



Community Fire Destruction During Extreme Wildfires: *A Home Ignition Problem*

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Wildland-Urban (WU) fire
disaster:

**Many homes and
businesses burn to total
destruction during extreme
wildfire conditions.**



To effectively manage wildland fire and prevent WU fire disasters we need to recognize the wildland fire context:

As a...

Natural disturbance - an appropriate ecological process,
and, as a

Natural hazard - an initiator of community burning.

Wildland Fire as a Natural Disturbance



Wildland Fire - A Natural Disturbance

- Wildland fire occurrence is inevitable.
- North American ecosystems, with a few exceptions, developed with and were maintained by fire, ignited by humans and lightning, since the end of the Ice Age (>12,000 yrs).
- Elimination of Native American burning along with European settlement of agricultural, urban development and modern attempts at wildfire exclusion, have greatly reduced and changed wildland fire occurrence

Specifically, for the last 100 years:

- Wildfire suppression has largely kept 98% of wildfires small, largely eliminating the historical ecological influence of wildland fire.
- A portion of the 2% of wildfires that escape initial attack become extreme during the most severe weather conditions (< 1% occurrence).

THE WILDFIRE PARADOX: Attempted wildfire exclusion has increased the potential for extreme wildfire conditions over extensive areas; the wildfires when WU fire disasters occur.

Wildland Fire as a Natural Hazard



A History of Community Destruction During Extreme Wildfires



1870 - 1919

- **1871 Peshtigo (Wisconsin)**
- 1881 Michigan
- 1894 Hinckley
(Minnesota)
- 1902 Yacolt (Washington)
- 1903 Adirondack (New
York)
- 1910 Great Idaho
- 1918 Cloquet (Minnesota)

Same time as well-known Great Chicago Fire

- **2000+ civilian fatalities**
- **Numerous entire towns destroyed**

1920 - 1984

- 1923 Berkeley (CA)
- 1929 Mill Valley (CA)
- 1941 Marshfield (MA)
- 1943 California (multiple)
- 1947 Maine (multiple)
- 1961 California (multiple)
- 1963 New Jersey and Staten Island
- 1964 California (multiple)
- 1970-80 California (multiple)

- **Less than 100 civilian fatalities**
- **400+ firefighter burn-over fatalities**
- **5000+ homes destroyed**

1985

1400 homes destroyed primarily in Florida, North Carolina and California motivated the National “Wildland-Urban Interface” (WUI) Initiative of Federal, state, and local agencies.

Firewise, Fire Adapted Communities and other current programs followed.

How has our national recognition influenced WU fire disaster occurrence since 1985?

WU Fire Disasters

(100 - 999 homes destroyed)

Year	Incident	Location (USA)	Homes Destroyed (approx.)
1990	Painted Cave	Santa Barbara, CA	479
1991	WA state 'Firestorm'	Spokane, WA	108
1993	Laguna Hills, Old Topanga	Laguna & Malibu, CA	634
1996	Millers Reach	Big Lake, AK	344
1998	Florida wildfires	Flagler & Volusia Cnty, FL	300
2000	Cerro Grande	Los Alamos, NM	239
2002	Hayman*	NW of Colorado Sprgs, CO	139
	Rodeo-Chediski	Heber-Overgaard, AZ	426
2003	Aspen	Summerhaven, AZ	340
2006	TX, OK Wildfires	TX & OK	723
2007	Angora	Lake Tahoe, CA	245
2010	Fourmile Canyon*	Boulder County, CO	168
2012	High Park* , Waldo Canyon*	Colorado Front Range	259, 346
2013	Black Forest*	El Paso County, CO	511
2014	Carlton Complex, etc.	Okanogan County, WA	342
2019	Kincade	Sonoma County, CA	374

WU Fire Disasters

(1000+ homes destroyed)

Year	Incident	Location (USA)	Homes Destroyed (approx.)
1991	Tunnel	Oakland, CA	2900
2003	Old, Grand Prix, Cedar, etc.	Southern CA	3640
2007	Witch, Slide, etc.	Southern CA	2180
2011	Bastrop Complex, etc.	Central TX	2725
2015	Butte, Valley	Amador & Lake Cty, CA	1797
2016	Smokey Mountain Complex	Gatlinburg, TN	2000
2017	Tubbs, Nuns, Thomas, etc.	No. & So. California	9000
2018	Carr, Camp, Woolsey, etc.	No. & So. California	16,000 <i>*(National total: 1985 – 1994, 9000)</i>

National attention, increased suppression resources, and federal, state and local collaborations have not effectively abated the increasing trend of WU fire disasters.

Continuing the Wildfire Paradox:

National focus on wildfire as a natural hazard, with suppression as the principal response, particularly for community protection, continues:

- Fire largely not occurring as an appropriate ecological factor in the western US;**
- Communities largely not becoming ignition resistant to extreme wildfires and hence, increasing WU fire disasters.**

We Have a Conundrum:

How can we have wildland fire as an appropriate ecological factor...

Without having WU fire disasters?



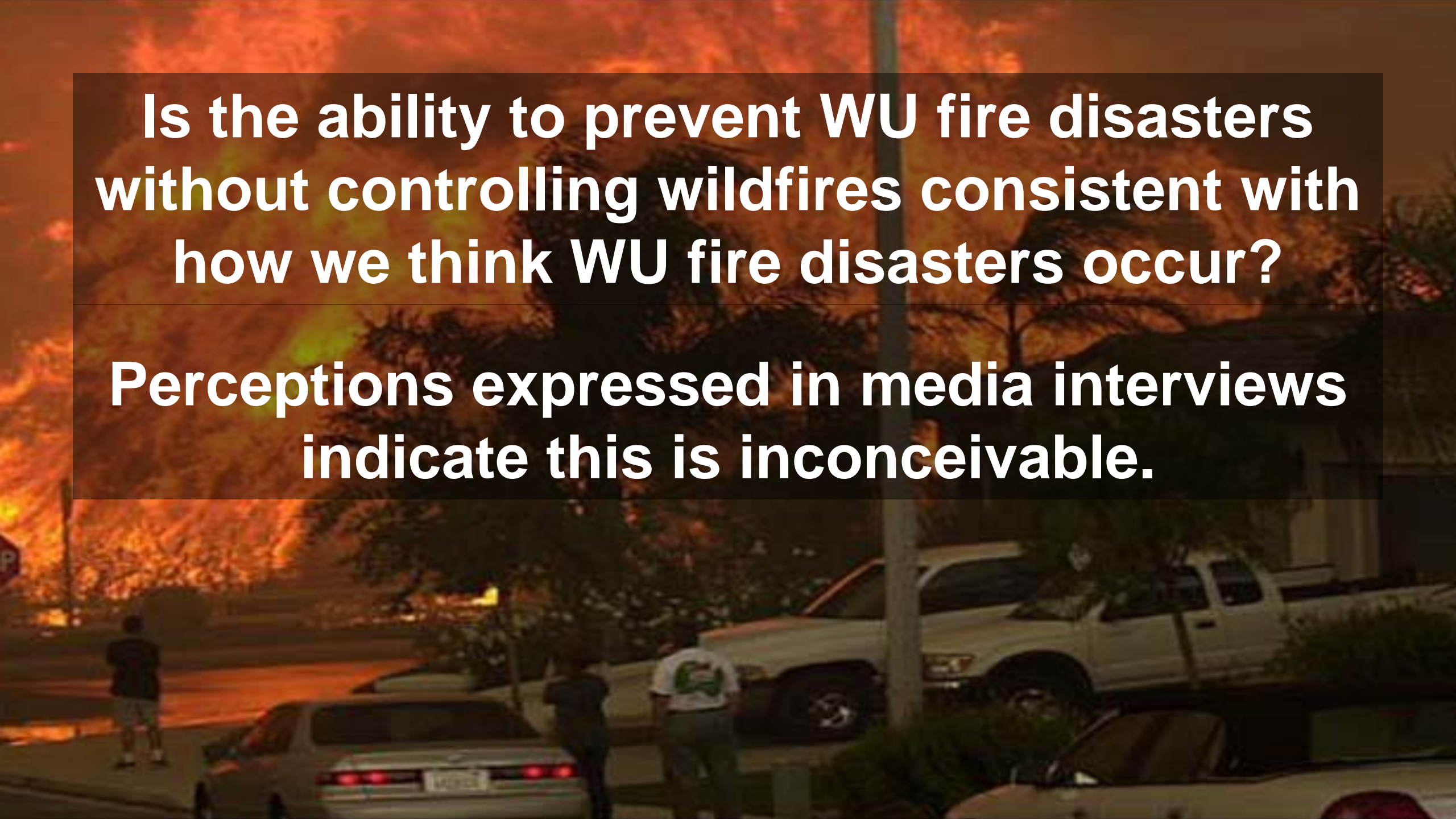
**Wildfires are inevitable; thus,
Extreme wildfires are inevitable.**

Does this mean **NO!** Wild-Urban (WU) fire
disasters are inevitable?



Given current best available science for understanding how homes ignite,

- **WU fire destruction during an extreme wildfire hazard is a readily preventable human disaster.**
- **WU fire science reveals opportunities for preventing WU fire disasters, without necessarily controlling extreme wildfires.**


A large wildfire is burning at night, with bright orange and yellow flames rising into the dark sky. In the foreground, several people are standing on a street, looking towards the fire. A white pickup truck and a white sedan are parked on the street. The scene is illuminated by the fire and some streetlights.

Is the ability to prevent WU fire disasters without controlling wildfires consistent with how we think WU fire disasters occur?

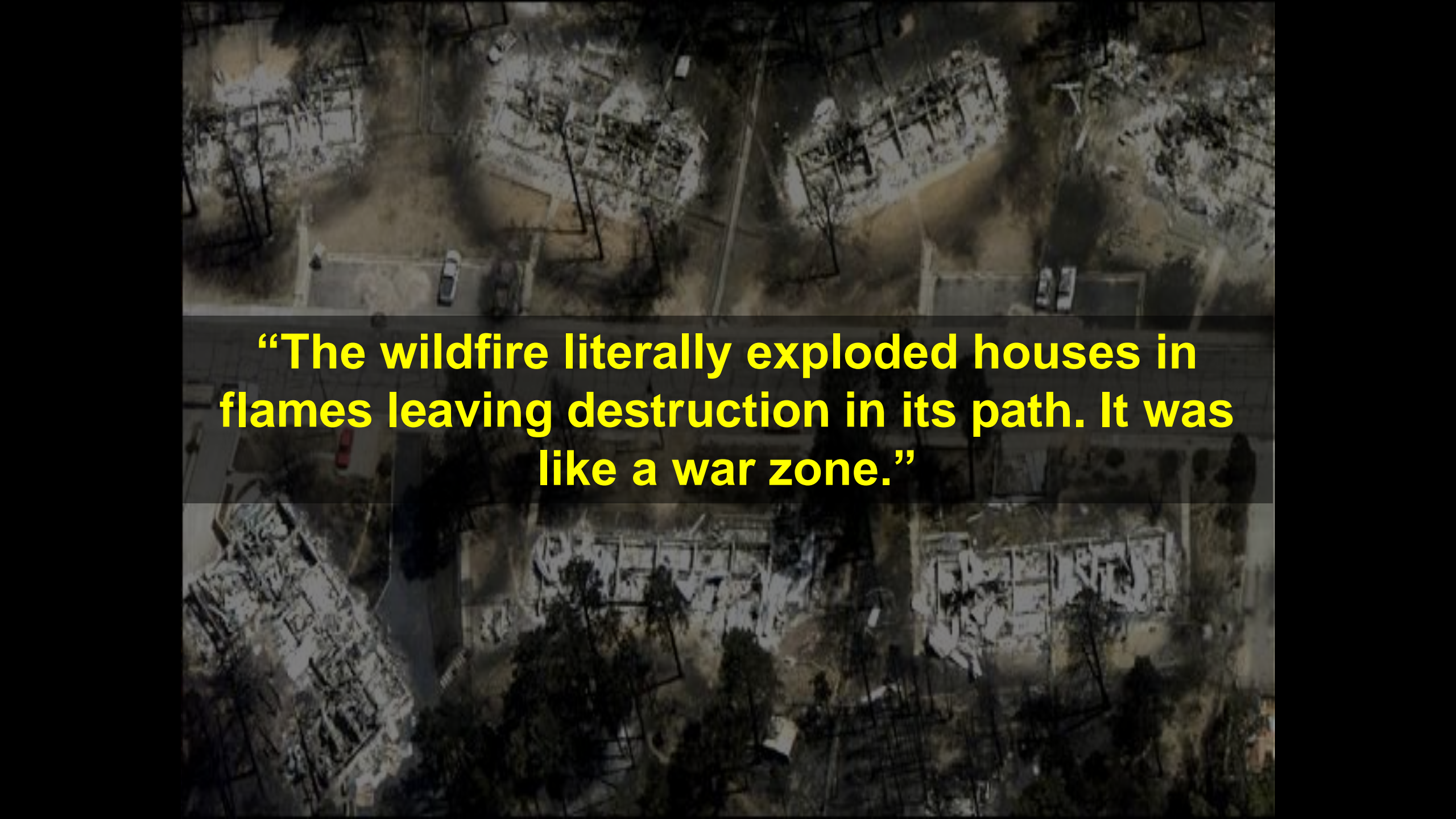
Perceptions expressed in media interviews indicate this is inconceivable.



“The firestorm descended like a dragon from hell on the foothill neighborhoods and laid them to waste.”



“The wildfire swept through the community with a tsunami of flame.”



“The wildfire literally exploded houses in flames leaving destruction in its path. It was like a war zone.”

2018 Paradise, CA Fire Destruction

Can you explain the unusual pattern of destruction?



This is the typical pattern of destruction!



and ignore the rest.

A photograph showing the aftermath of a disaster, likely a fire, with a semi-transparent text box overlaid. The scene is filled with charred debris, twisted metal, and the skeletal remains of buildings. In the background, several vehicles, including a white van and a car, are visible amidst the wreckage. The overall atmosphere is one of devastation and loss.

People see what they believe...



However...

Typical patterns of WU fire destruction do not support “*walls of flame sweeping*” through communities, and wildfires don’t *literally* explode houses in flames!



Miracle Vegetation?!

What else didn't burn?!
without protection.



**These homes ignited from lofted burning
embers not wildfire flames!**



**Los Alamos, NM
2000**

**Total home destruction
next to green vegetation!**



**Los Alamos, NM
2000**



Los Alamos, NM 2000

Homes burning hours after the wildfire passed the community.

Intense wildfire never spread to the residential area.

Houses are burning but not the tree canopies.



Typically, home ignitions result from:

- **Lofted burning embers,**
- **Low intensity surface fire spreading to contact the structure.**



The unconsumed tree canopies amid total home destruction indicate:

- **Wildfire flames did not spread though the community,**
- **Burning trees did not ignite the homes.**

The burned trees adjacent to and over the home destruction ignited from burning homes.



Victoria, Australia 2009



Napa 2017



**2018 Carr Fire
Redding, CA**

2020 WU Fires No Different



Berry Creek, CA



Gates, OR



Mill City, OR

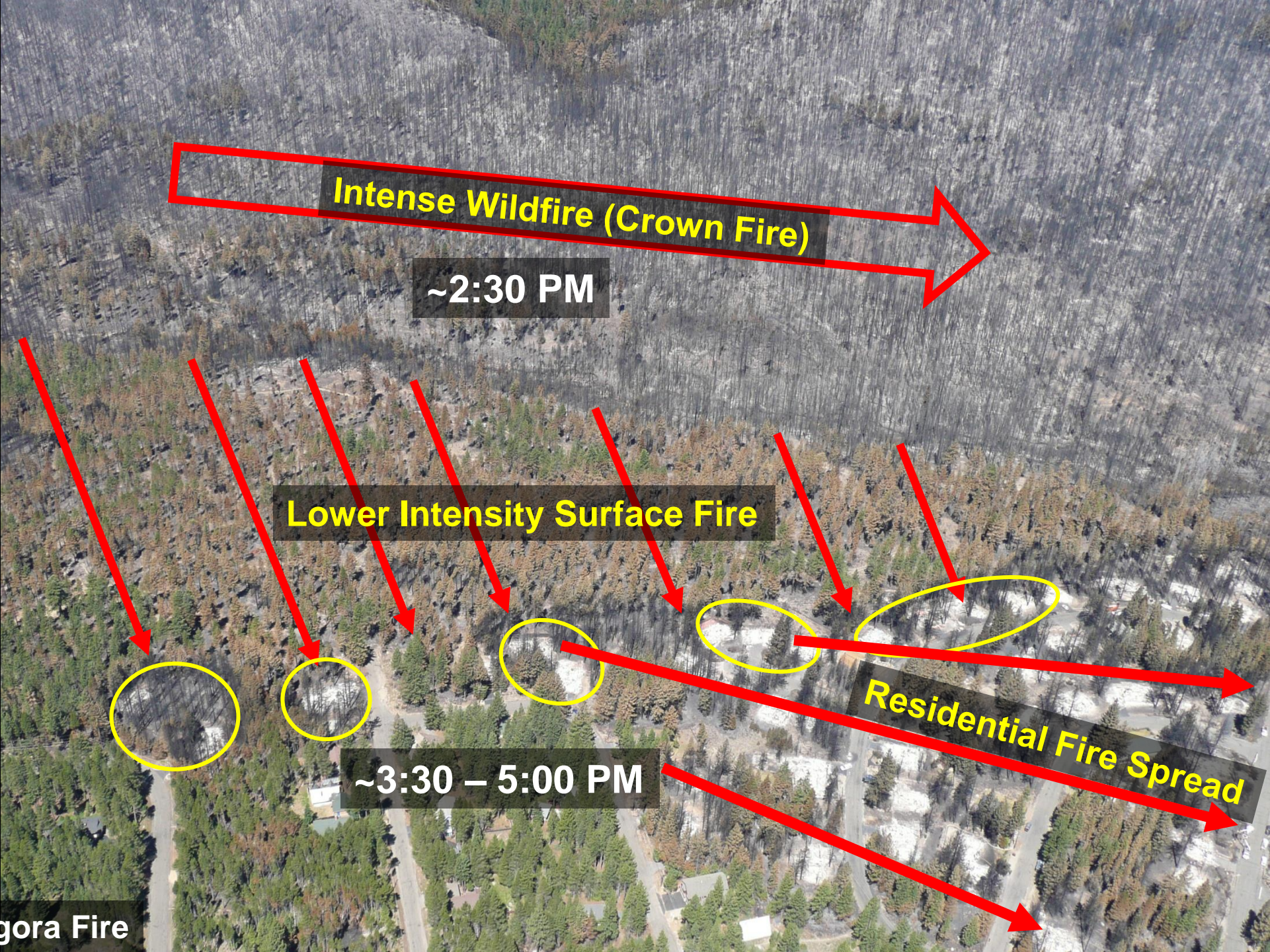
Commonly, communities burn by fire spreading through residential fuels – the vegetation and structures within the community.



Homes ignite and burn hours after significant wildfire activity has ceased at the community edge.

The community continues to burn without the wildfire!





Intense Wildfire (Crown Fire)

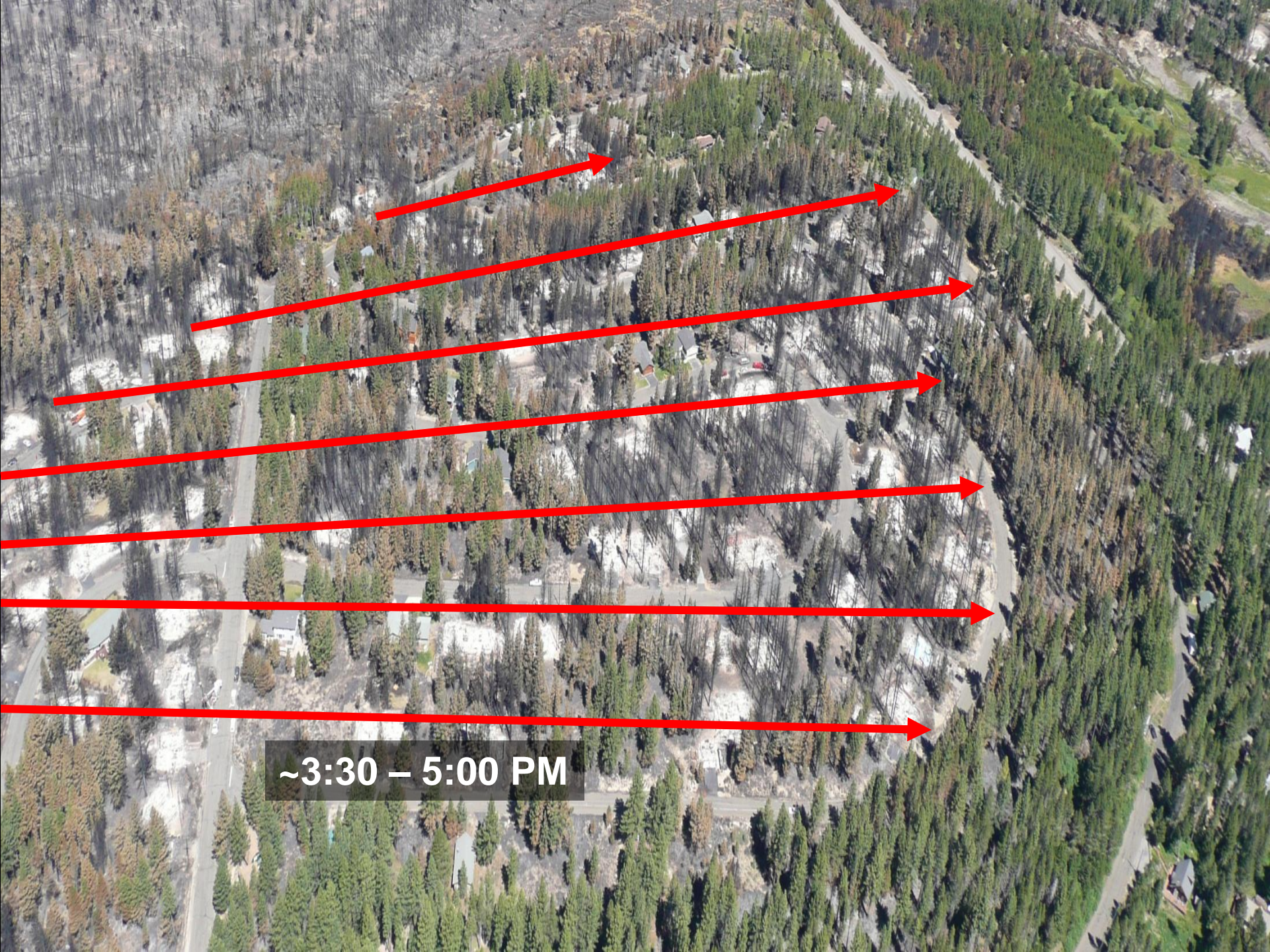
~2:30 PM

Lower Intensity Surface Fire

~3:30 - 5:00 PM

Residential Fire Spread

2007 Angora Fire



~3:30 - 5:00 PM

What do unconsumed vegetation and homes adjacent to total destruction indicate?



Wildfire does not spread through the community like a lava flow, flash flood or tsunami that “explodes houses in flame” leaving total destruction in its wake...



Intense, simultaneous heating across wide areas of structures does NOT occur.



Local conditions determine home ignitions.

Total destruction does not indicate high intensity wildfire exposure!



These homes ignited and freely burned to total destruction without available firefighters.



Although initiated largely by embers from intense wildfires, burning residential fuels – homes and vegetation – continue the fire spreading within the community.

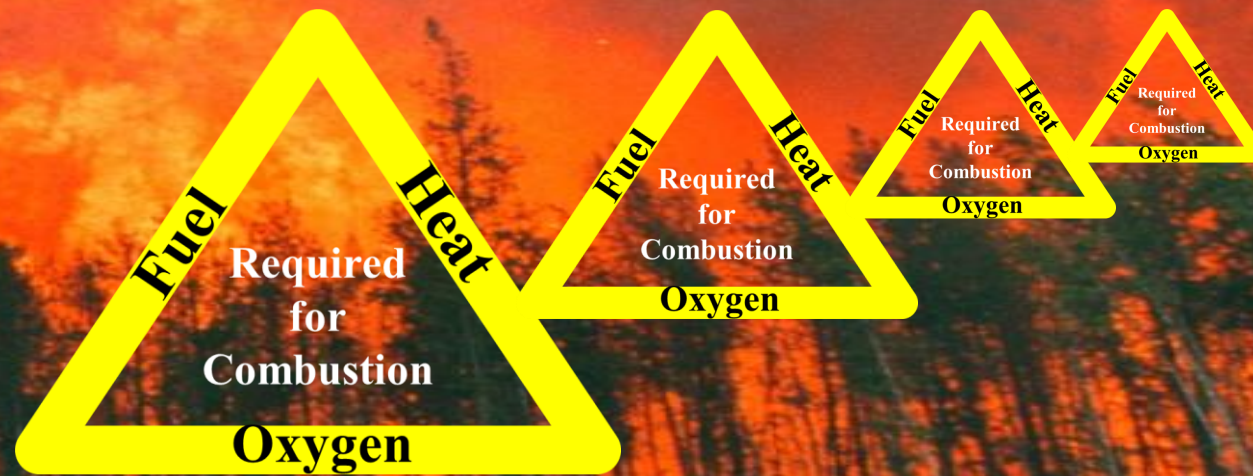


**Ignitions and thus fire, occur by meeting
the requirements for combustion...**

Fire is a process.



Wildfire spreads when ignition requirements are met at adjacent fuel during wildfires – Including extreme wildfires.



The requirements for combustion occur at the fuel surface.

Fire is not a “thing” that travels from place to place like tsunamis, floods and other natural hazards...

That provides opportunities to prevent WU fire disasters.



Wildland-Urban Fire

A Home Ignition Problem



The geographic classifications – “interface” and “intermix” do not determine home ignitions...

Wildfire (wildland) initiating
community (urban) burning
does occur,

Wildland-Urban (WU) fire.



Determined by
local conditions





**Local conditions were not
sufficient for ignition.**



**Local conditions were
sufficient for ignition.**

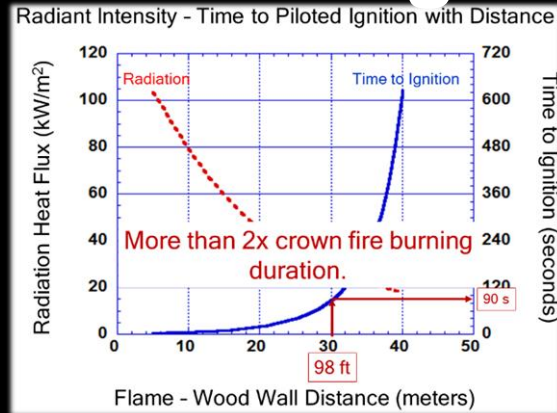
How far is local...

...and what conditions principally determine home ignitions during extreme wildfires?



WU Fire Research Results

Modeling



Experiments



Examinations

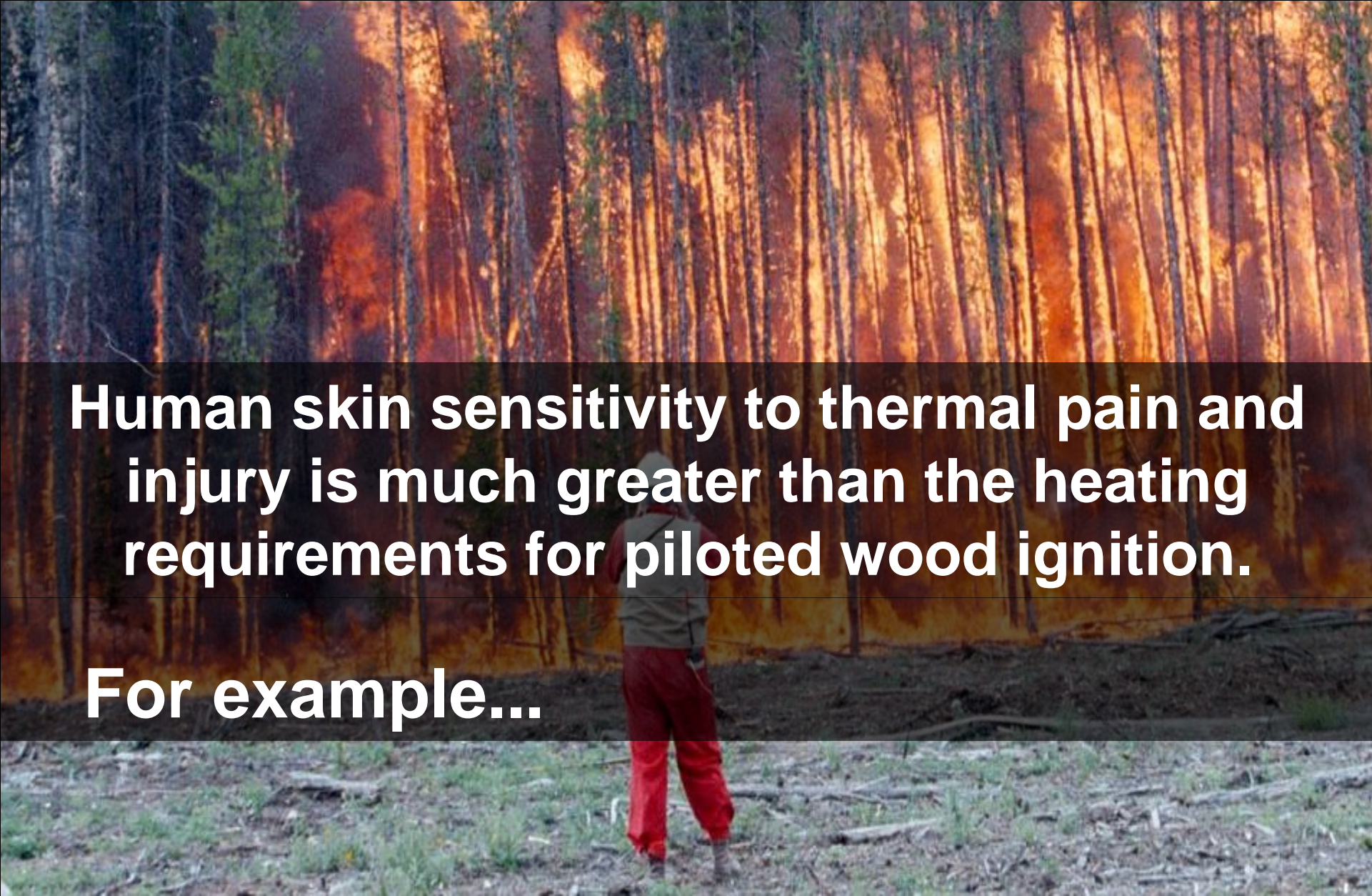


The characteristics of a home in relation to burning materials in the immediate surroundings within 100 feet

How can 100 feet be an overestimate?!

And, 100 feet is an intended overestimate.

How would we know?

A photograph showing a person from behind, wearing a red jacket and red pants, standing in a forest. The forest is filled with tall, thin trees, many of which are covered in bright orange and yellow flames, indicating a large fire. The ground is covered in dry leaves and twigs.

Human skin sensitivity to thermal pain and injury is much greater than the heating requirements for piloted wood ignition.

For example...

Human Burn Injury vs Wood Ignition

A flame radiative exposure that produces
a 2nd degree burn in 5 seconds,

Takes over

27 minutes to pilot ignite a wood wall.

Human perception of ignition
requirements is not reliable!

For example...





California 2007



**Destroyed Structure:
> 100 feet from large
flames**

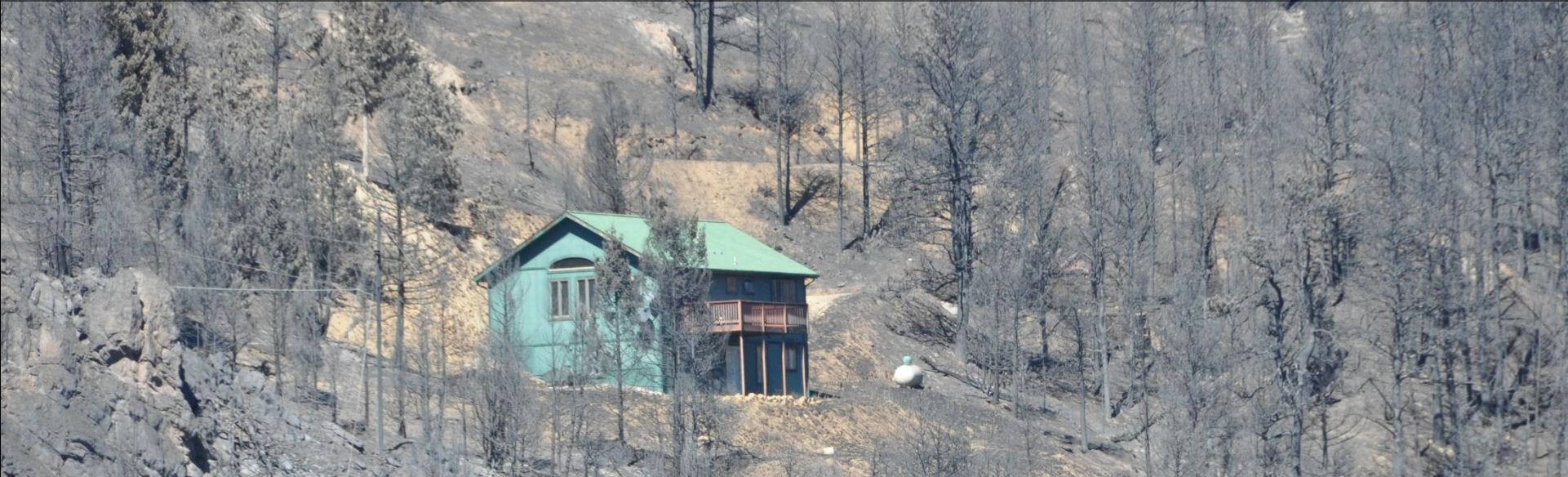


**Surviving wood
fence: ~45 feet**





Opportunity to reduce fuels within 100 feet of a home to:



- Discontinue intense fire spread,
- Prevent ignitions from intense radiant heating, and
- Prevent surface fire flame contact with the home, without necessarily controlling the wildfire.

Home ignitions during extreme wildfires are principally determined by the ignition characteristics of a home in relation to burning objects within 100 feet of a home.

This area is called the *home ignition zone* – the HIZ.



**Crown Fire
Spread**

**Insufficient flame heating;
Ember resistant house.**



Example HIZ Result

Typically extreme wildfires don't spread into developed neighborhoods.





40 feet



Crown Fire
Spread

Burning Embers

Crown Fire Spread

Total home destruction without crown fire.

Arizona 2002



Burning Embers – Principal Ignition Mechanism



Burning embers are inevitable during extreme wildfires;

Don't embers come from beyond the HIZ?



Yes,

Embers commonly ignite structures and vegetation within communities at distances of ½ mile and more during extreme wildfire conditions (varies by type of vegetation); however...



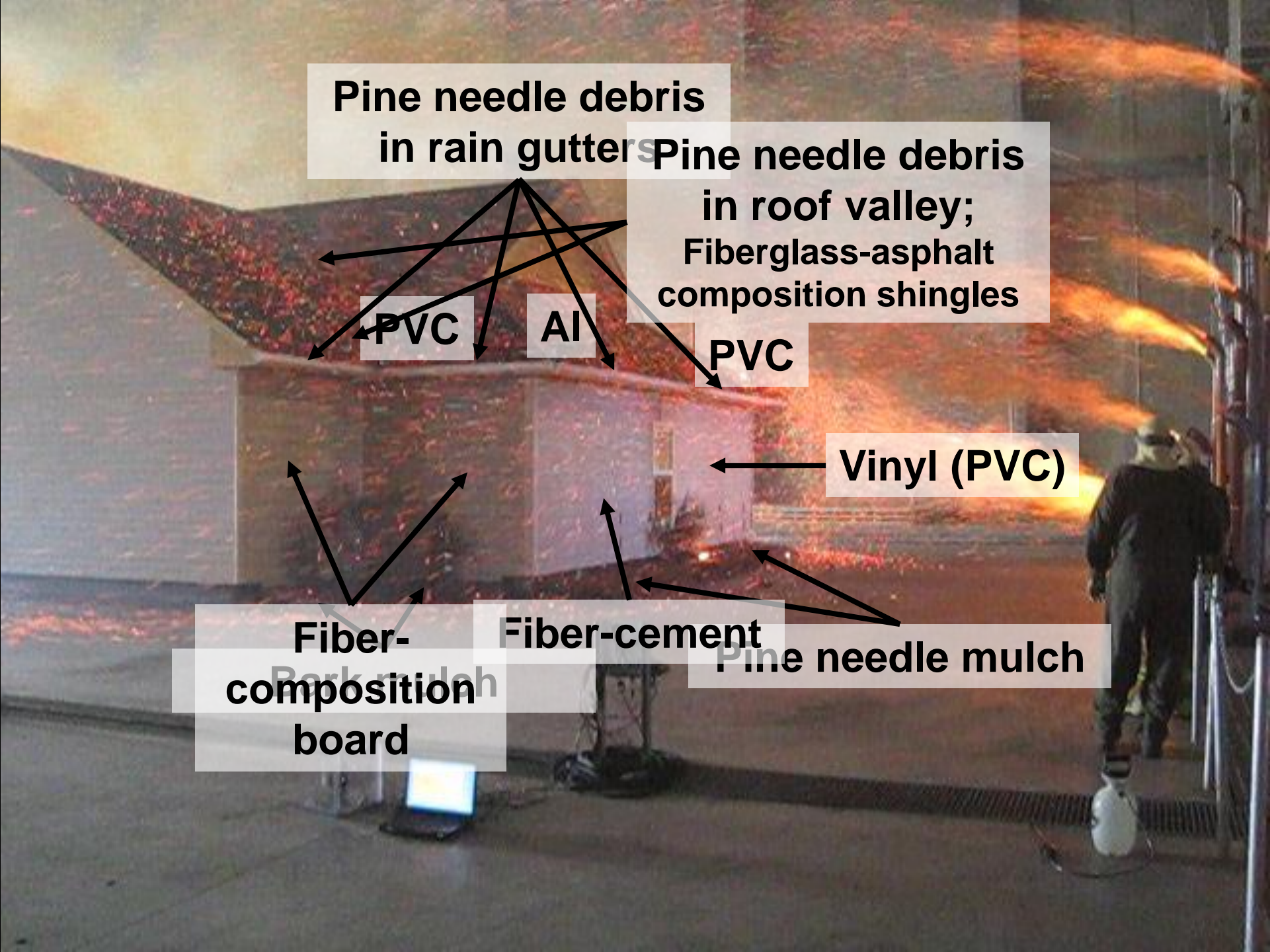
Regardless of the distance lofted from the wildfire, burning embers only generate home ignitions at locations of accumulation within the HIZ.



Ember Ignition Experiments



**Conducted at the IBHS Research Center
(Insurance Institute for Business and Home Safety)**



Pine needle debris

in rain gutters

Pine needle debris

in roof valley;

**Fiberglass-asphalt
composition shingles**

PVC

Al

PVC

Vinyl (PVC)

Fiber-

**composition
board**

Fiber-cement

Pine needle mulch

Ember Ignition Experiments



**Conducted at the IBHS Research Center
(Insurance Institute for Business and Home Safety)**

Residential fuels – burning structures and adjacent vegetation – are significant sources of embers that continue community fire spread hours after significant wildfire exposures have ceased.



**Embers generated by
burning homes.**



WU fire disasters do not occur from:

- A “tsunami of flame” sweeping through the community.
- Houses do not “literally explode in flames.” It is not a “war zone.” And...
- “Dragons from hell” are not to blame.

How do WU fire disasters occur?



WU fire disasters have only occurred during extreme wildfire conditions when wildfire suppression was ineffective, and ... structure fire protection was overwhelmed.

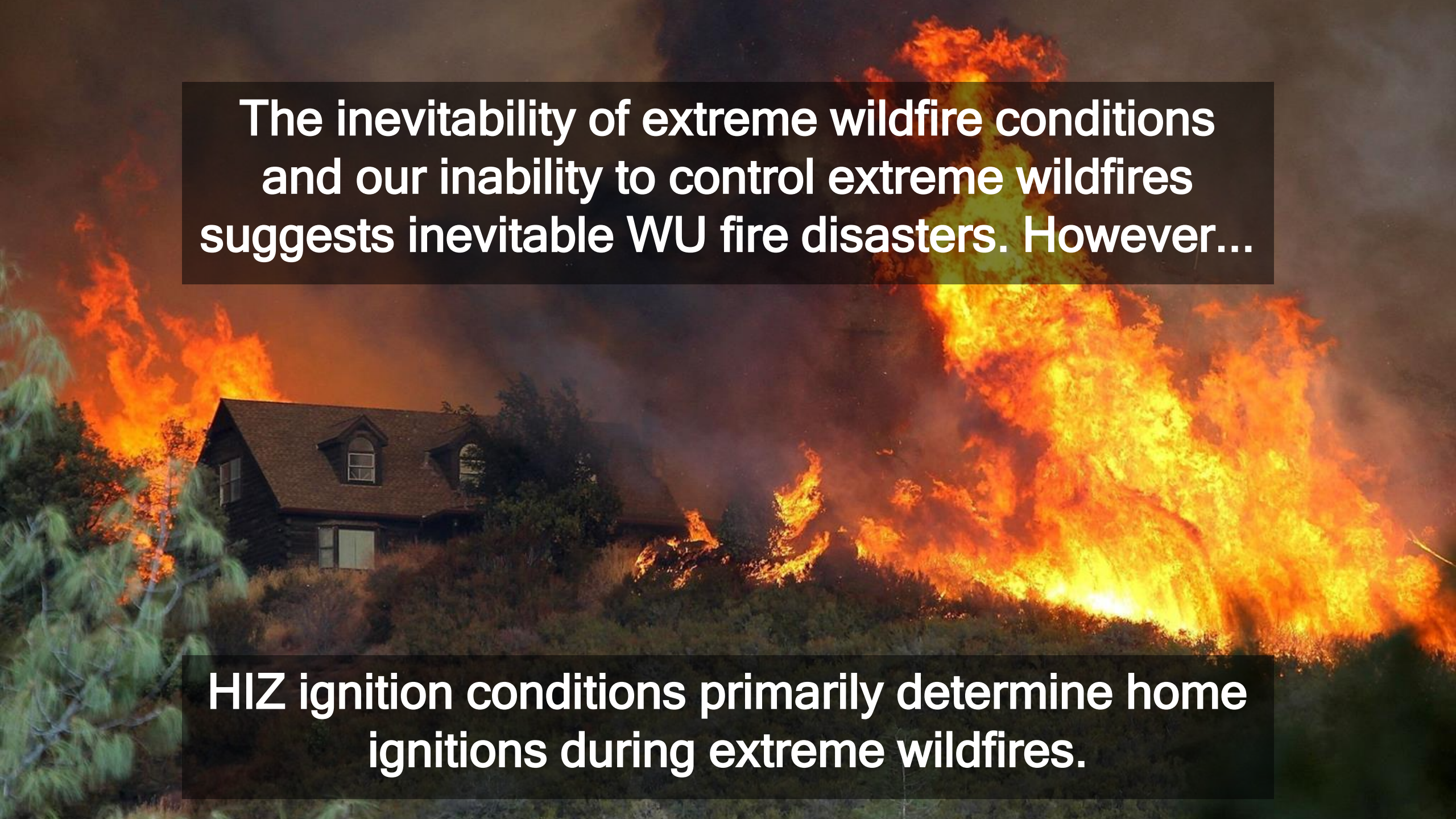


How do we attempt to prevent WU fire disasters?

Wildfire Suppression - Emergency Response...

And this fails to prevent WU fire disasters
during extreme WU fire conditions!





The inevitability of extreme wildfire conditions and our inability to control extreme wildfires suggests inevitable WU fire disasters. However...

HIZ ignition conditions primarily determine home ignitions during extreme wildfires.

Total destruction commonly starts with small ember ignitions on and adjacent to the home that can be readily prevented.



Severe Fire

Extreme Wildfire

Fuel, weather,
and Topography

Wildland Fire

and/or
High intensity

~~Wildland Fire~~
**Houses
Don't Ignite**
~~Ignitions~~

**We can make homes and communities
ignition resistant by eliminating and
reducing ignition factors within the HIZ!**

~~Fire
Suppression~~

~~Resources cannot
cover the exposure~~

~~Fire
Protection~~

~~Many homes burn
without attention~~

~~DISASTER!~~

~~Multiple homes
totally
destroyed~~

WU fire is a home ignition problem, not a problem of controlling extreme wildfire.



We can make homes ignition resistant during extreme wildfires by eliminating ignitions from flames within the HIZ and reducing ember ignitions of the home.

Remember:

Home ignitions during extreme wildfires are a local combustion process determined by local conditions within the HIZ,...

NOT by an “interface,” “intermix” or other geographic classification.



Ignition resistant homes:

- **Do not have flammable debris on the home and its flammable attachments;**
- **Do not have any ignitable material within 5 feet of the home and its flammable attachments.**
- **Do not have flame contact from within the HIZ;**
- **Do not have high intensity burning within the HIZ;**

Burning embers become the only ignition mechanism of wildfire home exposure.

Building Fire Codes?

Commonly fire codes designate fire performance:

- Materials and designs with slow flame spread ratings;
- Extended-time wall, ceiling and door fire penetration – “hour-ratings.”

Wouldn't such fire codes help prevent WU fire disasters?

Not Necessarily ...

Fire performance codes that facilitate fire control by reducing interior fire involvement rates assume firefighter response.

Without protection from firefighters or residents, any sustained ignition results in total destruction.

Home ignition resistance during extreme wildfires increases ignition performance and eliminates most ignitions ...

Codes appropriate for WU fire can be beneficial.



Reduced/No
Fire
Protection

Many homes burn
without attention

Urban conflagration in high density development

Entire community fire destruction



An extreme case of overlapping HIZs:

- **The physics of ignition does not change;**
- **But the social dynamics become critical.**



Making our homes ignition resistant means...



Montana 2003

having wildfires without WU fire disasters.



Thank you!

