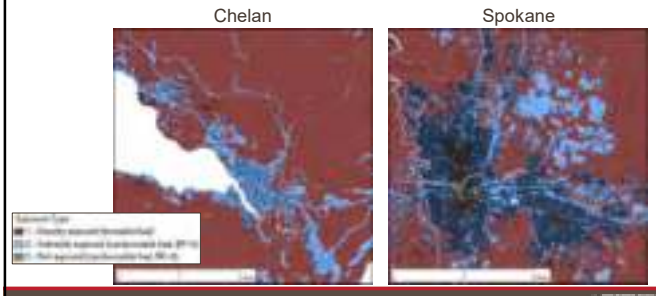
BROAD-SCALE SOLUTIONS: MODIFY MODEL OUTPUTS



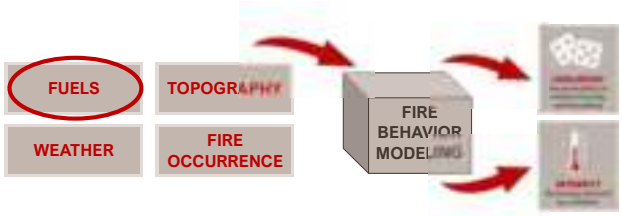
BROAD-SCALE SOLUTIONS: MODIFY MODEL OUTPUTS



BROAD-SCALE SOLUTIONS: MODIFY MODEL OUTPUTS



WHEN HOMES AND HAZARD DON'T INTERSECT



Can we develop fuel models for the built environment?

Questions?

Greg Dillon
USDA Forest Service, RMRS, Fire Modeling Institute
Missoula, Montana, USA
greg.dillon@usda.gov | (406) 829-6783

USDA

WILDFIRE RISK TO COMMUNITIES

wildfirerisk.org

Automated Real-Time Fire Spread and Risk Forecasting

Preparing for Disaster:
Advancing WUI Resilience

March 3, 2020
San Francisco, CA

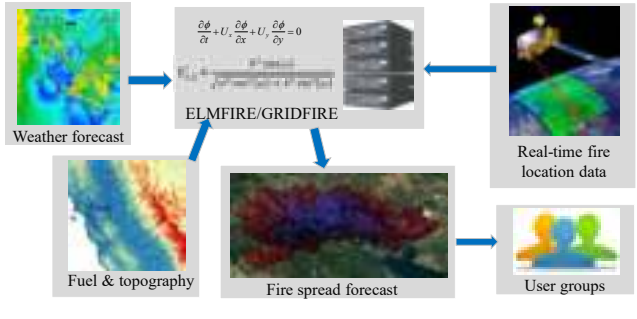
Chris Lautenberger, PhD, PE
Reax Engineering Inc.

CEC EPIC Grant: Next Generation Open Source Wildfire Models for Grid Resiliency

Part 1:

Automated Real-Time Fire Spread Forecasting

Automated Real Time Fire Forecasting



Ensemble Fire Forecasts

- Animation to the right is a series of 24-hour fire spread forecasts condensed to 2 seconds
- Multiple simulations are run with model inputs perturbed from baseline values
- Forecasts are aggregated to calculate burn probabilities
- Tested on over 300 fires during 2019 "fire season"

Part 2:

Automated Real-Time Fire Risk Forecasting

NFDRS Adjective Class during Camp Fire

Fire Risk Forecasting

- Millions of ignitions distributed across landscape at various times in the future
  - Fire spread is modeled under forecasted weather conditions
  - Impacts to assets at risk (structures, sensitive habitat, electrical infrastructure etc.) are quantified

"Prediction is very difficult, especially if it's about the future."

-Niels Bohr, Nobel Laureate in Physics

Downscaled Weather Modeling to Inform Hazard and Exposure to People And Property in California

Dave Sapsis

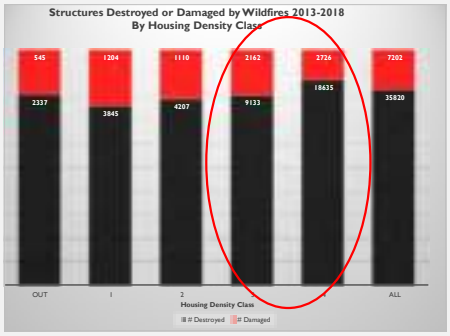
Preparing for Disaster: Advancing WUI Resilience

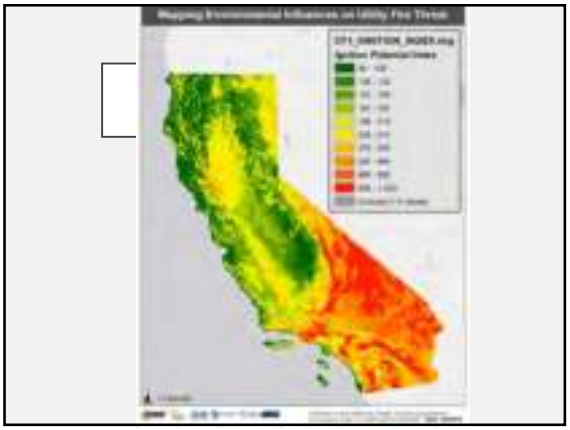
March 3, 2020 San Francisco

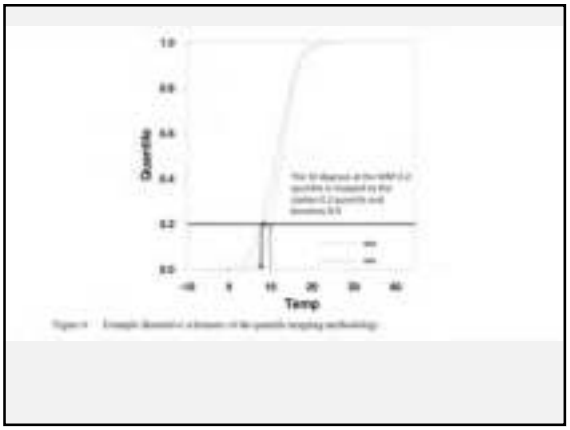
MAIN POINTS

- Hazard is not Uniform in Space
- Describing Land types for Hazard need to focus on specific elements that produce the hazard
- Modern Wildfire Risk (losses) have been dominated by fires burning in high density, urbanized areas
- These fires occur only under specific environmental conditions
- All historical urban conflagrations have occurred under severe, dry-wind conditions
- We are working to build maps that use climate distributions describing these conditions as foundational to urban wildfire hazard

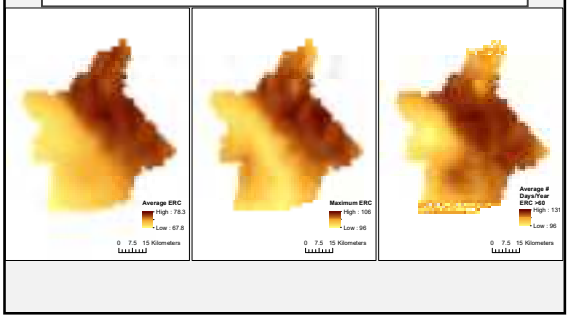
71% in high density land-use







BUTTE COUNTY 2003-2016 DAYS WITH ERC ≥60



MODELING HAZARD IN URBAN LANDS

- **Apply Spatial rules for distance buffering as a function of:**
  - **Wind directions, durations, speeds**
  - **Slope along dominant wind directions**
  - **Urban vegetation density**
  - **Calibrate to known events**

HISTORY

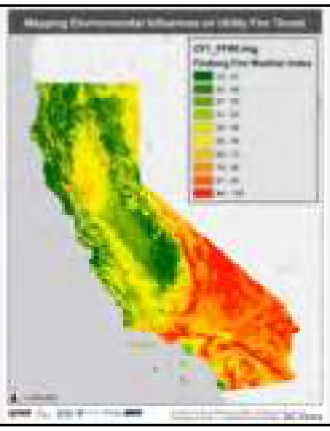
- CAL FIRE recruited to assist CPUC in applying new fire safety regulations to Utilities
- 2007 Notable fires in SoCal (Witch-Guajito/Malibu) -- > $billions in losses
- Initiated CPUC General Order Rulemaking
  - Revised/improved fire safety regulations
- Persistent Problem of Scoping – Where to apply
- Interim maps based on CAL FIRE FRAP Fire threat – not adequate

HISTORY (CONT.)

- 2013 Workshop Report and Decision
- Two Phase Mapping
- Map 1 – Agnostic map of Utility Specific Hazard
- Independent Expert Team (consultants)
- Final Report for Map 1
- WRF detailed temporal and spatial hourly weather data
- Utilized to determine severe fire weather days (FFWI threashold)

MAP 1 MODEL ARCHITECTURE: SEVERE FIRE WEATHER

- Develop gridded fire weather climatology using Weather Research and Forecasting (WRF) model
- Final output resolution at 2km grid (4 sq. km)
- Use surface outputs of wind, temperature, humidity
- Extract "Threshold" based on CDF of Fosberg Fire Weather Index
- FFWI combines wind, RH% and temperature into a single measure of fire weather potential
- Remove all records where Temp<50F
- Select top 2% of hourly records
- 73 records per WRF cell

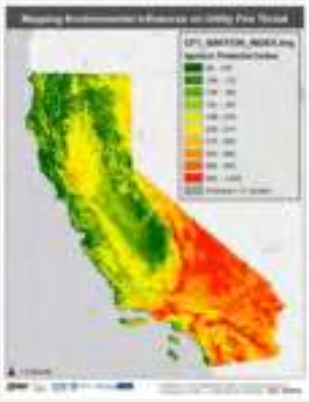


MAP 1 MODEL ARCHITECTURE: UTILITY THREAT INDEX

- UTI = probability x outcome
- Ignition Potential Index ~ "causal probability"
- Fire Spread Index ~ "outcome"
- So, final result is a product of two sub-indices

MAP 1 MODEL ARCHITECTURE: IGNITION POTENTIAL

- Ignition Potential Index
- Model: Wind^2 x Ignition Probability (Schroeder 1969)
- Average for all 73 records



MAP 1 MODEL ARCHITECTURE: FIRE SPREAD POTENTIAL

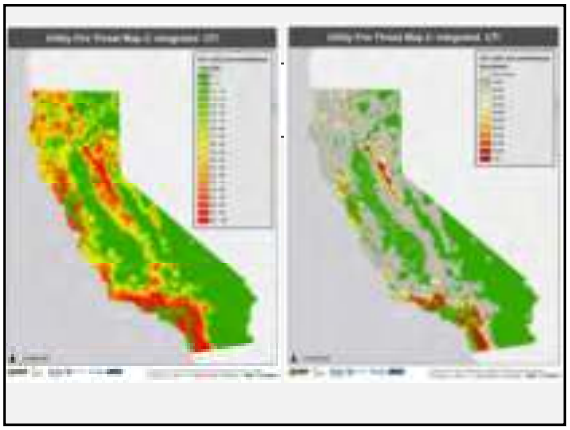
- Monte Carlo simulations: 1000 random ignitions across each cell
- Fuels from modified LANDFIRE 1.30
- Weather/fuel moistures* from random draws from severe weather stack
- Fire Spread using GridFire (1 hour)
- Model = fire volume (ave. Flame Length x area)
- Average for all fires in each cell

MAP 2: BASED ON A NEW DECISION (2015): FIRE HAZARD → FIRE RISK

- Use starting point from Map 1 (Shape B)
- Define two tiers (elevated and extreme)
- Parties define tier areas with local knowledge
- Map review/final map resolution vested in Independent Review Team (IRT)

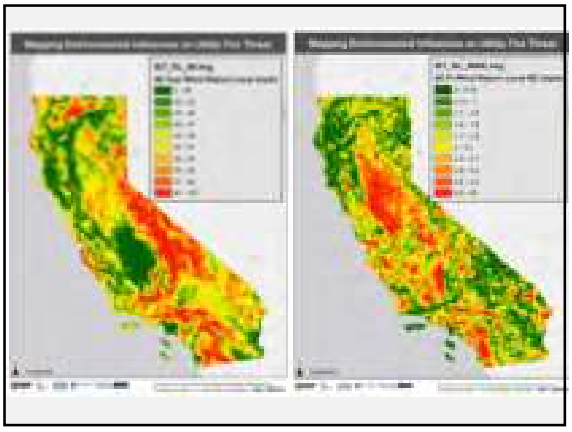
MAP 2: IRT RISK MODEL: INTEGRATED UTILITY THREAT INDEX

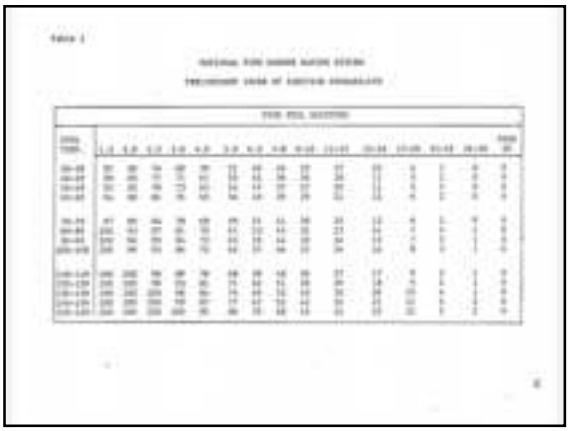
- Model: Ignition Index x Spread Index x Fsim Large Fire event set (J. Scott) x housing density (FRAP 2016 WUI model)
- Largely built to develop guidance in determining Tier 3 areas
- Comprehensive
  - Conditional probability of ignition
  - 1 hour spread volumes proxy for IA escape
  - Large Fire events drive losses
  - Overlay with key human assets (no assumption about vulnerability)



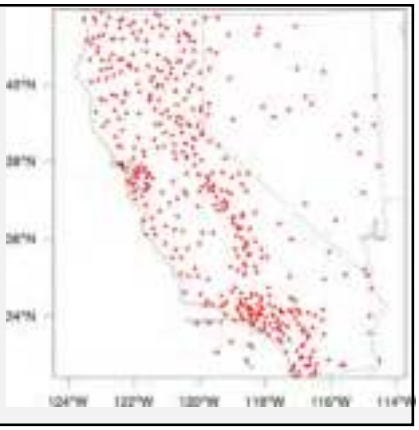
WHERE ARE WE GOING WITH FIRE HAZARD MAPPING?

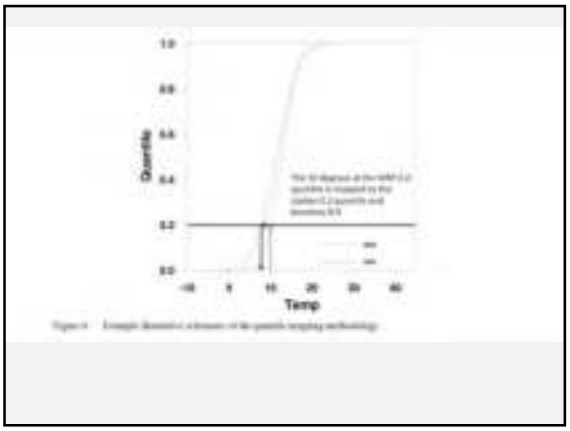
- State Fire Hazard Severity Zoning
- Missing spatial climatology
- Improved downscaled climatology
  - Moisture filtering for fire potential
  - NFDRS outputs
  - Extreme fire wind events (frequency and footprints)
- Wind loading for pole loading
- Extreme fire potential – urban conflagration

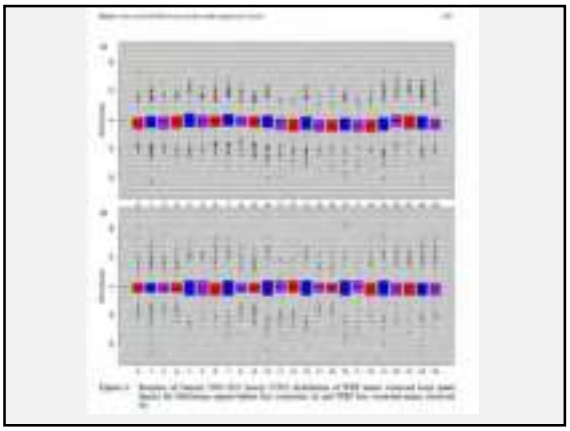


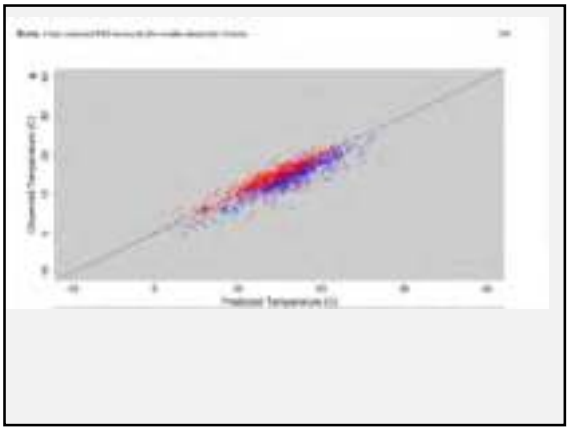


Station Locations
For Observed data/bias correction









California Forest Observatory

Dynamically mapping
forest structure & wildfire hazards
with deep learning

David Marvin & Christopher Anderson
salo.ai/observatory

partners

funders

The California Forest Observatory

Goal:

Regularly updated, high resolution
maps of vegetation fuel loads
to quantify wildfire behavior and exposure statewide

Advisors

Science

Land Management/Policy

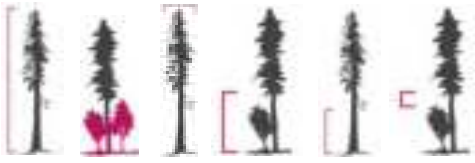
The California Forest Observatory

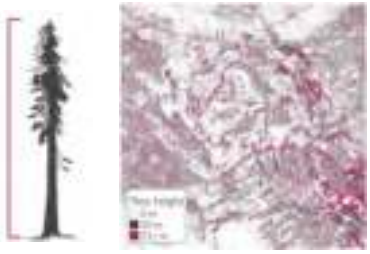
Technology & Methodology

Airborne lidar	+	Satellite imagery	+	Deep learning	⟶	Forest monitoring
Laser sensor <1 m resolution 3D maps of veg. structure One-time collection		*Multispectral & radar* 3-10 m resolution Statewide coverage Updated daily/weekly		*Pattern recognition algorithms* Used to link airborne lidar to satellite imagery and scale statewide		*Satellite-based fuel maps* Regularly updated predictions of canopy and surface fuels

The California Forest Observatory

Current fuel metrics and data products





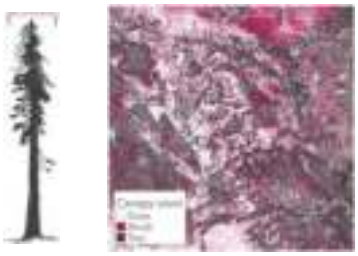
Tree height

The distance between the ground and the top of canopy

Maps available biomass, foliage for fire spread

Units: meters

California Forest Observatory metrics



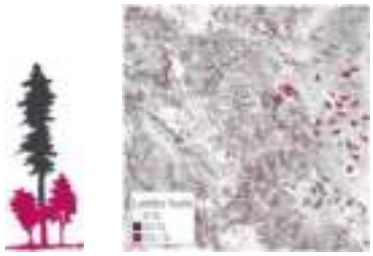
Canopy cover

The horizontal cover fraction of vegetation types

Maps vegetation community type, fire regime, and species habitat

Units: percent

California Forest Observatory metrics



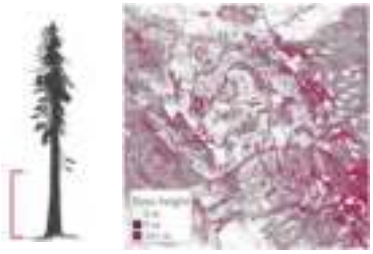
Ladder fuel density

The proportion of vegetation in the canopy understory

Maps where surface fires can transition to canopy fires

Units: percent

California Forest Observatory metrics



Canopy base height

The distance between the ground and the lowest branches in the canopy

Predicts how a surface fire may transition to a crown fire

Units: meters

California Forest Observatory metrics

Flame gap

The distance between ladder and crown fuels

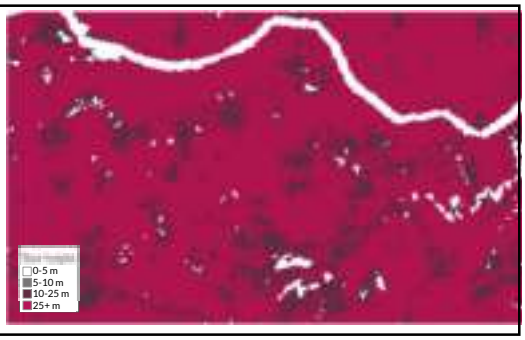
Distinguishes canopy fuel base from surface fuel base

Units: meters

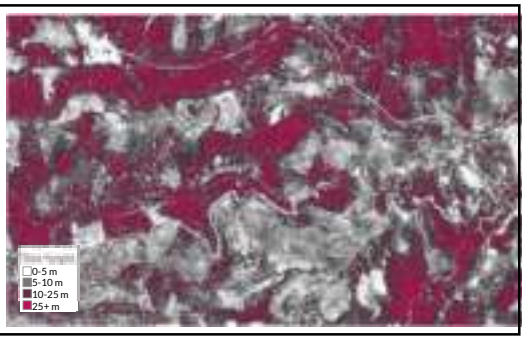
California Forest Observatory metrics

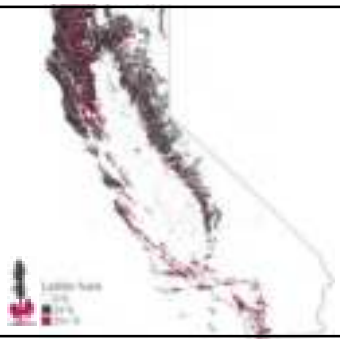
High-resolution, regularly updated

High-resolution, regularly updated



High-resolution, regularly updated





California Forest Observatory™

Early Adopter Program: Data Access

salo.ai/**observatory/early-adopter**

The California Forest Observatory

Future data and use-cases

Tree mortality

Tree species

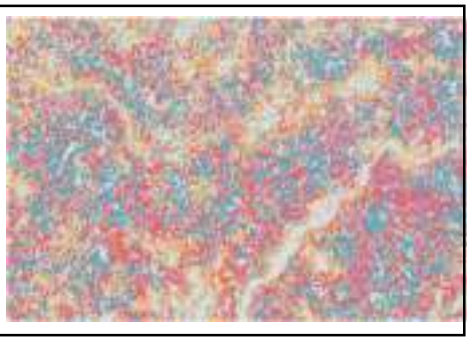
Wildfire hazard & exposure

Tree mortality mapping

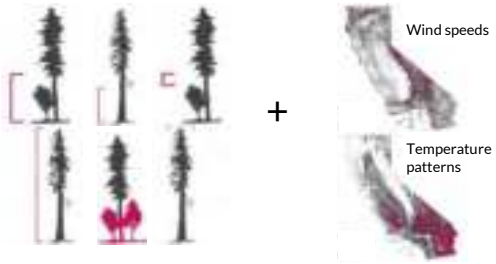
Tree mortality mapping

Tree species mapping

Tree species mapping



Wildfire hazard & exposure mapping



The power of community engagement

NFPA's Firewise USA® Recognition Program

March 4, 2020 Michele Steinberg WUI Resilience Workshop

A national problem with local solutions

The 98% problem

- Most of the homes at risk in the US are already built
- Codes and regulation have little impact
- How can we get people to act?

American beliefs and attitudes

Cedar Fire - 2003, San Diego, California

- Wildfire is the enemy
- It is the firefighter's job to rescue me
- Nobody can tell me what to do with my property…but government should aid me after a disaster
- I am helpless in the face of wildfire
- There is nothing I can do to reduce my risk

What can we do?

Overlapping Home Ignition Zones

- We can't control the wind, but…
- We can control the combustibles
- Everything on the house and right around the house

"It's not rocket science. It's much more complicated. It's social science."

- Dr. Jack Cohen, USFS Missoula Fire Lab, on preventing home destruction during wildfires

Village of Ruidoso, NM - Kokopelli Fire, 2002

Our vision – Firewise can save homes

Wildland fires can occur in areas of residential development **without** the occurrence of disastrous loss

Changing the results

Interrupting the fire's path

Small changes can have big results

If homes don't ignite, they don't burn

FIREWISE USA

RESIDENTS REDUCING WILDFIRE RISKS

- Individual responsibility
- Encourages neighbors to work together
- Voluntary participation
- A means to decrease risk for residents and first responders

Participation

- Active in 42 states
- More than 1,600 participating sites
- Increased growth in areas recently affected by wildfire

Benefits – Why Participate?

- Framework for action
- Learn about wildfire
- Get peace of mind
- Community-building
- Build citizen pride
- Access to resources
- USAA Insurance discounts (some states)

Members of Cascadel Woods Fire Brigade at April 15 work day - Carol Eggink

Steps to Achieving National Recognition

- Organize It!
- Plan It!
- Do It!
- Tell us about it!

Impact and influence

- Success stories and "saves"
- Sustained activity and growth
- Recognition of risk reduction by insurers

https://www.nfpa.org/Public-Education/By-topic/Wildfire/Firewise-USA/Firewise-USA-success

What the people say: Durango residents whose home survived the 416 Fire

"We helped the firefighters save our neighborhood and that was a big compliment to us to hear the fire professionals say, 'You did a great job here!'"

What the people say: Robert Boone, Maine resident leader

"Everybody has to be a part of it. If you have one cottage that poses a danger, it poses a danger to all the cottages. So there is a good understanding that Firewise is an island-wide effort to reduce fire danger."

What the people say: Durango Chief Hal Doughty

During the 416 wildfire: "Falls Creek is an area that we can stop this fire and the reason is that it is well mitigated and **it's a Firewise community**. We have the ability to slow this thing down and stop it at Falls Creek. This is where we turned it westward and stopped it from coming into the community, this was the pivotal neighborhood."

What the people say: Joyce Statz, Texas resident leader

"I think neighbors have a feeling of helplessness… …because they see all the videos of the wildfires where there is a big wall of flame crushing communities, but we explain to them that is not how it works. **Most of the losses from wildfire are from the embers** and that's the thing that we can deal with and so they can see that **they have the power** to make their homes impervious to the embers."

Preparing for Disaster: Advancing WUI Resilience

Education and Outreach: Capacity and Reality

Jerry McAdams, CWMS
Wildfire Mitigation Specialist
Boise Fire Department
MC Fire, LLC

Audience

- Who are your receivers?
  - Policy makers
  - NGO's
  - Other agency stakeholders
  - Architects and engineers
  - Landscapers, horticulturists, arborists, etc.
  - Developers and builders
  - HOA's and Neighborhood Associations
  - Homeowners/tenants/property managers
  - Realtors
  - Firefighters (community risk reduction efforts)
  - Think outside the box – who are we missing?

Educators

- How can we expect homeowners, or anyone else, to understand the truths behind home ignitions, or any other caveat of wildfire, if we, ourselves, don't understand?
  - Messaging should be truthful and data-driven, not merely anecdotal and/or misinformed.
- We need dedicated staff, trained to competency and interested in doing the job that they have been assigned.
- Share reality!
  - Limited capacity (e.g. apparatus and resources)
  - Local hazards
  - National Cohesive Strategy (we need partners)
  - Fire science behind structure ignition
  - Fire threats and associated ignition vulnerabilities (e.g. crown fire, surface fire and embers/firebrands)

Relationships

- The key lies in building relationships!
  - Take the time to build relationships before the fire.
    - Empathize and build trust.
    - Understand disparate values propositions.
    - Work within the framework of their reality and help them to better understand the situation.
    - Ask that they partner with you and take action.
  - Understanding the "why" will help people to own their part of the problem/solution.
  - Don't try to tell them how it is, or how it's going to be.

"Nobody cares how much you know, until they know how much you care."
Theodore Roosevelt

Things to Ponder

- Is our messaging appropriate, data-driven and effective?
- Are our senders and receivers understanding one another?
- Can prevention and mitigation take place on a broad scale, with receivers understanding the issues and supporting the need for more senders, or become senders themselves?
- Do we have adequate numbers of competent senders?
- Are we providing consistent messaging?
- Is our messaging cost-effective and effective overall?
  - What are our metrics?
- Is there a lack of action, and if so, why?
  - Again, how do we quantify this?
- Are we trying to address time and monetary constraints for homeowners, or providing other incentives?

Recommendations

- Increase capacity for education and outreach among all stakeholder groups with dedicated and competent staff.
- Tailor messaging to specific audiences. A broad silver bullet message does not really exist.
- Facilitate and help build relationships among various stakeholders.
- Provide Cohesive Strategy education in our institutions of higher education and among professional organizations
- Provide local education and certifications for stakeholder professionals (e.g. landscapers)
- Build local coalitions or collaborative partnerships to provide consistent, and truthful, messaging.
- Again, we need dedicated positions in our organizations.
- Don't get caught up in thinking you have it all figured out, because you don't!

Thank You

Jerry McAdams, CWMS
Wildfire Mitigation Specialist

Boise Fire Department
jmcadams@cityofboise.org

MC Fire, LLC
mcfirellc@yahoo.com

Camp Fire Evacuations

Lessons Reinforced and Learned

- Community Evacuation Planning is critical for both citizens and public safety officials
- Make sure the plan in known
- Hold community evacuation drills
- Expect the fire to test your plan



Camp Fire

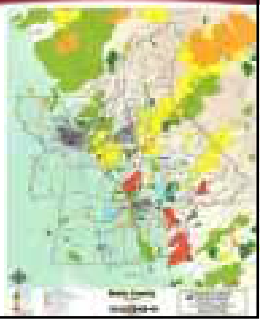
- November 8, 2018
- Most destructive fire in California history
  - 18,804 structures destroyed
  - 13,696 single family residences destroyed
  - 276 multi family residences destroyed
  - 528 commercial structures destroyed
  - 4,293 other minor structures destroyed
- Devastated the Town of Paradise and Concow in less than 12 hours
- Most deadly fire in California history
  - 85 people perished
- Burned 153,336 acres

Demographics of Paradise

- Population of Butte County: 227,621
  - Incorporated Town of Paradise: 26,682
  - Incorporated City of Chico: 92,348
  - Unincorporated area of Butte County: 81,707
- Number of housing units Paradise: 12,981
  - 708.5 houses per square mile
  - 70% owners, 30% renters
- Median income of Paradise: $48,831
  - 13.7% live at or below poverty level
- Median age in Paradise 49 (37)years old
  - 25.1% 65 or older
- More individuals with disability, regardless of age

Fire History

- Recent large fires and prolonged drought left behind an abundance of dead, down material and high ratio of dead to live vegetation in fire's path
  - 1999 – Butte Lightning Complex: Tens of thousands of acres on the east side of Highway 70
  - 2000 – Concow Fire: Killed one civilian, several firefighters, 16 homes destroyed, 1,845 acres
  - 2001 – Seventy: 1,711 acres
  - 2001 – Poe Fire: Destroyed 50 homes, 8,333 acres
  - 2008 – Humboldt Fire: Destroyed 85 homes, 5 in the Town of Paradise, 23,344 acres
  - 2008 – Butte Lightning Complex: Destroyed over 100 homes. Accounted for 59,000 acres consumed on the Complex



Extreme Fire Behavior

- Topography
  - Feather River drainage NV to Sac Valley
  - Steep, rough, inaccessible terrain
- Fuels
  - Timber, brush, litter & structures
  - 2017/18 late spring rain = grass
  - ERC above avg. October, record Nov 8
  - 1000 hr. fuels @ 5% Nov 1, avg. 17%
  - Manzanita @ 74%, critical 80%, avg. 93%
- Weather
  - 2012-2016 drought, dead component
  - 200 days of minimal rainfall
  - Strong Diablo (north) wind event began Nov 7 winds 25-30, gusts 50 from northeast

Rapid Fire Growth

06:31 – CAL FIRE dispatches response for Camp Fire.

07:44 – First reports of fire on the Paradise side of the West Branch of the Feather River.

Evacuation Orders for Town of Paradise Begin

07:46 – Incident Commander (IC) issues evacuation order for Zone 3, 8, 14, everything east of Pentz Road and everything north of Highway 70.

08:01 – IC issues evacuation order for Zones 2, 7, 13, the Morgan Ridge Zone, and everything west of that is issued an evacuation warning.

Additional Evacuation Orders

08:49 – Camp IC issues new evacuation orders from Stieffer Road to Town limits including Zones 1, 4, 5, 6, 9, 10, 11 and 12.

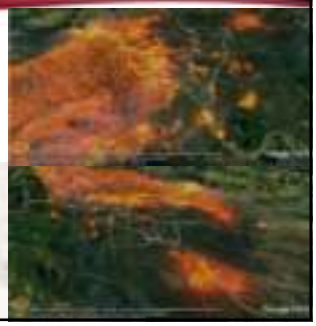
9:14 – Report well established fire in Butte Creek Canyon.

12.5 Miles from the origin

Camp Fire Progresses Through Paradise

09:42 – Pentz, Pearson, Billie, and Wagstaff all had evacuation issues. Roads were blocked and impinged by fire.

10:45 – Fire well established in about ½ of the Town of Paradise.

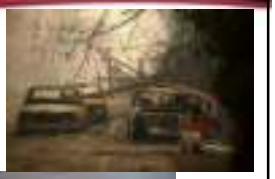


Evacuation Challenges

- The road network was taxed. Traffic jams became a big problem.
- Fire overran evacuation routes and outpaced the flow of traffic.
- Vehicles were trapped by fire on many major traffic arteries.
- Civilians stuck in traffic were exiting their vehicles and running. Abandoned vehicles blocked roadways.
- Power lines and power poles fell on roads, blocking traffic.
- Fire apparatus and bull dozers were used to push abandoned vehicles off the road.
- Two major traffic arteries were converted to one-way exit traffic.

Power Lines and Power Poles Down on Roads

09:47 – Multiple divisions reporting power lines down on roadways, blocking traffic and trapping civilians. PG&E advises power to Paradise is shut off. Firefighters start cutting downed power lines to allow people to escape.

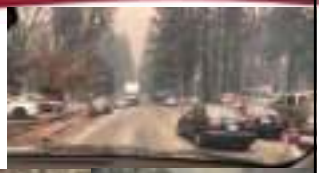


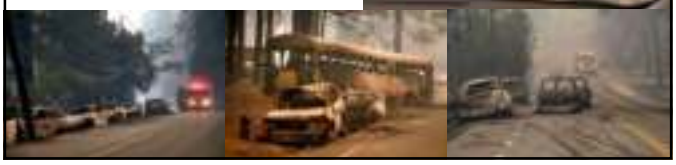
Evacuation Task Forces Created

2 Evacuation Task Forces (engine, buses and heavy equipment) were created and deployed.

Extreme Measures Used to Clear Roads

12:14 – Division H issues order for fire resources to begin pushing cars off the road. The IC ordered heavy equipment to assist in opening roads.





Temporary Refuge Areas

11:21 – 1,000 people on the road trapped by fire. Multiple Temporary Refuge Areas (TRAs) being set up. Decision made to pull people out of their vehicles and put them in the buildings and protect them with fire engine.

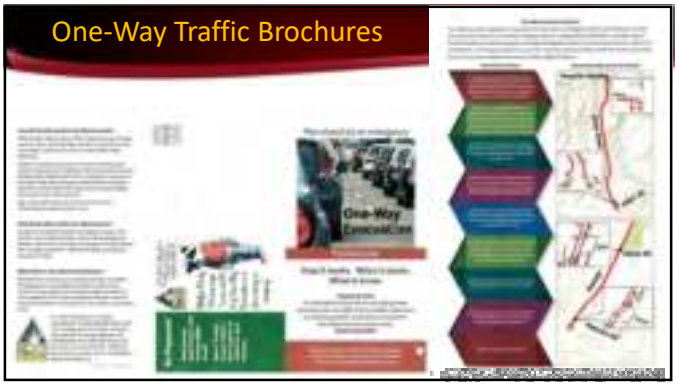
13:27 – Fireline supervisor reports 200 people trapped at Clark Road and Skyway. Trying to protect with fire engines and aircraft. Sheltered in buildings nearby.

Evacuation Preparedness before the Camp Fire

Town of Paradise & Butte County

Evacuation Maps

One-Way Traffic Brochures



One-Way Evacuation Plan

Lessons Reinforced and Learned

- Visit www.buttecounty.net/oem for Camp Fire Video Series on lessons learned
- Community Evacuation Planning is critical for both citizens and public safety officials
  - Citizen preparedness – Go Bags
  - Evacuation Plan, maps w/zones (name vs #)
  - One-way traffic Plan
  - Public Assembly Points & Community Refuge Areas (TRAs)
  - Evacuation centers & regional traffic management
  - Evacuation messaging, no notice events
  - Annual review by government officials and NGOs, included large stakeholders, schools, hospitals
    - Include neighboring jurisdictions in the planning process
- Community Evacuation Drills
  - Large number of at risk/vulnerable citizens: multi family care and retirement communities

Lessons Reinforced and Learned

- Limited ingress and egress
  - Ingress for first responders was challenged
  - Phased approach to evacuation
  - Pace of evacuations dictated by the fire
  - Many routes were quickly overrun by fire very early
  - Civilians stuck in traffic, abandoned vehicles
- Utility and communications infrastructure hardening
  - Cellular network and evacuation notifications
  - Power lines down across roads
- Community evacuation route fuel reduction
- Identify critical infrastructure
  - Harden or implement protection systems

Questions? Thank You!!

Steven Hawks
Staff Chief
Wildfire Planning & Engineering
steven.hawks@fire.ca.gov

ReadyForWildfire.org

Evacuation Planning for Dire Scenarios

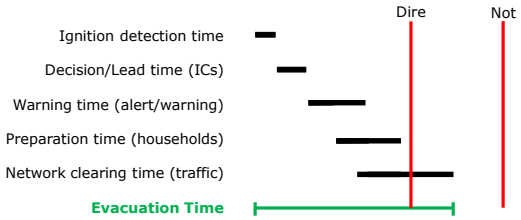
Tom Cova
Center for Natural & Technological Hazards (C^nth)
Department of Geography
University of Utah, Salt Lake City

Preparing for Disaster: Advancing WUI Resilience
San Francisco, March 4, 2020

Dire-scenario formation

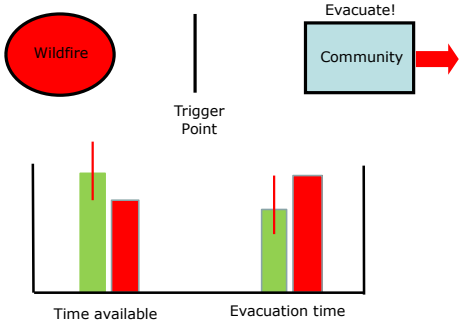
duration + *design* + *decision* ➡ *direness*
(time to act) (community) (officials/public)

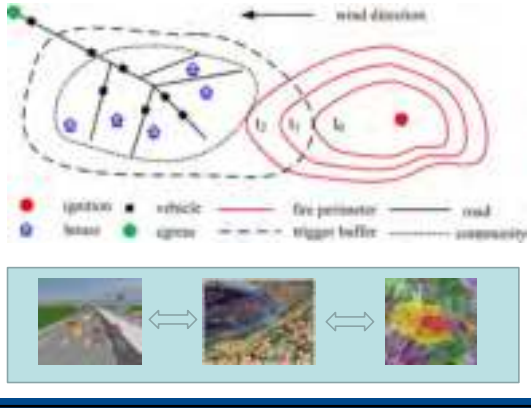
Evacuation planning phases



Can the fire reach the community in less time than it would take to evacuate it?

Dire scenario: dynamic & uncertain





2000 homes

Fire Shelter

Barona Casino
2003 Cedar Fire

Westmont College Gym
2008 Tea Fire

The Future

11

Dire Scenario Planning

1. Work to reduce dire-scenario likelihood: officials/public and community/households.

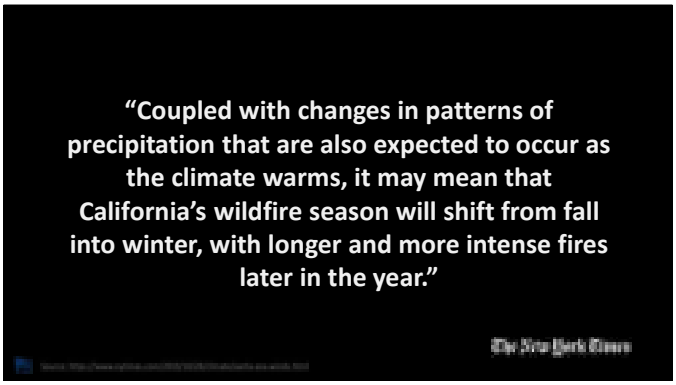
2. Develop back-up plans if they happen anyway (e.g. fire shelter).

…. in the WUI.

cova@geog.utah.edu


IBHS RESEARCH
RoysterWright
DisasterSafety
BUILDING THE FUTURE OF RESILIENCE
Roy Wright | President and CEO
Insurance Institute for Business & Home Safety


IMPERATIVES
LEAD WITH THE ROOF
SOLVE WITH RESEARCH
PREVENT AVOIDABLE DAMAGE

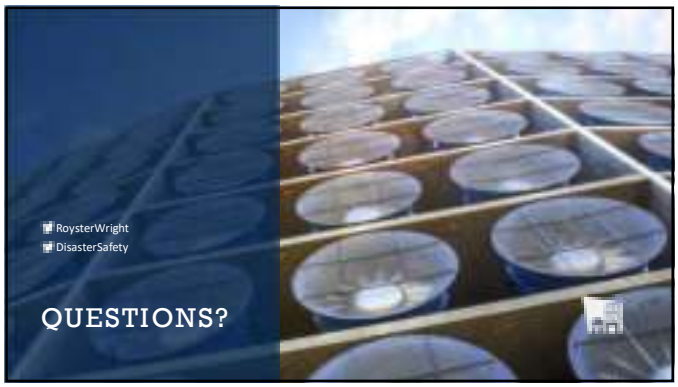

"Coupled with changes in patterns of precipitation that are also expected to occur as the climate warms, it may mean that California's wildfire season will shift from fall into winter, with longer and more intense fires later in the year."
The New York Times


:00


Wildfire-Resistance: Make the "RIGHT" Choices

IGNITION POTENTIAL: PRELIMINARY FINDINGS

Based on radiant heat from free-burning structures in no-wind conditions



APPENDIX D: BREAKOUT GROUP PRESENTATIONS

1. The State of Things: The problem, its history and projections for the future

•••

Group 1 - Breakout Session 1
Preparing for Disaster: Advancing WUI Resilience
11:10 - 12:00, Tuesday, March 3, 2020

ARUP Berkeley REAX

1

Group 1

Group discussion (50 minutes)

1. Introduce yourselves - quickly :)
2. Outline current challenges and barriers to (positive) change. Look for agreement on the definition of the problem and what success (resilience) looks like.
3. Form statements like "in a perfect world, it would look like this," or, "with the right solutions, in 20 years this would be the change we would see."

Report back on *key issues* (5 minutes)

2

2

Group 1

Discussion notes

- Desirable locations will continue to be desirable; framework, in the 'perfect world' where communities can self-select where to live, they will have the needed information, they will know when to go
- Central issue, in our society, push and pull between personal freedom vs. institutional structure, governance structures to keep us safe.
- Can we leverage the right technologies to inform the public
- Building codes exist, but have difficulties with existing infrastructure.
- Too much of a black and white thing, but there is a lot of gray area in what we do now, so there is compromising that can happen.
- Perception challenge, the thought that we can just 'put it out'. Widespread public perception problem, the thought that we just have to put it out
- Greatest challenge...prediction of fire risk, managing your own risk, the actions that people take where they live only pertains with their own home, that has to go hand in hand with protecting the wildland. Educating people, fuel management,
- Making sure people know that there are models, fire danger rating system
- Keeping the long term solutions takes cooperation
- Education piece requires more information about the role of fire
- Range of people who are considered educators because you get listened to
  - People are listened to because of the hat their wear-- there needs to be education
- Three phases. 1) pre-fire (mitigation) 2) real time 3) pos-fire (recovery)
- From a technologist's perspective, in 20 years and in terms of fire shielding and fire shaping: Use natural properties of wind to shield a WUI area. creating some technologic shields or to detect ignition. sensing the problem early
- Keywords: Perceptions, educating the public, educating the educator, ignition sensing, research needs, fuel treatments

3

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Group 1

Key issues

- **In a perfect world we want an educated, informed, receptive, resilient population (of households, officials, stakeholders) that receive information from trusted sources which allows them to act and know whom to work with and be the influence towards the change process.**

4

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1. The State of Things: The problem, its history and projections for the future

•••

Group 2 - Breakout Session 1
Preparing for Disaster: Advancing WUI Resilience
11:10 - 12:00, Tuesday, March 3, 2020

ARUP Berkeley REAX

5

Group 2

Group discussion (50 minutes)

1. Introduce yourselves - quickly :)
2. Outline current challenges and barriers to (positive) change. Look for agreement on the definition of the problem and what success (resilience) looks like.
3. Form statements like "in a perfect world, it would look like this," or, "with the right solutions, in 20 years this would be the change we would see."

Report back on *key issues* (5 minutes)

6

6

Group 2

Discussion notes

Current challenges

- Historical conflicts
- Regulation conflicts
- Economical challenges
- Risk communication: wildfire index/scale
- Communication between scientist, policy maker and community
- Guidance: standardized policy vs. local community (landscape, human)
- Financial challenge

7

7

Group 2

Key issues

In a perfect world:

- With regular fire but without fire disaster
- Fire will be treated as Natural Hazard, with infrastructures and programs to tackle wildfire problems
- Improve technical solutions
- Addressing legacy structures while redirecting new future development for low risk areas (e.g. existing urban)

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1. The State of Things: The problem, its history and projections for the future

•••

Group 3 - Breakout Session 1
Preparing for Disaster: Advancing WUI Resilience
11:10 - 12:00, Tuesday, March 3, 2020

ARUP Berkeley REAX

9

Group 3

Group discussion (50 minutes)

1. Introduce yourselves - quickly :)
2. Outline current challenges and barriers to (positive) change. Look for agreement on the definition of the problem and what success (resilience) looks like.
3. Form statements like "in a perfect world, it would look like this," or, "with the right solutions, in 20 years this would be the change we would see."

Report back on *key issues* (5 minutes)

10

10

Group 3

Discussion notes

- (Brainstorming space. Add additional notes slides as needed.)
- (For group reporting, you may highlight key points from these notes slides, or consolidate main points on "Key issues" slide - up to you!)

11

11

Group 3

Key issues

- Whether we really understand fire risk? (only depends on risk map?)
- Public need to have perception of risk or need to know how to minimize risk?
- People don't trust government.
- How to make community discuss together about "wood pile problem "?
- How to understand and take the current situation into hazard analysis? - historical hazard based on previous data but now things change
- What mitigation matters? - matters for both insurance side and public side.

12

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Group 3

Key issues

- Wildland fires are not easy to map
- Building codes needed for new structure - risk not from the building itself, also from neighborhood - Where structures should be built? - building construction now lacks fire risk research
- Cannot do protection without people getting out
- How to define resilience? - 0 fatality?
- Sprinkle, water - no standard for design for how much water should be on site, how to keep the pressure - also, expensive

13

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Group 3

Key issues

- Sprinklers was designed for small fire - not for mega-fire - technological problem - need participation of technical people
- Policies, policies maker - should understand what they are doing - now lack contact with academia

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1. The State of Things: The problem, its history and projections for the future

•••

Group 4 - Breakout Session 1
Preparing for Disaster: Advancing WUI Resilience
11:10 - 12:00, Tuesday, March 3, 2020

ARUP Berkeley REAX

15

15

Group 4

Group discussion (50 minutes)

1. Introduce yourselves - quickly :)
2. Outline current challenges and barriers to (positive) change. Look for agreement on the definition of the problem and what success (resilience) looks like.
3. Form statements like "in a perfect world, it would look like this," or, "with the right solutions, in 20 years this would be the change we would see."

Report back on *key issues* (5 minutes)

16

16

Group 4

Discussion notes

- What makes people behave the way they do? How to get people to behave in particular ways beforehand? Social factor is the biggest challenge
  - Coffey Park not required for VHFSHZ codes because not in VHFHSZ
  - Plus economic costs involved in construction and rebuilding
  - How to get people to understand that they need to have policies in place, neighborhood is at risk
  - Can be hard to produce good maps and data for wildland models; lack of tools
  - Need to figure out ways to make the technology be used by people (emergency managers, public datasets, anyone can access and view for fuels data, weather data, historical data, etc.)
  - Need to have practitioners involved in the process. (e.g. NSF application)

17

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Group 4

Discussion continued

- Not enough funding for wildfire research in general; need to stabilize the funding after the big fires and even after small fires
- Only interested in the fires that affect our own state/area, even though happening around the world
- Policymakers need to be concerned and thinking about fire early in their careers - before they get to the state legislature/federal
- Resilience needs to have added benefit day-to-day; there's a perspective that "this doesn't happen to me"
  - Educating children in the school
  - Simulators for what a wildfire would look like (fear, hope, demonstrating the reality of a wildfire)

18

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Group 4

Discussion continued

- Challenge of deference to personal property
- If you choose to build somewhere hazardous, who is going to be responsible for that risk?
- How to create/avoid economic incentives for building in fire-prone areas?
- How can this be applied outside of California?
- Need to engage at the federal AND state level

19

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Group 4

Successes

- Community awareness and engagement into problem
- Problem will never go away
- Maintain media focus on wildfire
  - Not really done for wildfire the way for floods

20

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Group 4

Key issues

- Challenges:
  - Need integration of social science and political issues
  - Tools that are being developed are not developed for the public/emergency managers
  - Need to understand what makes people do what they do to prepare or not
  - Need consistent funding available from the federal and state governments
- Success looks like: Community awareness
  - Get local electives when they are early in their career
  - Educate children!
  - Media focus on wildfires
  - Bottom-up engagement from individuals to community to region to state, etc.
  - But also need top-down enforcement and maybe financial incentives on individual homeowner + neighborhood to act

21

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1. The State of Things: The problem, its history and projections for the future

•••

Group 5 - Breakout Session 1
Preparing for Disaster: Advancing WUI Resilience
11:10 - 12:00, Tuesday, March 3, 2020

ARUP Berkeley REAX

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Group 5

Group discussion (50 minutes)

1. Introduce yourselves - quickly :)
2. Outline current challenges and barriers to (positive) change. Look for agreement on the definition of the problem and what success (resilience) looks like.
3. Form statements like "in a perfect world, it would look like this," or, "with the right solutions, in 20 years this would be the change we would see."

Report back on *key issues* (5 minutes)

23

23

Group 5

Challenges & Barriers

1. Outline current challenges and barriers to (positive) change. Look for agreement on the definition of the problem and what success (resilience) looks like.
   - Overwhelmed public
   - Siloing of government - lack of understanding of the real issues
   - Planning & development - overwhelming priorities/interests
   - Accurately quantifying risk & translation to stakeholders
   - Get folks to see the role that they play - wildfire is everyone's fight!
   - Lack of capacity and dedicated specialists
   - Economic disparity
   - Higher education and training for stakeholder groups

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24


Group 5
In a Perfect World
2. Form statements like "in a perfect world, it would look like this," or, "with the right solutions, in 20 years this would be the change we would see."
Understanding of natural world and the role of fire
Owning their part of the problem/solution
Land stewardship vs. management
Risk & natural solutions values built into decision and policy making
No more fatalities (e.g. civilian/firefighters) from wildfire
Fire service emphasis on pre-fire community risk reduction & public engagement
Monetary shift - smarter investment (suppression vs. mitigation)
Systems thinking
Dedicated mitigation & outreach staff among stakeholder groups
25

25

2. Land Use and Wildfire Planning Tools for the WUI

Group 1 - Breakout Session 2
Preparing for Disaster: Advancing WUI Resilience
1:45 - 2:30 PM, Tuesday, March 3, 2020

1

Group 1

Group discussion (45 minutes)

1. How can we maximize the application of land use and wildfire planning tools to address the WUI?
2. What barriers exist to developing and implementing these tools?
3. What are key actions in the short, near, and long-term that may improve the effectiveness of these tools?

Report back on *key issues* (5 minutes)

2

2

Group 1

Discussion notes

On maximizing the application of planning tools

- Specialized fire planning personnel/representatives in public agencies
- Getting tools to the hands of people living in unincorporated areas

On key actions to improve effectiveness of tools

- Implementing economic and other non-fire behavior information to fire risk modeling
- Currently for a long term solution, we don't forecast fire as well as we can, ideally we would have these models better predict fire behavior
- There is usefulness in doing modeling at various scales

3

3

Group 1

Discussion notes (cont.)

On Barriers to developing and implementing tools

- To maximize CWPP integrate as many stakeholders as possible
- On CWPP, to maximize get as many stakeholders as possible
- Barriers would be getting the best available data. Messaging is also a barrier

4

4

Group 1

Key issues

- Wildfire Preparedness Coordinator Position

5

5

2. Land Use and Wildfire Planning Tools for the WUI

Group 2 - Breakout Session 2
Preparing for Disaster: Advancing WUI Resilience
1:45 - 2:30 PM, Tuesday, March 3, 2020

6

Group 2

Group discussion (45 minutes)

1. How can we optimize the application of land use and wildfire planning tools to address the WUI?
2. What barriers exist to developing and implementing these tools?
3. What are key actions in the short, mid, and long-term that may improve the effectiveness of these tools?

Report back on *key issues*. (5 minutes)

7

7

Group 2

Discussion notes

1. Optimize the application of land use and wildfire planning tools to address the WUI
- Legitimation
- Use dataset to simulate the actual scenarios
- Simplification
- The input/output of the tool needs to be consumer based (community, planner, insurance company, etc)
- Quantify the hazard, exposure, expense of the wildfire model

8

8

Group 2

Key issues

2. What barriers exist to developing and implementing these tools?

- Tools to produce output in units relevant to the audience
- Need a series of translators between the scientists and stakeholders
- Improving the user experience (UI/UX)
- Improving the models to have an agreement between scientists and users

9

9

Group 2

Key issues

3. What are key actions in the short, mid, and long-term that may improve the effectiveness of these tools?

- Short-mid term: improve the translation, bring specialists, improve user experience
- Long-term: targeted tools
- Overall: develop tools which have a temporal framework to improve effectiveness

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2. Land Use and Wildfire Planning Tools for the WUI

•••

Group 3 - Breakout Session 2
Preparing for Disaster: Advancing WUI Resilience
1:45 - 2:30 PM, Tuesday, March 3, 2020

ARUP Berkeley REAX

11

Group 3

Group discussion (45 minutes)

1. How can we maximize the application of land use and wildfire planning tools to address the WUI?

Lack of communication - good collaboration on planning land use; parcel level, mapping well helps evaluate parcel level, dynamic hazard map, snapshot;

2. What barriers exist to developing and implementing these tools?

How to rank risk level on hazard map, and need long-term data? Tough to tell people do not build at high-risk area; climate change affects the application, long-term; existed structures present risk; lack of mitigation to control the transport of ember; lack specific local government people focus on problem of fire risk; no change until code is made .....?; lack scientific investigation for deciding insurance rate; much more knowledge still cannot help make accurate decision; lack ability to define, quantify risks.

3. What are key actions in the short, near, and long-term that may improve the effectiveness of these tools?

Quantify what we have to show risk to folks; research-driven lab experiments;

12

12

Group 3

Discussion notes

- (Brainstorming space. Add additional notes slides as needed.)
- (For group reporting, you may highlight key points from these notes slides, or consolidate main points on "Key issues" slide - up to you!)

13

13

Group 3

Key issues

1. **Application**

Good collaboration on planning land use (now lack communication)
Mapping well helps evaluate parcel level and develop dynamic hazard map.

2. **Barriers**

How to rank risk level on hazard map, and how to acquire long-term data?
Climate change affects the application, long-term.
Lack of specific local government people focus on problem of fire risk.
Lack of ability to define and quantify risks.
Much more knowledge still cannot help make accurate decision.

3. **Key Actions**

At least, quantify what we already have to show risk to folks.

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2. Land Use and Wildfire Planning Tools for the WUI

•••

Group 4 - Breakout Session 2
Preparing for Disaster: Advancing WUI Resilience
1:45 - 2:30 PM, Tuesday, March 3, 2020

ARUP Berkeley REAX

15

15

Group 4

Group discussion (45 minutes)

1. How can we maximize the application of land use and wildfire planning tools to address the WUI?
2. What barriers exist to developing and implementing these tools?
3. What are key actions in the short, near, and long-term that may improve the effectiveness of these tools?

Report back on *key issues* (5 minutes)

16

16

Group 4

Discussion notes

- Make tools publicly available, so people can look up their house and community
  - Integrate tools into existing maps (like Zillow or Google Maps) or general estimate of insurance in the area
- Make fire hazard/risk known for buying homes everywhere; general notification for risk among disclosure laws across individual states
- Better labeling and mapping of risk and hazards and threats
- Example of Tubbs Fire - averages v extremes; goal post has changed; worst case scenario is not the worst case scenario in 10 years
- Tension between how far we can reasonably protect structures given economic realities - need to choose where to focus efforts
- Many different tools and offices working, but many only now engaging with each other - How can we integrate different silos together? (windows → energy + fire!)

17

17

Group 4

Key issues

- Tools should be publicly available and integrated into existing structures (e.g. Zillow)
- Improve disclosure laws around the country
- Improved labeling of risks/hazards throughout communities
- Worst case scenario today may not be the worst case scenario in the future
- We need to choose where to focus efforts
- Offices with different but overlapping resilience goals need to be better integrated
  - Ex: double-pane windows → energy + fire prevention!

18

18

2. Land Use and Wildfire Planning Tools for the WUI

Group 5 - Breakout Session 2
Preparing for Disaster: Advancing WUI Resilience
1:45 - 2:30 PM, Tuesday, March 3, 2020

ARUP

19

Group 5

Group discussion (45 minutes)

1. How can we maximize the application of land use and wildfire planning tools to address the WUI?
2. What barriers exist to developing and implementing these tools?
3. What are key actions in the short, near, and long-term that may improve the effectiveness of these tools?

Report back on *key issues.* (5 minutes)

20

20

Group 5

Discussion notes

- (Brainstorming space. Add additional notes slides as needed.)
- (For group reporting, you may highlight key points from these notes slides, or consolidate main points on "Key issues" slide - up to you!)

21

21

Group 5

Key Points

- Planning smarter in general
- Misperceptions of costs for (re)constructing to a higher standard
- Political backing for enforcement of smart building codes and standards
- Use of existing technology and techniques (land use planning and construction)
- Lack of capacity for code enforcement and plans review
- Communication across disciplines (e.g. Fire, Parks, Planning, Public Works, etc.)
- Merging of plans (plans referencing other plans)
- Accurate, data-driven riskmaps
- Fully-loaded land use planning cost tool
- Michael Gollner is still awesome!

22

22

3. Technology for Planning and Risk Assessment for Communities

Group 1 - Breakout Session 3
Preparing for Disaster: Advancing WUI Resilience
4:00 - 4:45 PM, Tuesday, March 3, 2020

1

Group discussion (45 minutes)

Group 1

1. What research and market gaps exist?
2. Do we know if there are already solutions or promising work being done?

Report back *key points* (5 minutes)

2

Discussion notes

Group 1

- Can we identify foundations which may fund wildfire research?
- Bridging funding sources across research institutions/agencies
- How do different jurisdictions deal with ongoing development? How to get banks/insurance/agencies to reduce wildfire risk/losses?
- Research gaps exist regarding post-fire impacts such as increased mudslides, emissions, water quality.
- Research gaps exist in understanding how different fire research themes interact and intersect across the broader 'wildfire problem'
- Technology needs and redundancy for public warning systems which depend on power, i.e. dealing with power losses.

3

3. Technology for Planning and Risk Assessment for Communities

Group 2 - Breakout Session 3
Preparing for Disaster: Advancing WUI Resilience
4:00 - 4:45 PM, Tuesday, March 3, 2020

4

Group discussion (45 minutes)

Group 2

1. What research and market gaps exist?
2. Do we know if there are already solutions or promising work being done?

Report back *key points* (5 minutes)

5

Discussion notes

Group 2

- (Brainstorming space. Add additional notes slides as needed.)
- (For group reporting, you may highlight key points from these notes slides, or consolidate main points on "Key takeaways" slide - up to you!)

6

Group 2

Key takeaways

Research and market gaps

- Material science for wildfire application (wildfire material)
- Balance between certification and incentives
- Regulation, education, training up field engineers, social science
- Uncertainties due to human factor

Existing solutions or promising work being done?

- 'Wildfire Action Plan' vs. Climate Action Plan
- Institutional responsibility for wildfires - breaking this down (public has a role to play)
- Real-time location information on wildfires

7

7

3. Technology for Planning and Risk Assessment for Communities

•••

Group 3 - Breakout Session 3
Preparing for Disaster: Advancing WUI Resilience
4:00 - 4:45 PM, Tuesday, March 3, 2020

8

Group 3

Group discussion (45 minutes)

1. What research and market gaps exist?

2. Do we know if there are already solutions or promising work being done?

Report back *key points* (5 minutes)

9

9

Group 3

Discussion notes

- (Brainstorming space. Add additional notes slides as needed.)
- (For group reporting, you may highlight key points from these notes slides, or consolidate main points on "Key takeaways" slide - up to you!)

10

10

Group 3

Key takeaways

1. What research and market gaps exist?
   - Need real-time data, provide to right people and help make decisions.
   - Map fires with higher resolution, possibly using more portable devices .
   - People have different resolution needs.
   - Provide fire risk evaluation including things like weather conditions, to increase the transparency of information.
   - Pre-fire data
2. Do we know if there are already solutions or promising work being done?
   - Real-time detection
   - You can't be sustainable if your house burns down...

11

11

3. Technology for Planning and Risk Assessment for Communities

•••

Group 4 - Breakout Session 3
Preparing for Disaster: Advancing WUI Resilience
4:00 - 4:45 PM, Tuesday, March 3, 2020

12

Group 4

Group discussion (45 minutes)

1. What research and market gaps exist?

2. Do we know if there are already solutions or promising work being done?

Report back *key points* (5 minutes)

13

13

Group 4

Discussion notes

- Research and market gaps
  - Different PPPs - work is often the role of public organizations (USFS, CAL FIRE, NGOs), but government can move slowly, and the private sector is faster
  - We don't have the public funding to do things, meaning that private sector is necessary, but how do we integrate that into the public sector?
  - We trust apps normally (like Waze), and we need to understand how people would use this kind of information; we don't understand how people interact with apps and emergency information
  - How is information going out to the first stage of the user groups?
  - Need to be clear about the use of this kind of information (avoid arson)
  - Need to better define at what level people interface with the tools/products -- why not determine that up front when starting the project?
  - Need more mapping of social aspects, not just physical aspects

14

14

Group 4

Discussion notes

- Solutions or promising work being done
  - Whisker Labs' product Ting - for residents to prevent electrical fires at home. If they have a dense enough network, they can detect issues with the power grid

15

15

Group 4

Key takeaways

- Research and Market Gaps
  - Opportunities for PPPs, especially when government is slow or has inconsistent funding
  - Need to better define at what level people interface with the tools/products -- why not determine that up front when starting the project?
  - Need more mapping of social aspects, not just physical aspects, and linking them together (consider the picture holistically)
  - There is a high standard for models to work every time, but they also need to be usable by all fire departments
- Solutions or promising work
  - WiFire - continual buy-in for each piece of information
  - Evacuation modeling - WUI-NITY
  - Whisker Labs' product Ting - for residents to prevent electrical fires at home. If they have a dense enough network, they can detect issues with the power grid
  - FirescoreOPS - Jupiter Intelligence, available for free for state agencies and first responders

16

16

3. Technology for Planning and Risk Assessment for Communities

•••

Group 5 - Breakout Session 3
Preparing for Disaster: Advancing WUI Resilience
4:00 - 4:45 PM, Tuesday, March 3, 2020

ARUP Berkeley REAX

17

Group 5

Group discussion (45 minutes)

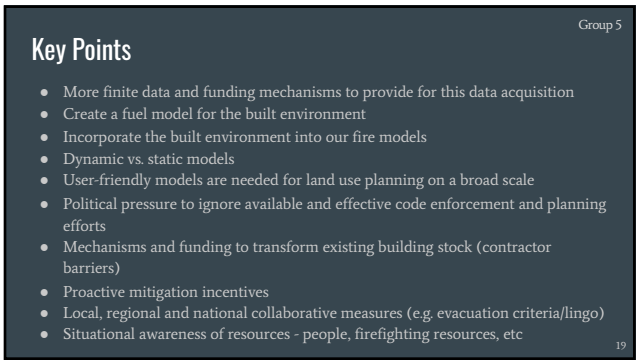
1. What research and market gaps exist?

2. Do we know if there are already solutions or promising work being done?

Report back *key points* (5 minutes)

18

18


Group 5
Key Points
More finite data and funding mechanisms to provide for this data acquisition
Create a fuel model for the built environment
Incorporate the built environment into our fire models
Dynamic vs. static models
User-friendly models are needed for land use planning on a broad scale
Political pressure to ignore available and effective code enforcement and planning efforts
Mechanisms and funding to transform existing building stock (contractor barriers)
Proactive mitigation incentives
Local, regional and national collaborative measures (e.g. evacuation criteria/lingo)
Situational awareness of resources - people, firefighting resources, etc
19

19

4. Outreach and Community Action

Group 1 - Breakout Session 4
Preparing for Disaster: Advancing WUI Resilience
10:00 - 10:45, Wednesday, March 4, 2020

ARUP Berkeley REAX

1

Group 1

Group discussion (45 minutes)

1. What are the gaps in current outreach programs?
2. What are the needs and next steps to reduce destruction and encourage adoption of mitigation measures?

Report back *key points*. (5 minutes)

2

2

Group 1

Discussion notes (1/2)

- Having a unifying message on mitigation
- A gap could be that a lot of certification teaching materials are old, a solution could be providing revisions
- To put a certification in order to have a consistent message
- Buy in from local officials and policy makers
- Popularizing that homes which adhere to fire safety standards are not ugly
- Have research to show local elected officials that the cost of retrofitting homes is better than the cost of dealing with wildfire damage
- Wildfire certification programs for homes as a possible option

3

3

Group 1

Discussion notes (2/2)

- Having financial incentives for mitigation measures
- There needs to be a coordinated effort where the different features of mitigation are linked
- One outreach gap is not having materials in foreign languages
- Cultural barriers to outreach efforts as an outreach gap
- The challenges of doing mitigation work in communities where residents are renters as opposed to homeowners

4

4

4. Outreach and Community Action

Group 2 - Breakout Session 4
Preparing for Disaster: Advancing WUI Resilience
10:00 - 10:45, Wednesday, March 4, 2020

ARUP Berkeley REAX

5

Group 2

Group discussion (45 minutes)

1. What are the gaps in current outreach programs?
2. What are the needs and next steps to reduce destruction and encourage adoption of mitigation measures?

Report back *key points*. (5 minutes)

6

6

Group 2

Discussion notes

- (Brainstorming space. Add additional notes slides as needed.)
- (For group reporting, you may highlight key points from these notes slides, or consolidate main points on "Key takeaways" slide - up to you!)

7

7

Group 2

Key takeaways

Gaps & Next steps

- Lacking of fully dedicated wildfire specialists to do outreach education
- Barriers for evacuation: can not make it orderly, can not declare the shelter
- Education in elementary school (terminologies, wildfire drill, curriculum)
- Evacuation preparedness (community-wise, where to go? what to do?)
- Post-fire recovery, rebuilding
- How do we measure the success of outreach? (empowerment)

8

8

4. Outreach and Community Action

Group 3 - Breakout Session 4
Preparing for Disaster: Advancing WUI Resilience
10:00 - 10:45, Wednesday, March 4, 2020

ARUP Berkeley REAX

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Group 3

Group discussion (45 minutes)

- What are the gaps in current outreach programs?
  - Insufficient and ineffective, lack of price-signal risk.
  - Let people understand fire is controllable and they can do something. Fire is not like hurricane!
  - Community leaders just look forward to fund from government. They should understand they are protecting their own community.
  - Need a general and uniform model for mitigation.
  - Need to work together with neighbors - within community. At a system level, not parcel by parcel.
  - People who benefit should pay the bill
- What are the needs and next steps to reduce destruction and encourage adoption of mitigation measures?
  - Tie community outreach to incentives and pricing.

10

10

Group 3

Group discussion (45 minutes)

1. What are the gaps in current outreach programs?

2. What are the needs and next steps to reduce destruction and encourage adoption of mitigation measures?

Report back *key points*. (5 minutes)

11

11

Group 3

Discussion notes

- (Brainstorming space. Add additional notes slides as needed.)
- (For group reporting, you may highlight key points from these notes slides, or consolidate main points on "Key takeaways" slide - up to you!)

12

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4. Outreach and Community Action

Group 4 - Breakout Session 4
Preparing for Disaster: Advancing WUI Resilience
10:00 - 10:45, Wednesday, March 4, 2020

ARUP Berkeley REAX

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Group 4

Group discussion (45 minutes)

1. What are the gaps in current outreach programs?
   - Child outreach
   - Discussion of evacuation procedures standardization - who is holder and manager of this information organization, coordination, and distribution
   - Urban vs. rural differences
   - Disclosure/gathering of information, hazards, etc. to those who need to know
     - Home buyers, homeowners, travelers, vacation rentals, tourists, etc.
   - Concern about liability of where to advise evacuation before and during an event
   - Funding for outreach
   - Conflicting perspectives - ex: air quality vs. prescribed burns
   - Reach out and learn from indigenous nations on how they work with the land
   - Getting messages out to people - Facebook algorithms has limitations to disseminate
2. What are the needs and next steps to reduce destruction and encourage adoption of mitigation measures?

14

14

Group 4

Discussion notes

- Outreach: Children education programs - middle school, highschool. Part of long-term solutions
  - Education and Empowerment - Mitigation, smoke health, creating solutions
  - Projects
- Rural vs. Urban
- Policy to inform of hazardous conditions - Flood, earthquake, fire - in/out
  - When information is disclosed is inconsistent, state and regional differences
- Political and monetary drivers into wildland areas
- Ready-set-go outreach

15

15

Group 4

Key takeaways

- Increase education and outreach to children (middle school, high school), higher education, and multidisciplinary communities-part of long term solutions and increased long term community engagement. Child->Parent motivation
- Disclosure and gathering of relevant information (hazards, etc.) to those who need to know
  - Home buyers, homeowners, travelers, vacation rentals, tourists, etc.
- Resolve conflicting perspectives - ex: air quality vs. prescribed burns
- Reach out and learn from indigenous nations on successful stewardship of the land
- Better communication of hazards - AND social media, geo positional - fire data, shared with google layer for larger community access, policy (current disclosure inconsistent),
- Increase marketing: continuing outreach for preparedness messages that are positive and or funny (ex: TSA: nunchucks, NP, etc.) to keep people following/listening and engaged
  - 'Deep marketing scheme' - personalized billboard-specific ads
- Performance indicators - community specific comparisons, competitive comparison for driving additional motivation, outreach success

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5. Notification and Evacuation

Group 1 - Breakout Session 5
Preparing for Disaster: Advancing WUI Resilience
12:30 - 1:15 PM, Wednesday, March 4, 2020

ARUP Berkeley REAX

1

Group 1

Group discussion (45 minutes)

1. What are the current gaps in our notification and evacuation plans?
2. What can be done to improve the process in the near and long term?

Report back *key points* (5 minutes)

2

2

Group 1

Discussion notes (1 / 2)

- Technology needs and redundancy for public warning systems which depend on power, i.e. dealing with power losses.
- The gap is that there are no plans!
- There is some resistance to planning
- Is the word evacuation the right word? Is this a defeatist word? Should a different word be used?
- It's difficult to have a generic plan because plans should have the neighborhood/regional context. A solution to this could be to include a generic section in the plan and follow with a local/regional section

3

3

Group 1

Discussion notes (2/2)

- Planning necessary to designate appropriate shelters
- Even if there is a plan, how do you communicate to people who are not locals, ie tourists? Furthermore, can evacuation plans be available in foreign languages?
- Evacuations is done by law enforcements, but planning is done by the fire protection/planning agencies, is there interagency coordination?
- Learning about notification and evacuation from other disaster planning communities such as the hurricane planning community.
- Having expert assessments of buildings to understand whether a structure will be viable during a fire event

4

4

5. Notification and Evacuation

Group 2 - Breakout Session 5
Preparing for Disaster: Advancing WUI Resilience
12:30 - 1:15 PM, Wednesday, March 4, 2020

ARUP Berkeley REAX

5

Group 2

Group discussion (45 minutes)

1. What are the current gaps in our notification and evacuation plans?
2. What can be done to improve the process in the near and long term?

Report back *key points* (5 minutes)

6

6

Group 2

Discussion notes

- (Brainstorming space. Add additional notes slides as needed.)
- (For group reporting, you may highlight key points from these notes slides, or consolidate main points on "Key takeaways" slide - up to you!)

7

7

Group 2

Key takeaways

Gaps:

- Lacking of real-time data (sensor network, between agencies, official source, real-time fire spots marking, where fire is going, how people move)
- How much of the notification is automated? If is human triggered, what is the trigger criteria (decision making process)?
- Different fire scenarios need to be considered (worst condition) in evacuation plan
- Shift the focus from properties to life

8

8

Group 2

Key takeaways

What to do?

- Receive more personalized instructions by zone (where to go)
- Using the community as a probe

9

9

5. Notification and Evacuation

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Group 3 - Breakout Session 5
Preparing for Disaster: Advancing WUI Resilience
12:30 - 1:15 PM, Wednesday, March 4, 2020

ARUP Berkeley REAX

10

10

Group 3

Group discussion (45 minutes)

1. What are the current gaps in our notification and evacuation plans?

2. What can be done to improve the process in the near and long term?

Report back *key points* (5 minutes)

11

11

Group 3

Discussion notes

- (Brainstorming space. Add additional notes slides as needed.)
- (For group reporting, you may highlight key points from these notes slides, or consolidate main points on "Key takeaways" slide - up to you!)

12

12

5. Notification and Evacuation

Group 4 - Breakout Session 5
Preparing for Disaster: Advancing WUI Resilience
12:30 - 1:15 PM, Wednesday, March 4, 2020

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13

Group 4

Group discussion (45 minutes)

1. What are the current gaps in our notification and evacuation plans?
   - Reaching everybody - domestic workers,
   - Standardization of evacuation communication ('green' exit signs).
   - Community planning - signage
   - Sheltering options - But limited capacity. Incident commanders only to know sheltering to prevent civilian groupings?
   - Design variables and interaction - how they interact with egress
   - Tracking progress?
2. What can be done to improve the process in the near and long term?

14

14

Group 4

Discussion notes

- Multiple systems - failure tolerant combinations
  - Simple and robust - Sirens, radio, cell, social media
- Science-based data evacuation
- Notify everybody: reach domestic workers, homeless communities (and transport)
  - Inform of hazard and what to do
  - Who maintains? Where to put them?
- Standardization of communication
- Disasters don't happen at convenient times
- Public education to translate distinctions to "normal speak"
  - Other groups may not know distinctions as well, may not have been reached, nor have appropriate PPE - Police, etc.
- Communication between teams
- Use herd mentality - line of cars providing urgency, smoke in the air,
  - Dynamic - wildfire is, and so does the evacuation route (depends on current conditions and threats)
  - Not fixed metal sign..
- Waze and other transportation apps, route choice etc.
- What are barriers to providing an evacuation plan
  - Funding, staffing, overwhelmed feeling; enormity and 'fantasy documents' that can't accommodate everything,
- State-wise standard
- What situations do we plan for? How for to build worst case?
- Logistics of moving people
- Logistics: Real time information for decisions - wind direction, likely fire spread, evacuation progress
- Urgency
- Precise instructions based on cell tower connected to. Sirens lead to chaos not organization

15

15

Group 4

Key takeaways - We have a lot of work to do

- Multiple systems - failure tolerant combinations
  - Simple and robust - Sirens, radio, cell, social media
- Science-based data evacuation
- Notify everybody: reach domestic workers, homeless communities (and transport)
  - Inform of hazard and what to do
  - Who maintains the communication system? Where to put them?
- Public education to translate distinctions to "normal speak"
  - Other groups may not know distinctions as well, may not have been reached, nor have appropriate PPE - Police, etc.
- Communication between different response teams - Police, fire, etc.
- Dynamic - wildfire is, and so needs to be the evacuation route (depends on current conditions and threats)
- Barriers: Funding, staffing, overwhelmed feeling; enormity and 'fantasy documents' that can't accommodate everything,
- Standardization of communication
- Uncertainty of what situations do we plan for
- Logistics: Real time information for decisions - wind direction, likely fire spread, evacuation progress

16

16

6. Long-Term Trends and Market Challenges

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Group 1 - Breakout Session 6
Preparing for Disaster: Advancing WUI Resilience
2:15 - 2:45 PM, Wednesday, March 4, 2020

ARUP Berkeley REAX

1

Group 1

Group discussion (45 minutes)

1. You made it through an intensive 2 days! Thanks for all your participation.
2. Please reflect on the panel session we just heard. Now think with foresight and discuss: How will long term trends influence your role(s) in the bigger picture of WUI resilience? Are there groups that need to work more closely together in the future? Other insights?
3. Rank (number) top needed actions/solutions and research needs
   a. We will compile these as a group to come up with a list to be provided in the final report

Report back *key points*. (5 minutes)

2

2

Group 1

Discussion notes

Insurance:

- Gap for insurance: helping the insurance companies get to a point where they feel comfortable insuring homes in high risk areas, maybe a checklist approach for homeowners to abide by
- Learning from insurance "models" for other types of hazards - e.g. in Florida
- Consumer education is lacking and needed, not clear to consumers what they are buying, standard communications important
- Issue: retirement communities or those who have completely paid for homes can opt to not have insurance
- Connect the dots between science, mitigation standards, fire service mitigation work, and industry-recognized best practices - take to legislators to enact into policy around insurance
- Homeowners not aware of their insurance coverage - consumer education
- Are we considering semi-transient populations (college towns, short-term renters, etc) and how?
- Should we tell people not to live in WUI? Urban sprawl is incentivized in California - we should change this frame of mind such that it doesnt make economic sense to build into the WUI
- Make it "financially infeasible" to build without appropriate WUI design instead of prohibiting development into the WUI
- Existing stock housing a challenge - recent devastated communities were built in 80's
- NFPA's "Cost of fire" does not include wildland fire

3

3

Group 1

Top Actions/Solutions

Near-Term (ready to go)

1.
2.

Mid-Term (need work to implement)

1.
2.

Long-term (I wish we could...)

1.
2.
3.

4

4

Group 1

Top Research and Development Needs

Near-Term (ready to go)

1.
2.

Mid-Term (need work to implement)

1.
2.

Long-term (I wish we could...)

1.
2.
3.

5

5