Camp Fire
Fire Progression Timeline

Wildfire Resilient Structures (WiReS) Conference and Tradeshow

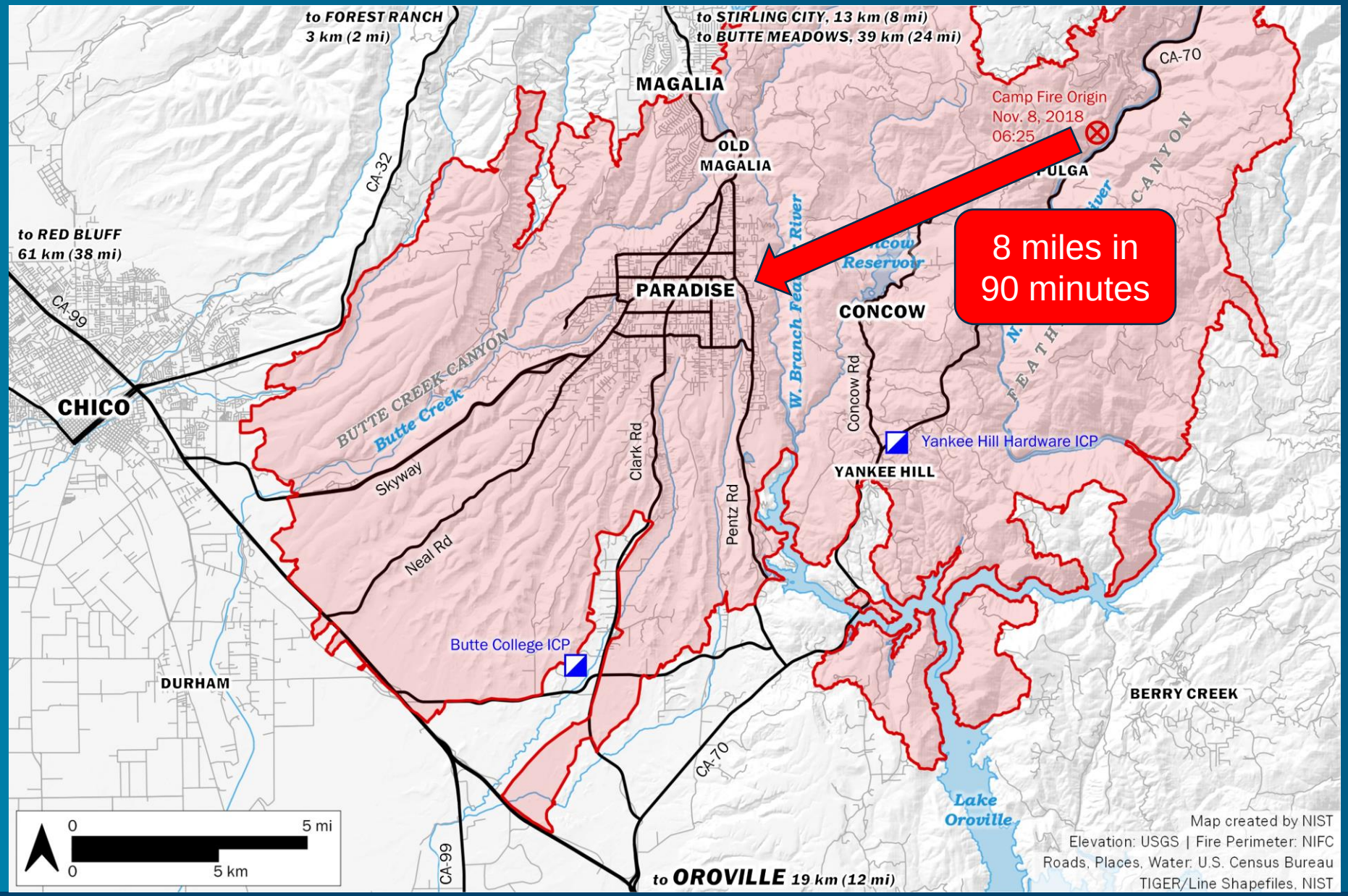
February 7 - 10, 2023 • San Diego, CA

Keynote

Steve Hawks and Alexander Maranghides

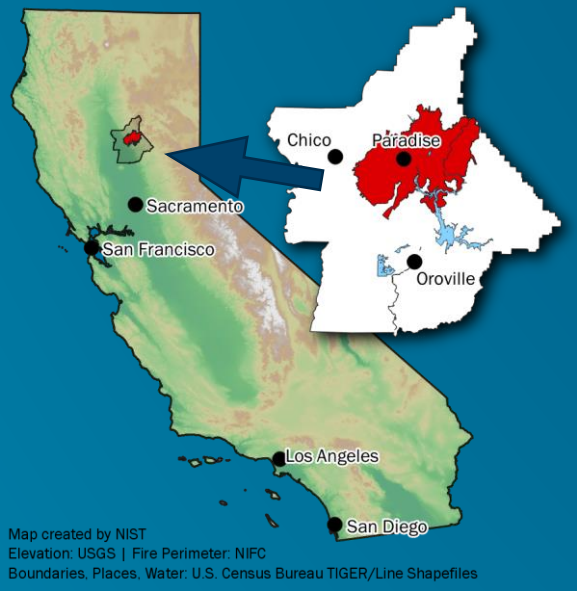
Enhancing Life Safety and Reducing WUI Fire Loses

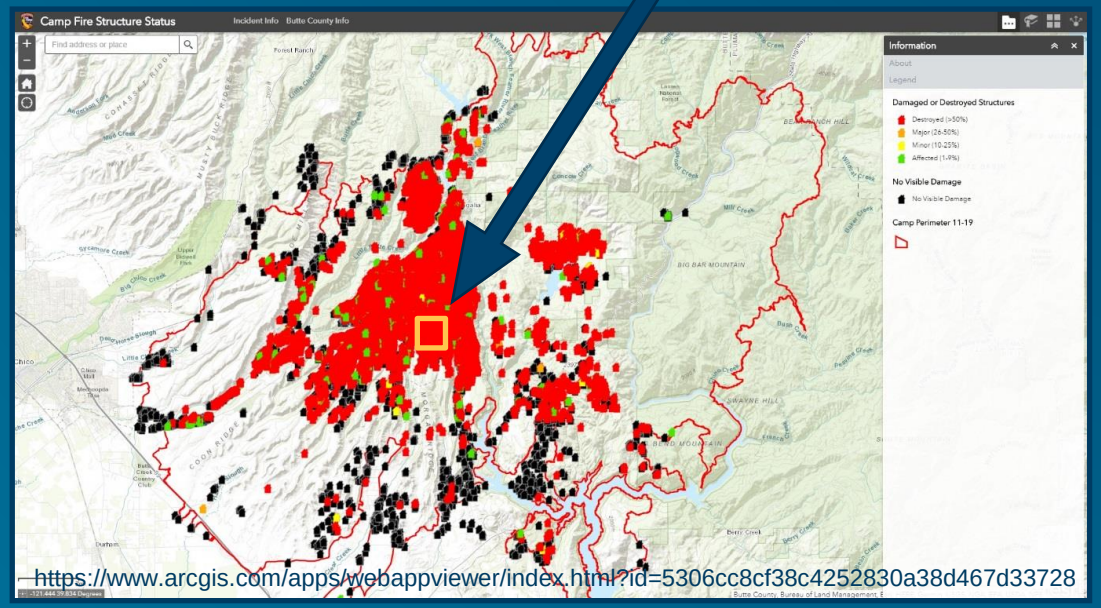
Camp Fire


to FOREST RANCH
3 km (2 mi)
to STIRLING CITY, 13 km (8 mi)
to BUTTE MEADOWS, 39 km (24 mi)
MAGALIA
OLD MAGALIA
CA-70
Camp Fire Origin
Nov. 8, 2018
06:25
PULGA
CANYON
8 miles in
90 minutes
CA-32
to RED BLUFF
61 km (38 mi)
CA-99
PARADISE
Concow Reservoir
CONCOW
W. Branch Feather River
BUTTE CREEK CANYON
Butte Creek
CHICO
Skyway
Clark Rd
Pentz Rd
Concow Rd
Yankee Hill Hardware ICP
YANKEE HILL
Neal Rd
Butte College ICP
DURHAM
BERRY CREEK
CA-70
Lake Oroville
0
5 mi
0
5 km
CA-99
to OROVILLE 19 km (12 mi)
Map created by NIST
Elevation: USGS | Fire Perimeter: NIFC
Roads, Places, Water: U.S. Census Bureau
TIGER/Line Shapefiles, NIST

Camp Fire Overview Statistics

- *Size:* 153 336 acres
- *Start:* Nov 8, 2018, ~6:30 am
- *Dates:* Nov 8–25, 2018 (18 days)
- *Structures Damaged/Destroyed:* 19 531
- *Population Displaced:* over 50 000
- *Fatalities:* 85
- *Persons Located:* 3266





Camp Fire Structure Losses

Category of Damage[a]	Affected (1-9%)	Minor (10-25%)	Major (26-50%)	Destroyed (>50%)	Total
Single Residence	439	47	3	13 696	14 185
Multiple Residence	21	3	1	276	301
Mixed Commercial/Residential	1	1	0	11	13
Non-residential Commercial	76	18	8	528	630
"Other" Minor Structures[b]	87	32	13	4286	4418
Infrastructure[c]	2	0	2	7	11
Total	626	101	27	18 804	19 558

[a] Damage categories are adopted from Federal Emergency Management Agency preliminary damage assessment guidelines.
[b] "Other" includes uninhabitable structures such as detached garages and sheds > 11 m^2 (120 ft^2).
[c] Infrastructure includes communications towers, water supply equipment, and bridges.

90% of all structures damaged or destroyed

NIST Camp Fire Report #3, Table 1.

192 Contributors — THANK YOU!

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Office of the State Fire Marshal

Damage Inspectors (DINS)

Data Collectors

Fire Departments

Law Enforcement

Town of Paradise

Transportation

Water Districts

Emergency Medical Services

National Weather Service

Reviewers

Public Affairs Office

Presentation Themes

- ***Well prepared Intermix community***
- ***Rapid Fire Spread to and within Paradise***
  - impact on life safety, response and losses
- ***Burnovers***
  - large number (documented *versus* reported)
  - occurred in town and on major egress arteries
  - significant impact on life safety
- ***Structure Ignition Pathways and Community Hardening***
  - what can/should be dome at the structure and parcel
  - What should be done at the community level
  - Coupled approach to structure/parcel/community hardening and wildland treatments - NIST Hazard Mitigation Methodology (HMM)

NIST *Interface* Case Studies & WUI Scale

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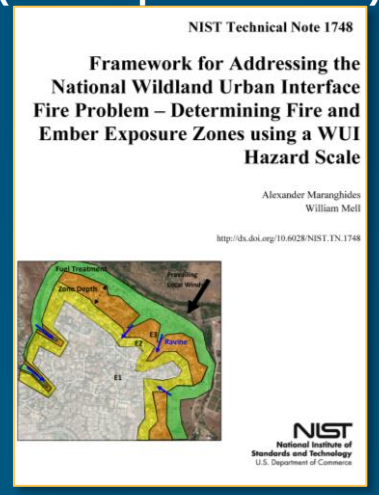
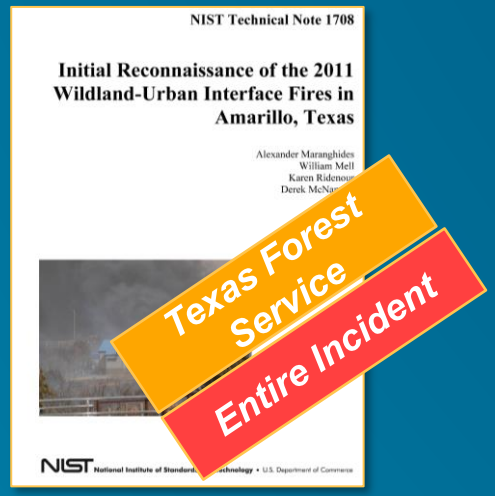
NIST TN 1635 (Witch #1)

NIST TN 1796 (Witch #2)

NIST TN 1748 (WUI Exposure Scale)

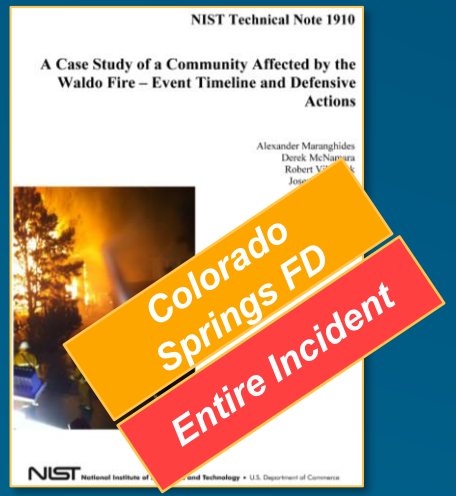


NIST TN 1708 (Amarillo #1)



NIST TN 1909 (Amarillo #2)

NIST TN 1910 (Waldo)



Intro and Previous Case Studies

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Summary of Findings:

- WUI fires vary significantly geospatially and temporally
- Exposures (fire and embers) can vary on a parcel level (less than ¼ acre) scale
- Defensive actions have significant impact on structure survival
- Defensive actions are more effective in low exposures
- Damaged = defended
- Cannot understand the post fire scene unless we understand exposure *and* defensive actions
- Parcel level combustibles (including auxiliary structures) bring fire to the structure

Key Takeaways:

- Know your community; where the fuels are and what can be safely defended
- If a structure is damaged it was most likely defended
- Reduce “fuel wicks” (fences, hedge rows, other linear features)
- Auxiliary structures can pose significant hazard as they can be readily ignitable and frequently are not regulated

Why The Camp Fire?

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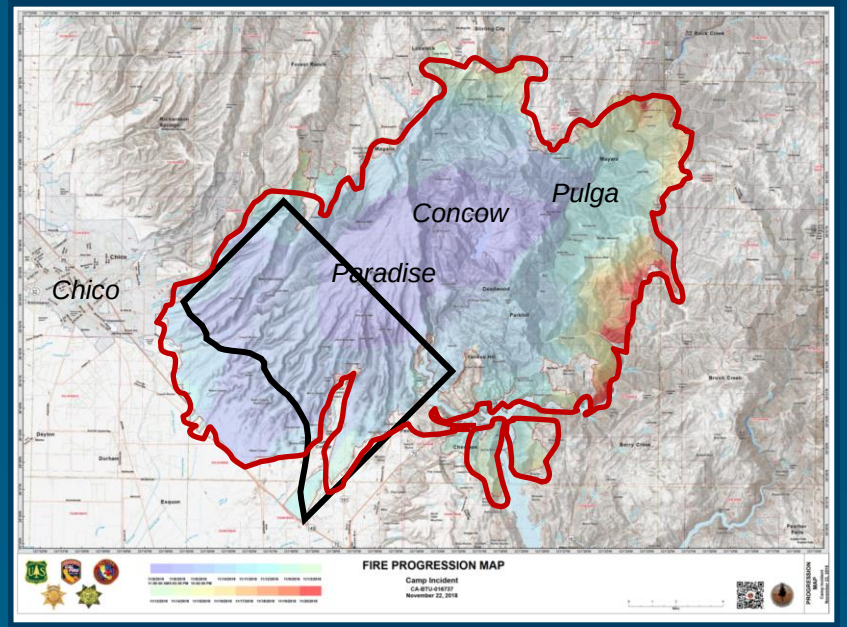
- Intermix Fire with:
  - extreme fire behavior
  - size and losses and
  - evacuation of entire town
- Data-rich scene
- NIST technical partnerships in place
- Fully integrated with local officials (CALFIRE)
- Representative of many other similar communities

Camp Fire ~ 14 % Butte County area



Camp Fire ~ 4× Washington, D.C. area

The NIST Camp Fire Case Study

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- ✓ Report #1: Camp Fire Preliminary Reconnaissance
- ✓ Report #2: Preliminary Data Collected from the Camp Fire Reconnaissance
- ***Report #3: Fire Progression Timeline***
- Report #4: Notification, Evacuation, Temporary Refuge Areas, and Burnovers
- Report #5: Emergency Response and Defensive Actions
- Data Visualization Tool

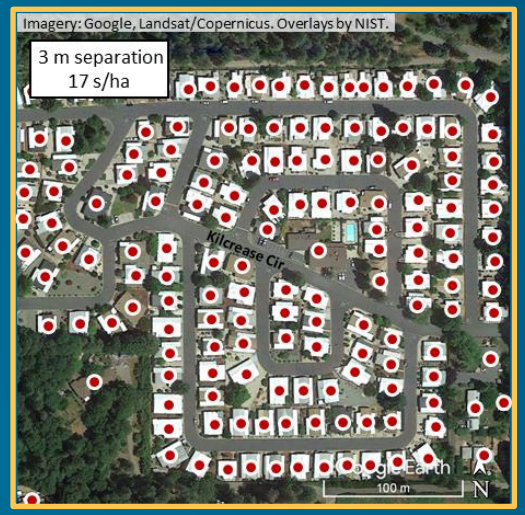
Pre-Fire Conditions

wind + drought + topography + fire history

Range of Housing Density in Paradise

a) Apple Tree Village Mobile Home Park

- ≤ 3 m (10 ft) separation
- 7 structures / acre



b) Lancaster Dr (Bille Rd)

- 3 m (10 ft) separation
- 2.9 structures / acre

c) Valley Ridge Dr

- 8 m (26 ft) separation
- 1.4 structures / acre

d) Round Valley Ranch Rd

- 25 m (82 ft) separation
- 0.3 structures / acre

NIST Camp Fire Report #3, Figure 2.

Pre-fire Conditions

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Summary:

- Fire history, drought, weather event and topography all came together – the perfect storm
- Well prepared intermix community:
  - Evacuation plan in place, practiced
  - Hardened infrastructure
  - Public works trained in fire
- Fire fighting staffing at increased level in town and regionally

Implementation:

- Prepare, prepare, prepare
- Know your community (fire history, fuel loadings, local conditions and severe weather events)
- Consider fuel treatments around critical infrastructure
- Plan for COG
- Assess communications in context of power outages and evacuation of key in-town facilities
- Assess the potential for loss of water

Fire Progression

IC overview* | *detailed narrative* | *analysis* | *maps

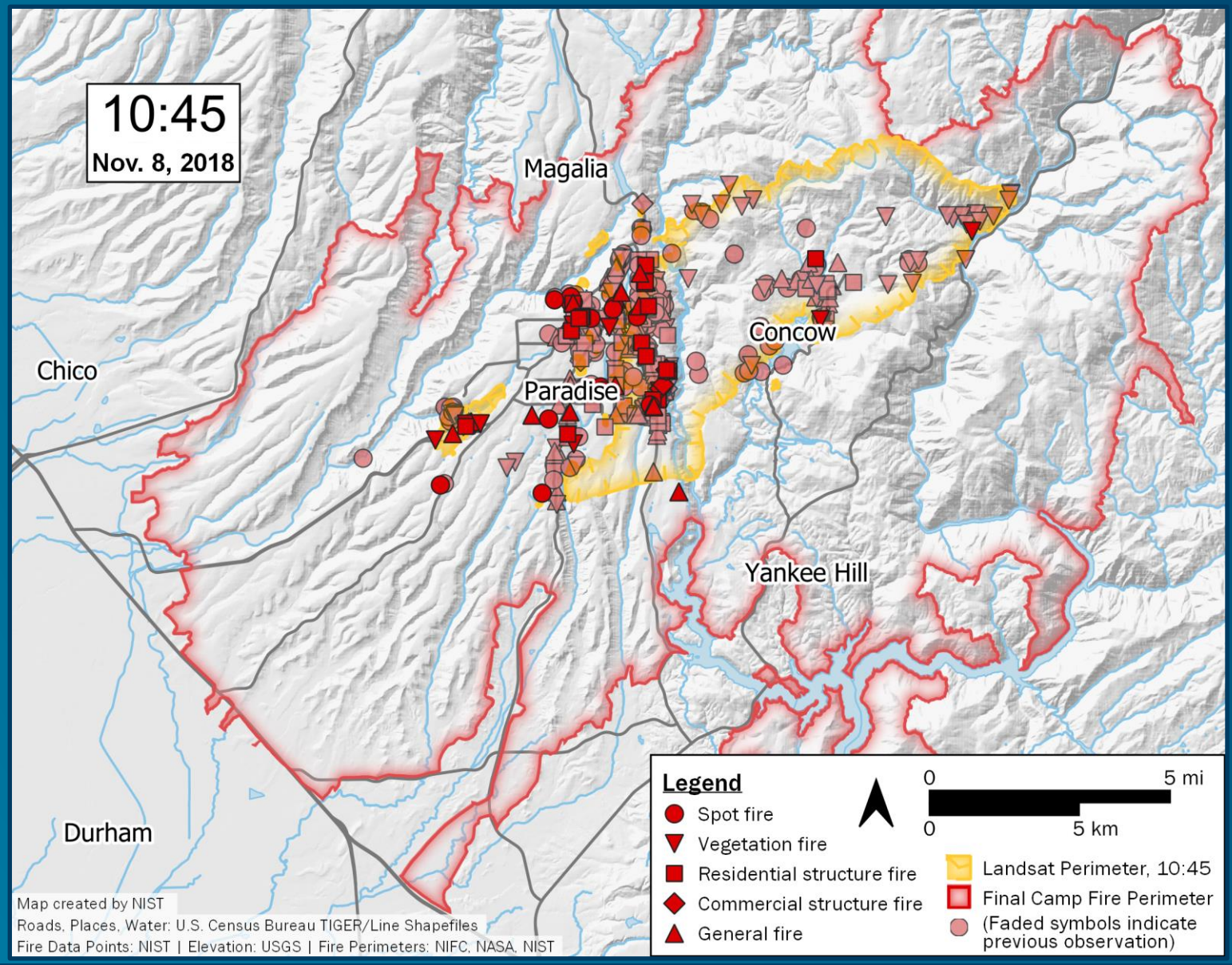
Strong Wind at Rim Road

Video courtesy of TD-005, 07:32.
Used with permission.

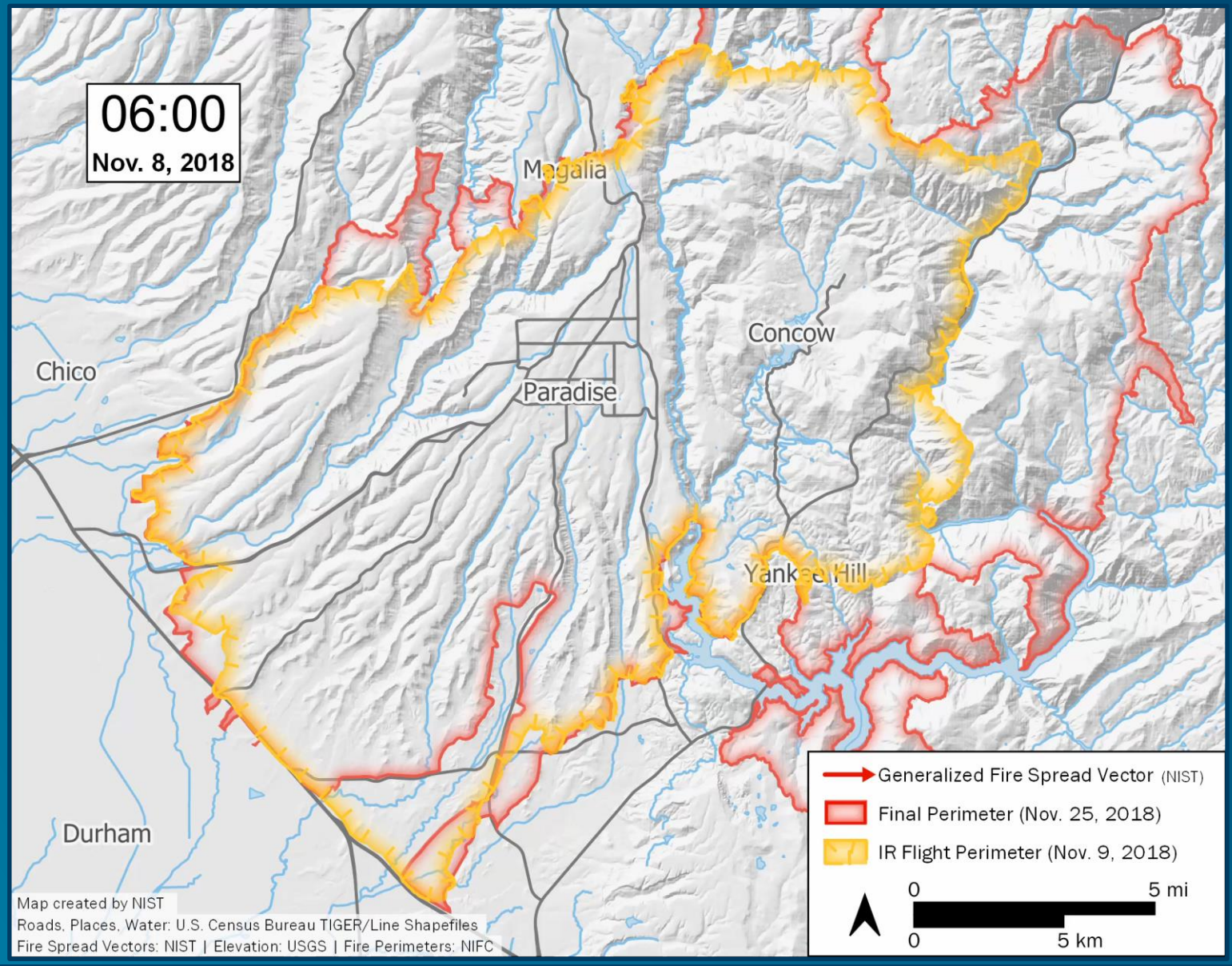
- Spot fires on ridgetop and into Concow
- Strong east/northeast winds blowing rocks

NIST Camp Fire Report #3, Figure 25.

Fire Progression Summary by 10:45



Fire Progression Summary (Day 1)



NIST Camp Fire Report #3, Figure 22.

Fire Progression

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Summary:

- Fire spread rate of 7 miles in 90 minutes (4.7 mph)
- Spotting arrived 40 minutes before fire front
- Fire spread was not unidirectional
- At several locations fire “hang-up” for many hours
- Local extreme fire behavior with flame lengths over 100 ft

Implementation:

- Consider extreme weather when establishing trigger points for evacuation
- Consider spotting potential of local fuels
- Consider impact of far field spotting on egress routes
- Identify high hazard locations and installations and have info ready to communicate to mutual aid

Burnovers

19 documented

11 incidents occurred 7:50 am – 10:00 am

19 Identified Burnovers

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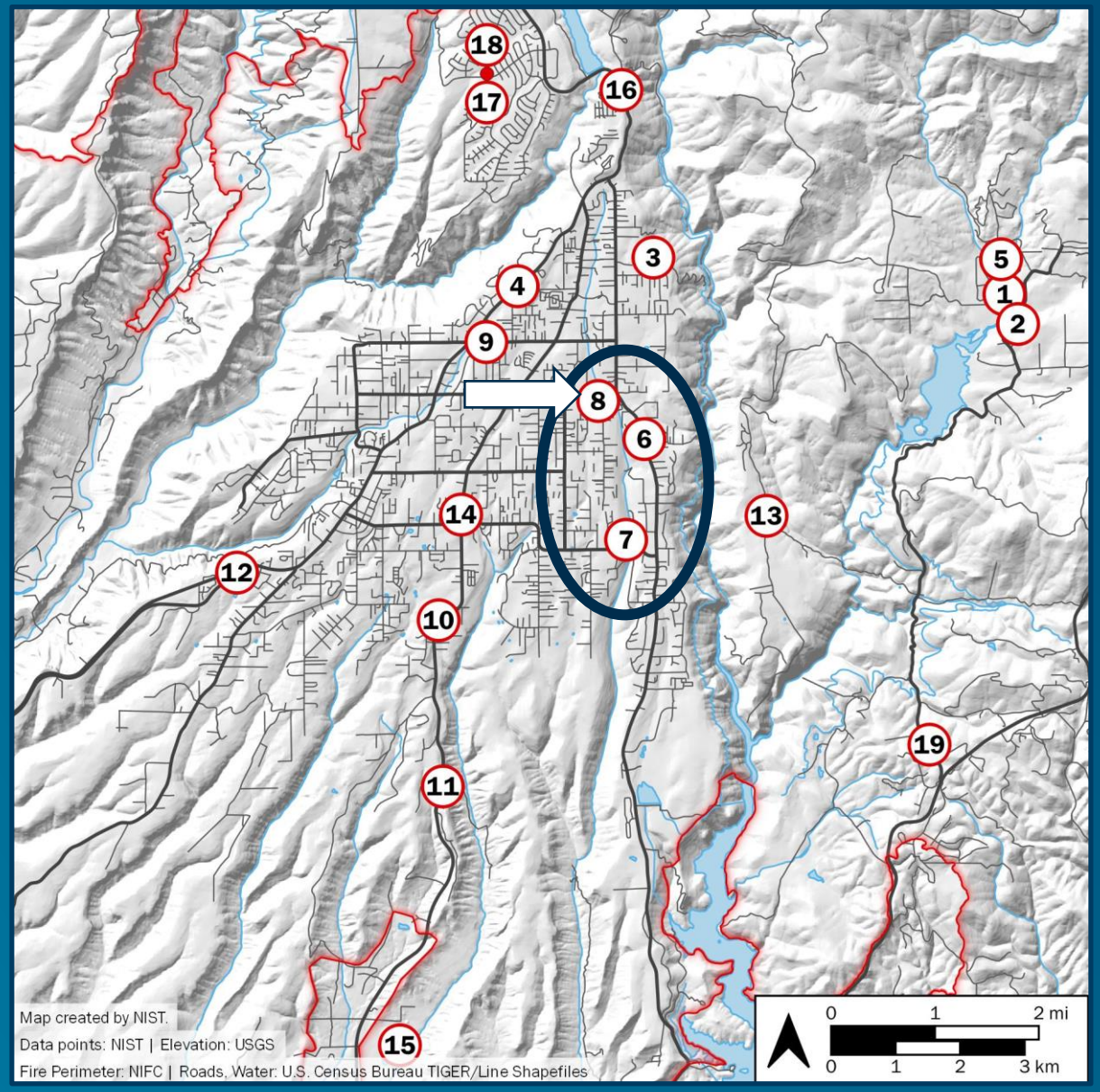
Report describes identified:

burnovers, entrapments, and "near misses"

- Unexpectedly caught
- Life-threatening position
- Fire overtakes personnel or equipment
- Escape routes or safety zones are absent, inadequate, or compromised
- May or may not result in injury
- Possible damage to equipment

Source: ViralHog
Used with permission.

Burnover #8: Bille Road



NIST Camp Fire Report #3, Figure 47.

Burnover #8: Bille Road

- Fire impacted standstill traffic
- Evacuees fled on foot, abandoning vehicles
- Fire engine at Pentz Rd and Bille Rd protected temporary refuge area with water spray
- Burning vehicles blocked roadway all day

NIST Camp Fire Report #3, Figure 34.

Life Safety

Photo courtesy of TD-041, 10:49 (Nov 9). Used with permission.

Photo courtesy of TD-122, 09:40. Used with permission.

Photo courtesy of TD-041, 09:04 (Nov 10). Used with permission.

- 13 of 19 impacted civilian evacuation
- Standstill traffic; abandoned vehicles
- Zero visibility
- Burning vegetation, structures, and vehicles along roadway
- Multiple civilian rescues
- Shelter-in-place and traffic redirection

Severity of Local Conditions

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- Severe local exposures impact life safety and buildings
- Parcel and fuel ownership may not correlate
- Might not have control over fuels giving the high exposures


Photo courtesy of TD-155, 10:21.
Used with permission.


Video courtesy of TD-127, 10:17.
Used with permission.


Photo courtesy of TD-112, 11:53.
Used with permission.


Photo courtesy of TD-101, 12:22.
Used with permission.


Photo courtesy of TD-101, 12:01.
Used with permission.


Photo courtesy of TD-209, 09:03.
Used with permission.


Photo courtesy of TD-209, 09:07.
Used with permission.

Difference 0.25 mi and 4 min.

Burnovers Summary

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Summary:

- Life safety issue for public and first responders
- Can impact not only local traffic but overall community egress
- Can block arteries for hours
- Can generate extreme local fire behavior impacting local traffic and surrounding parcels/fuels
- Backups from one burnover can cause traffic to get in another
- Can prevent first responders from accessing parts of the incident
- Exposures may be from fuels on neighboring parcels

Implementation:

- Consider possible burnover locations in and out of town
- Consider fuel treatments to reduce burnover potential
- Consider safety zones in and out of town, in context of extreme fire spread and burnovers
- Consider fuel ownership in assessing and mitigating potential burnovers

General Fire Behavior

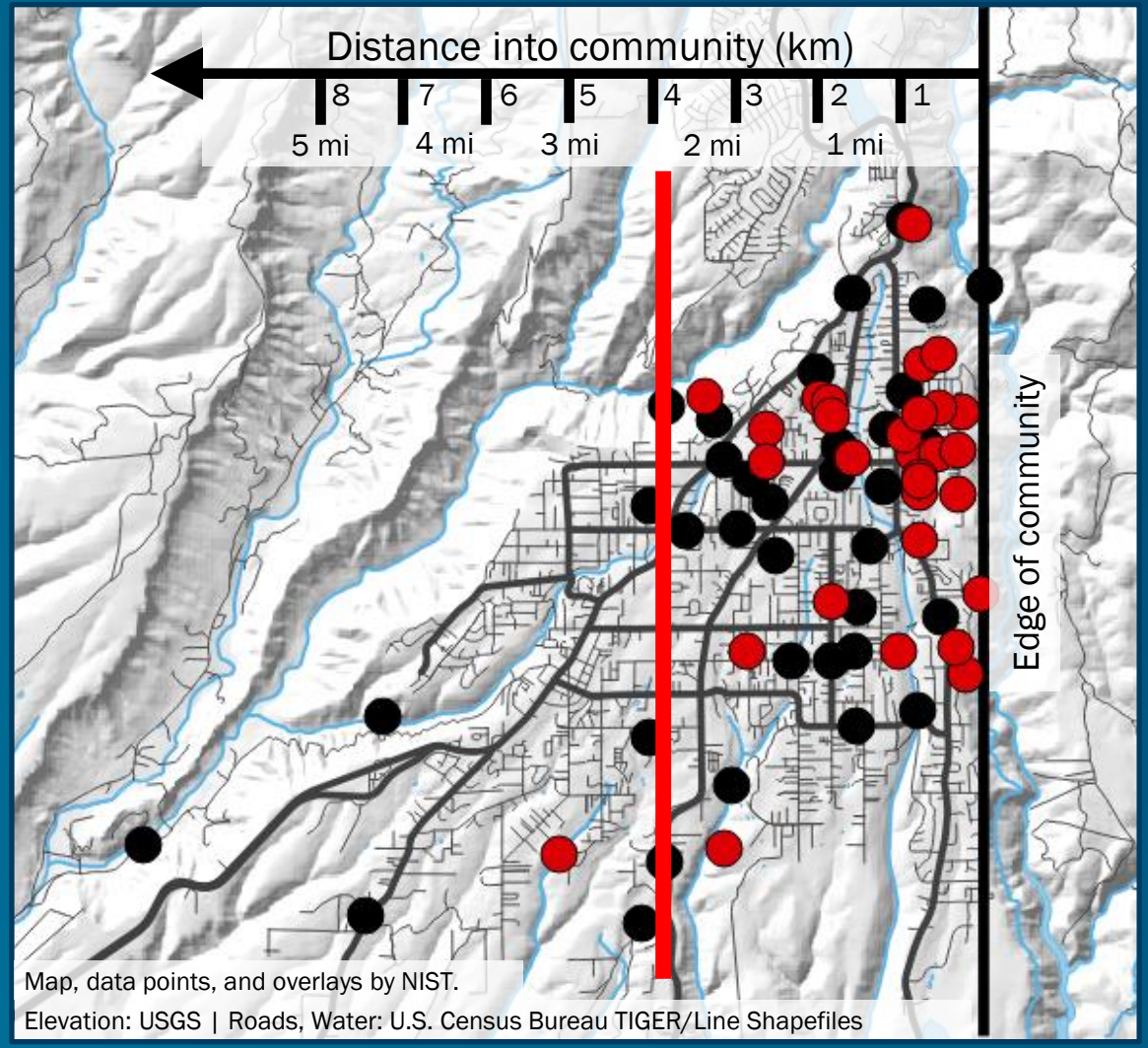
effects of wind and terrain | spot fires

structure ignition pathways

Early Spot Fires in Paradise

Spot Fire Ignitions

- 07:49 – 08:30 (N=30)
- 08:30 – 10:30 (N=35)

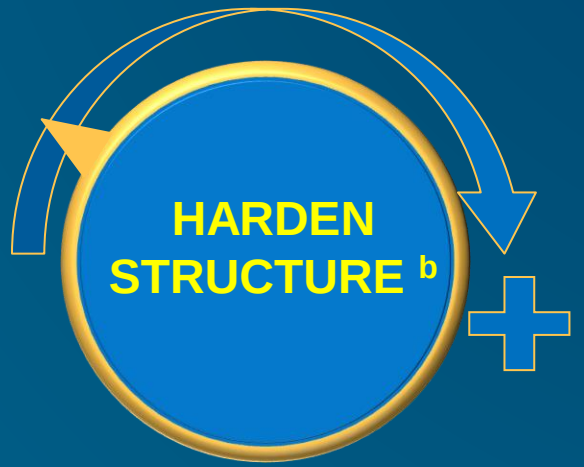


30 identified spot fires within first 40 minutes (red)

NIST Camp Fire Report #3, Figure 51.

Structure Ignitions – Exposure and Structure Hardening Relationship

Chapter 49,
Defensible Space
Chapter 7A Subcommittee 6

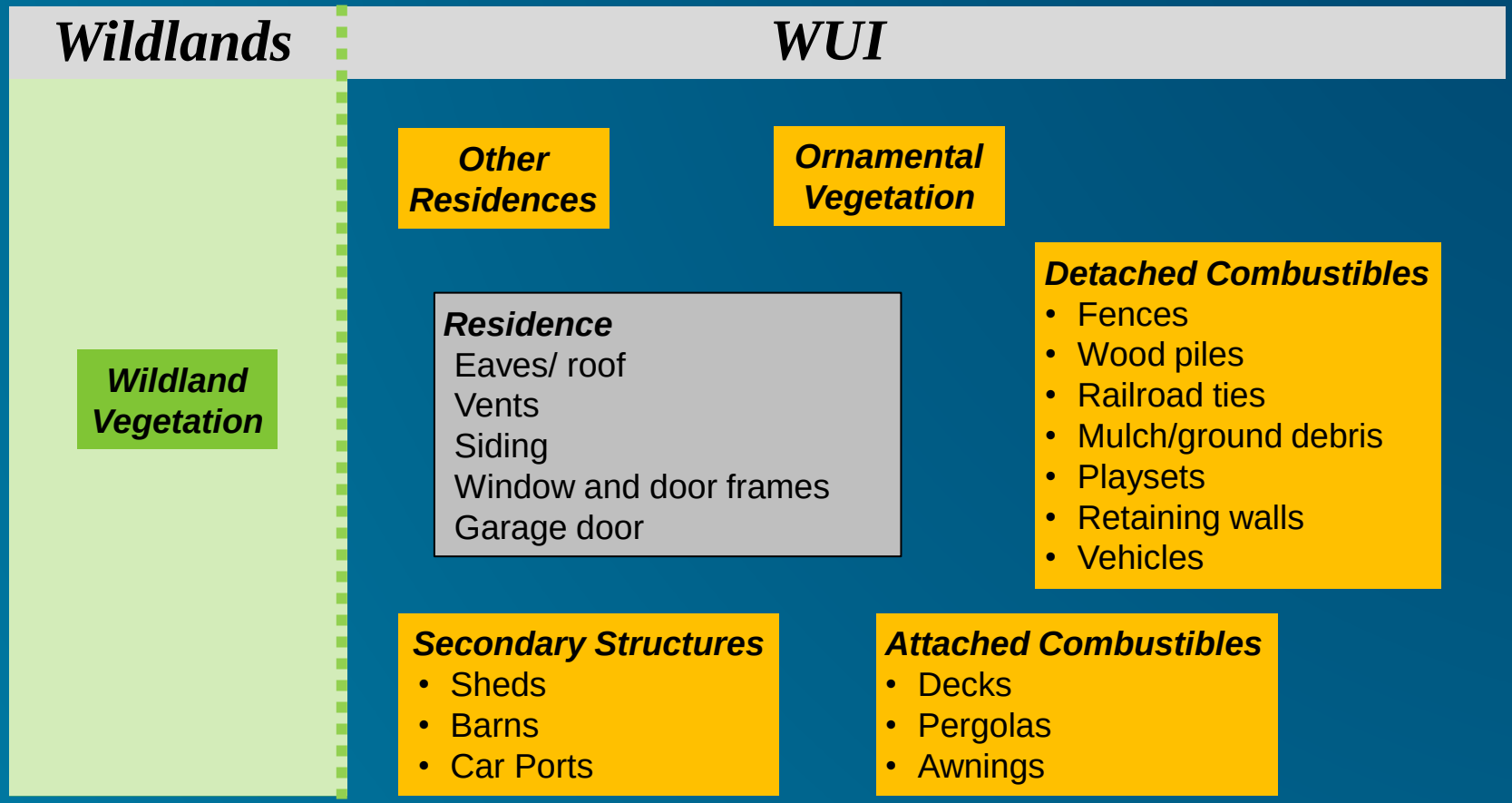


Chapter 7A

a Reduce fire and/or ember exposures

b Hardening for embers and/or fire

Structure Ignition Pathways



NIST Camp Fire Report #3, Figure 54.

Vulnerabilities – Failure Points

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windows

NIST Photo. Camp Fire 2018.

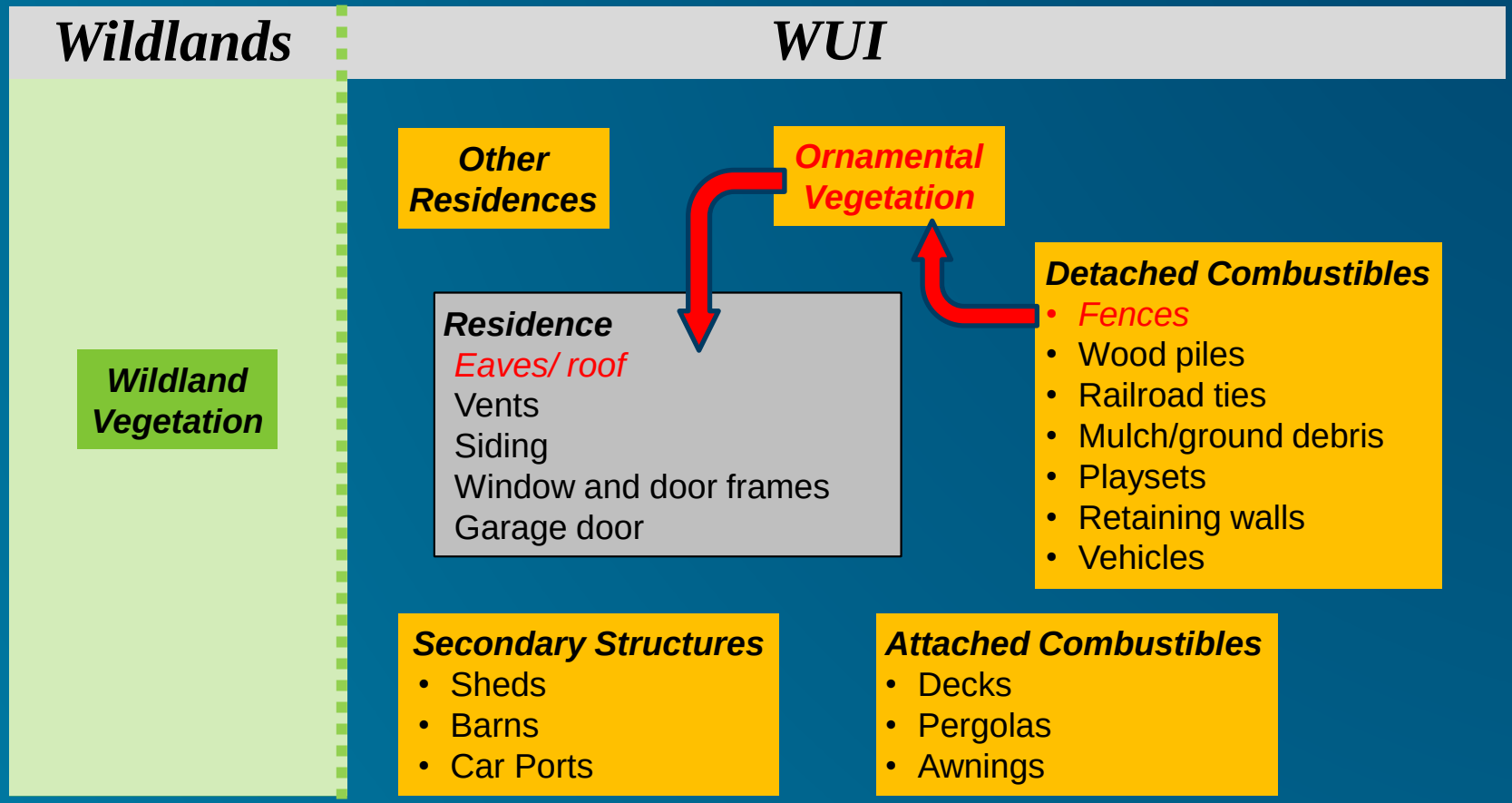
NIST Photo. Camp Fire 2018.

roof / eaves

NIST Photo. Camp Fire 2018.

NIST Photo. Camp Fire 2018.

Structure Ignition, Example 1



NIST Camp Fire Report #3, Figure 54.

Structure Ignition, Example 1

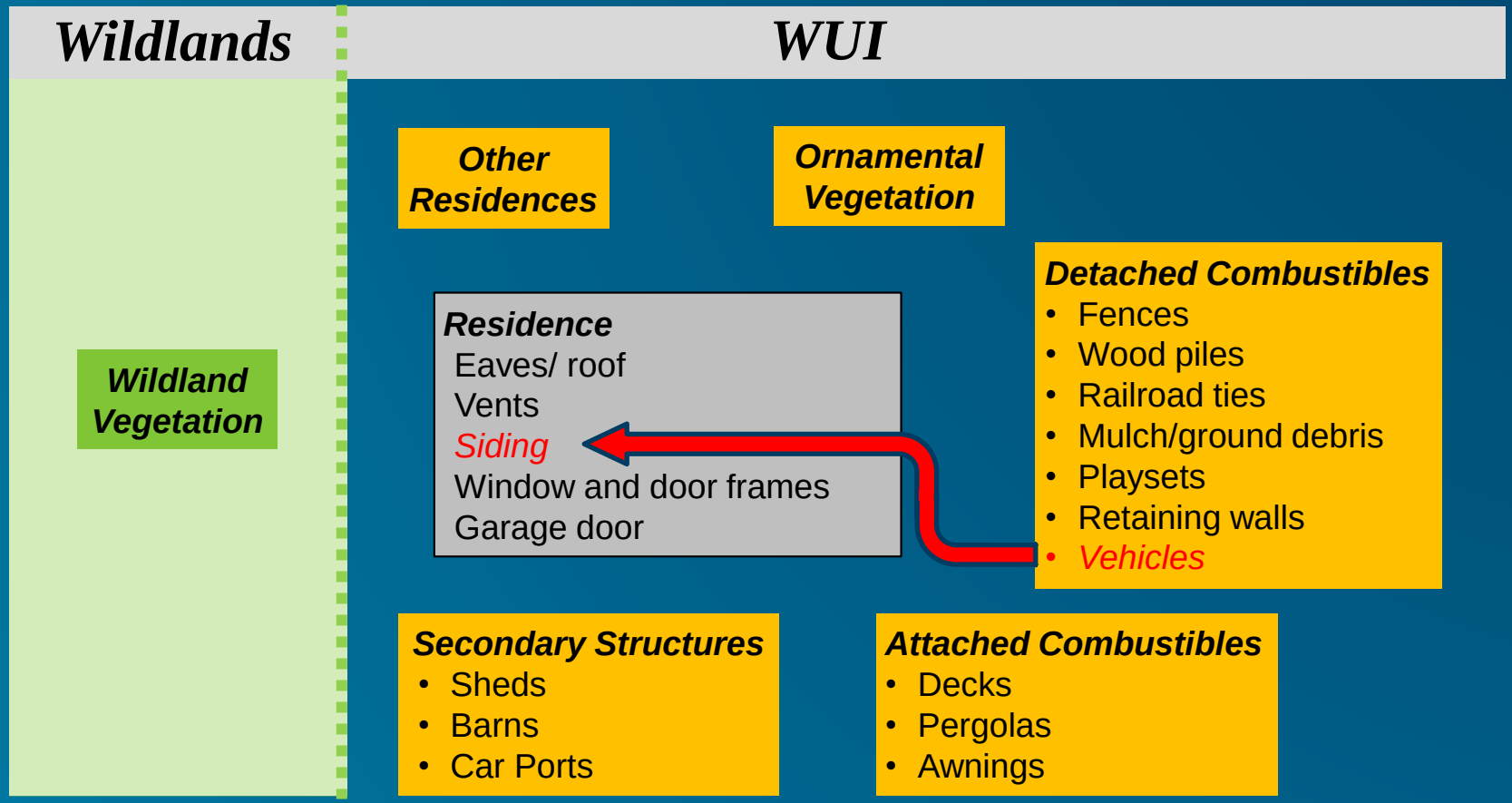
a) t = 0 s

b) t = 139 s

Structure ignition on Dade Ct in Magalia. Images are two minutes apart and show fire spread from surface fuels to fence to vegetation to eaves. The combustible fence is estimated to be approximately 1.8 m (6 ft) away from the structure.

NIST Camp Fire Report #3, Figure 53.

Structure Ignition, Example 2



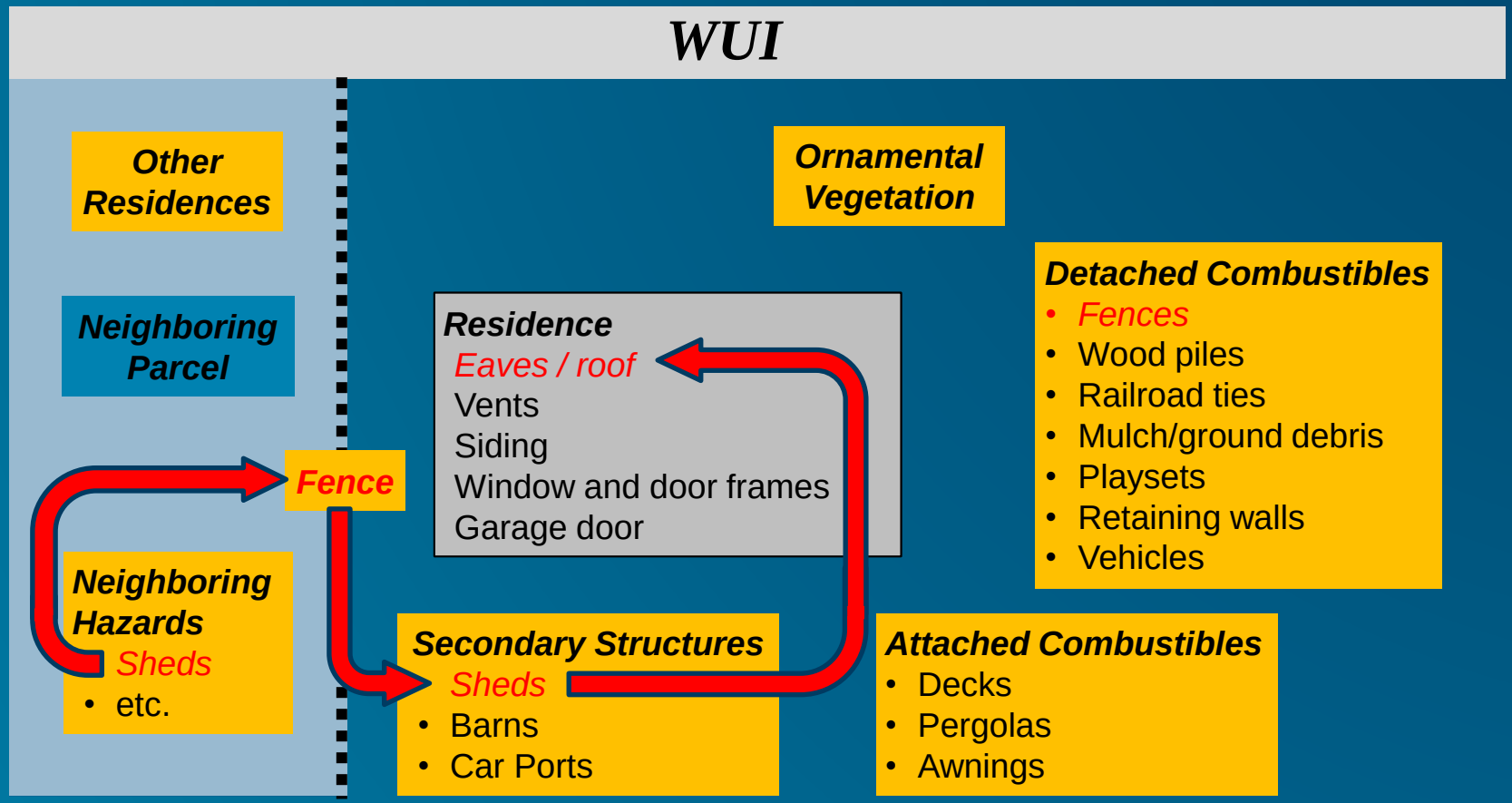
Structure Ignition, Example 2

a) A dozer displaced the vehicle to stop fire spread

b) Associated evidence of the fire ignition and defensive actions encountered during NIST damage assessments.

NIST Camp Fire Report #3, Figure 52.

Structure Ignition, Example 3



Structure Ignition, Example 3

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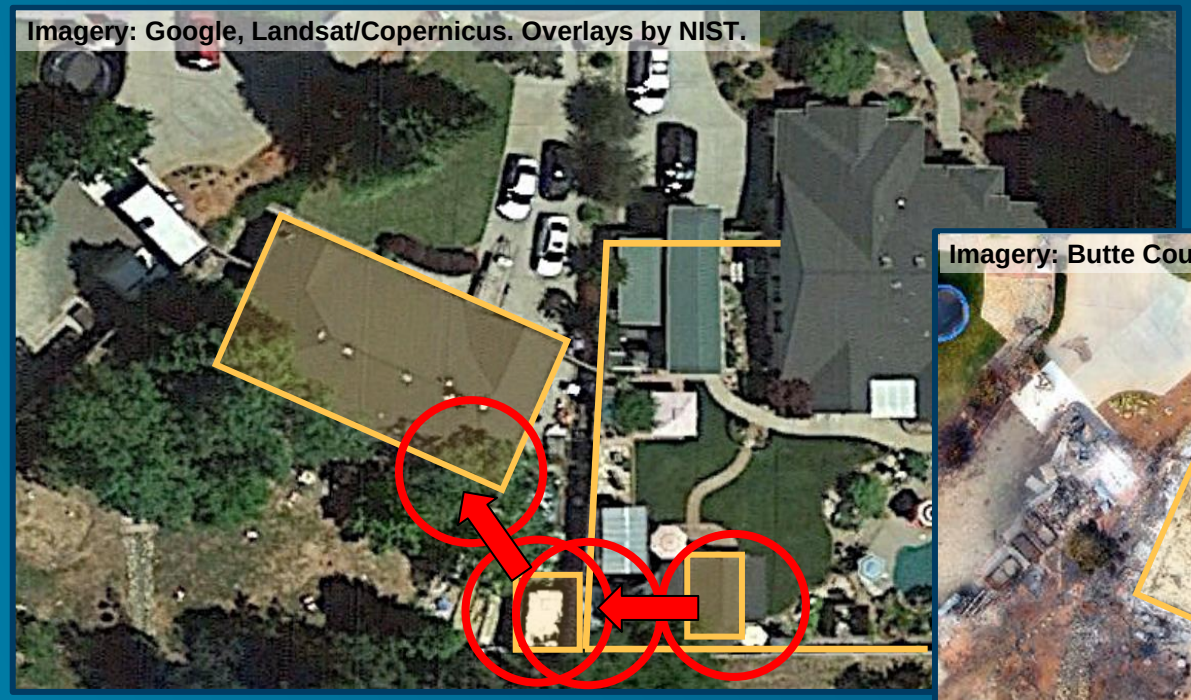
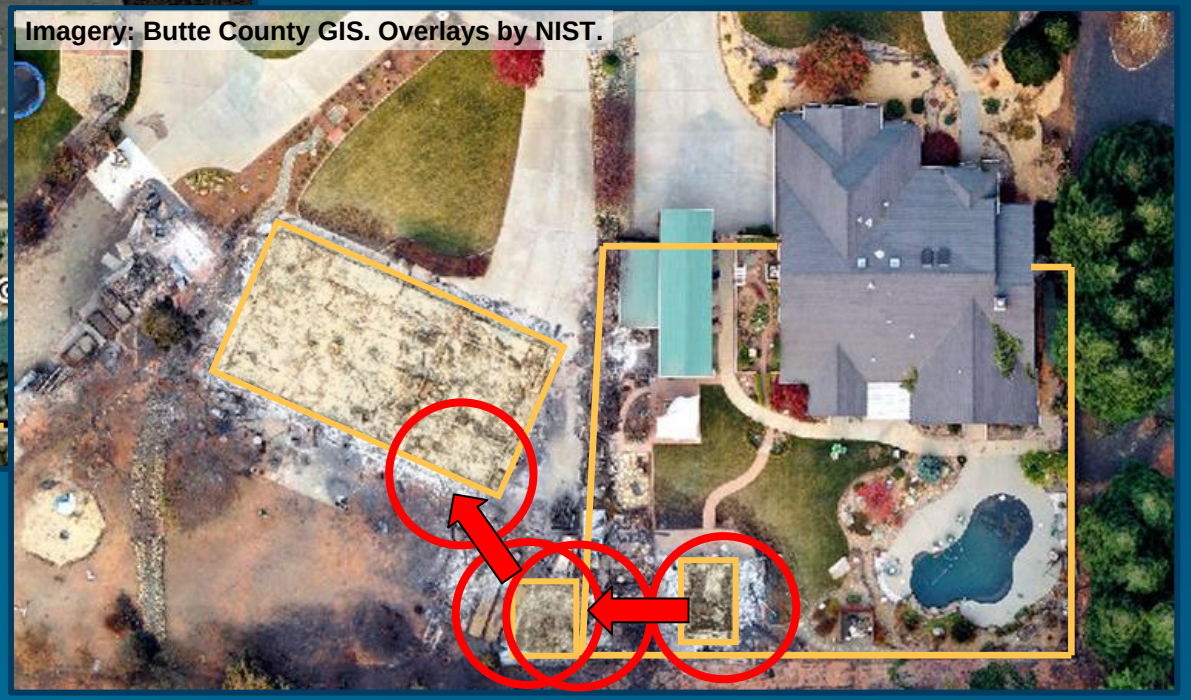
Shed ignition leading to residence destruction





Fire Spread Pathway:
Shed **to** ***Fence*** **to** ***Shed*** **to** ***House***

General Fire Behavior

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Summary:

- Spotting rate in town was 30 in 40 minutes (45/hour)
- Heavy spotting occurred in the first 3 miles from the community's upwind edge
- Spotting could have traveled from further upwind in the wildfire
- Structure ignitions result from relationship between exposures and structure hardening
- Structure ignitions at the parcel level can occur from flames and/or embers
- Structure ignitions can occur through one or more parcel fuels

Implementation:

- Consider spotting and ignition potential in and around town
- Consider structure survivability in the absence of defensive actions
- Consider parcel-level hazard reduction
- Consider parcel-to-parcel fire propagation

Primary Driving Factors

ignition potential + fuel density + wind/terrain + extent of fire front

Primary Drivers Influencing the Extent of Damage and Destruction

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1. Fuel ignition potential
2. ***Density of vegetative and structural fuels***
3. Wind and terrain
4. Extent/size of fire front reaching the communities

It was the confluence of these four factors that resulted in very aggressive fire behavior.

Density of Vegetative and Structural Fuels – Addressing the Hazard

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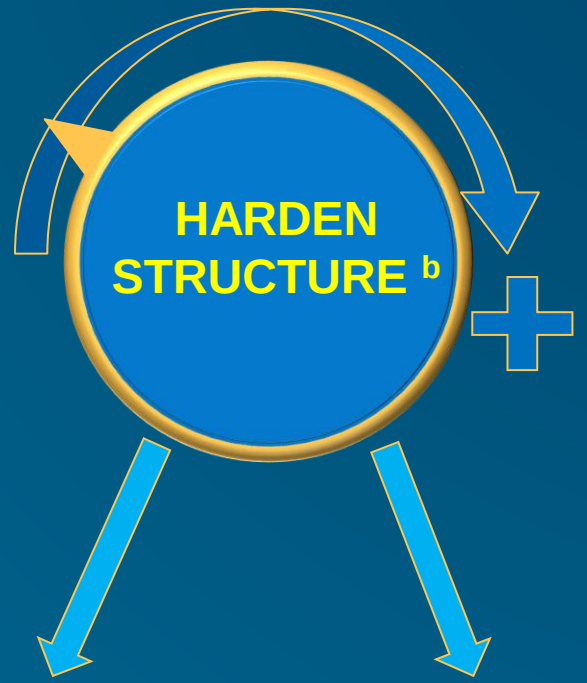
Displace Fuels

Remove Fuels



Fire Resistant Design

Ignition/Fire Spread Resistant Materials

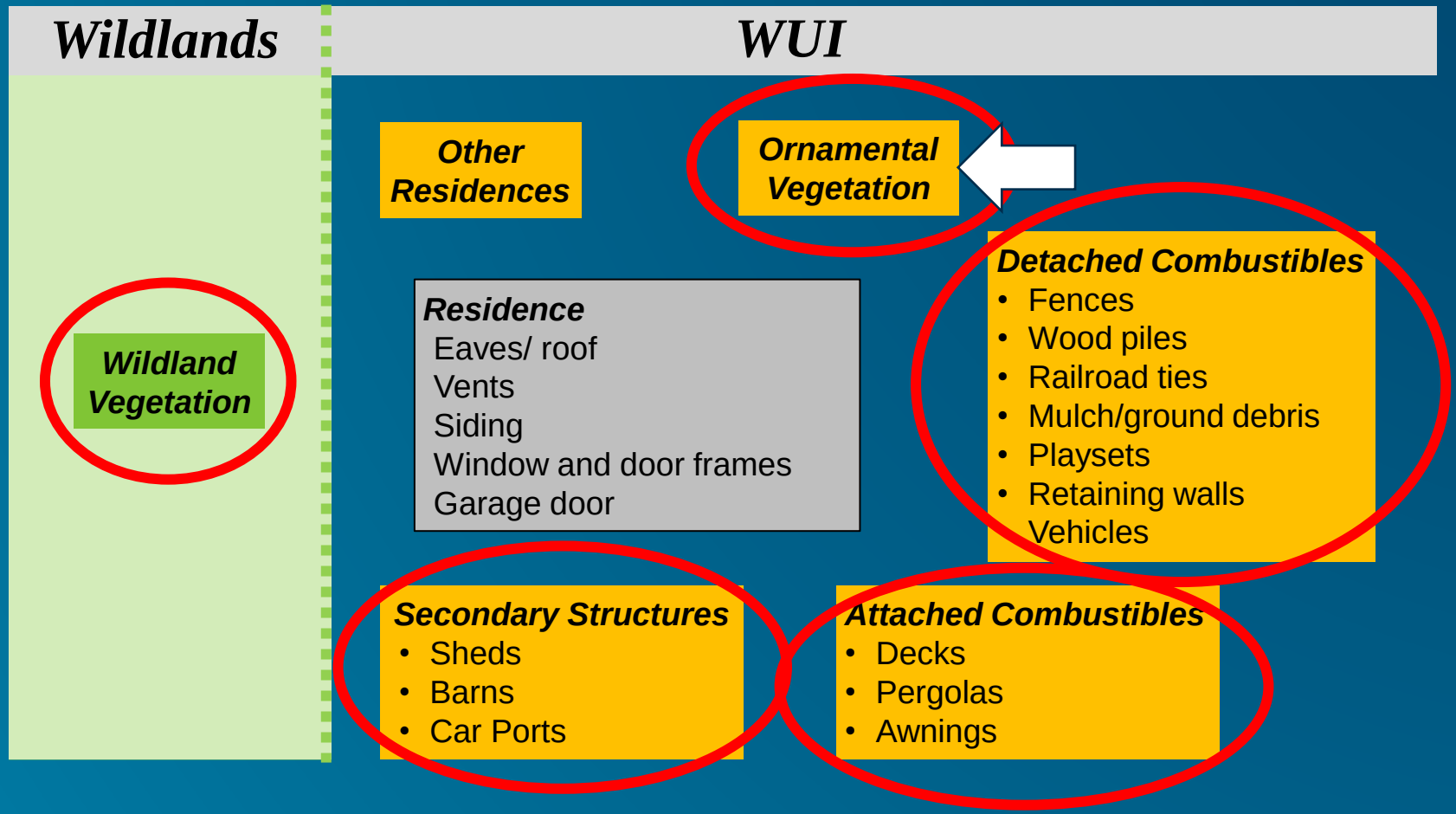
Community Design

Active Systems

a Reduce fire and/or ember exposures

b Hardening for embers and/or fire

Structure Ignition Pathways – Fuels Reduction



NIST Camp Fire Report #3, Figure 54.

Fuel Treatment Around Critical Infrastructure (Paradise Irrigation District)

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Fuel treatment and reduction conducted pre-fire, 2018

Rapid post-fire vegetative growth in pre-fire fuel treatment areas

Note: Imagery captured before completion of fuel treatment

Fuel treatments can reduce exposure but must be maintained

NIST Camp Fire Report #3, Figure 56.

Fuel Treatment Around Critical Infrastructure (Pine Ridge School, Magalia)

Photo by NIST (June 24, 2019).

Thinning and mastication fuel treatment and reduction conducted pre-fire

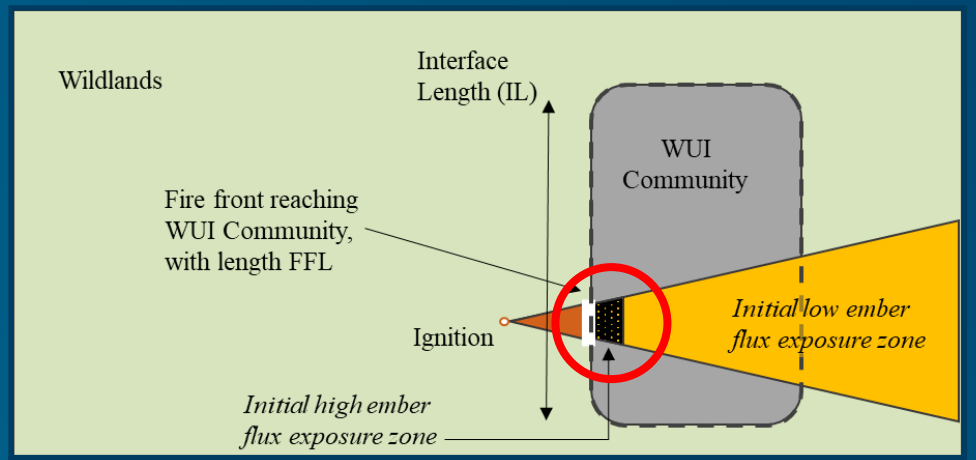
- Reduced severity of fire exposure
- Firefighter safety zone
- Designated, pre-planned community assembly point (not used in Camp Fire)

Extent/Size of Fire Front Reaching the Communities

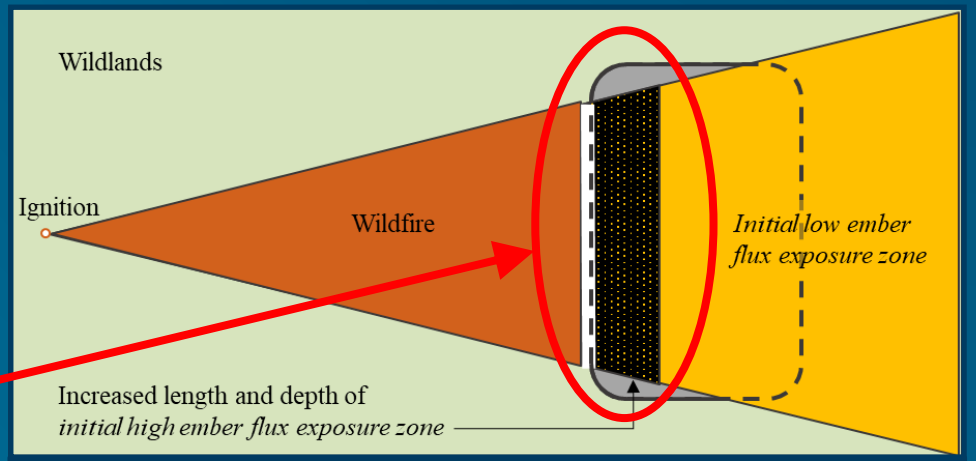
Idealized relationship between ignition location, near or far from WUI Community, and fire front and ember exposures reaching the community.

The wind is directed from left to right.

Critical difference in community-scale exposure



Ignition near WUI community



Ignition far from WUI community

NIST Camp Fire Report #3, Figure 57.

Primary Driving Factors Summary

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Summary:

- Ignition potential, terrain and wind played significant role is extreme fire behavior and losses
- Fuel density vegetative and structural/parcel level also played a significant role
- Fuel density is the only critical attribute that can be controlled on and around residential and commercial parcels
- Extend/size of fire front reaching the community rapidly overwhelmed available resources and impacted community evacuation

Implementation:

- Identify areas where local high winds may cause extreme fire behavior and consider how this may impact evacuations
- Consider fuels reductions within communities, at the parcel level, to reduce ignition potential
- Consider far field ignitions and potential size of fire front reaching the community under extreme conditions
- Consider far field ignitions when developing evacuation trigger points

Contributors – Technical Discussions

THANK YOU!

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U.S. DEPARTMENT OF COMMERCE

151 Technical Discussions

100 Fire Department

19 Law Enforcement

15 Town of Paradise

13 Transportation

2 Water Districts

1 Emergency Medical Services

1 National Weather Service

Community WUI Fire Hazard Framework

- WUI fire spread has significant impact on communities well beyond the loss of structures:
  - community evacuation
  - incident response

- WUI Fire Hazard Framework components:
  - Community details
  - Demographics
  - Vegetative and structural fuels
  - Fire history
  - Weather
  - Notification / Evacuation
  - Critical infrastructure
  - Continuity of operations and government
  - Response

Standardized comprehensive community pre-fire hazard documentation is needed

Thank You

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NIST

Camp Fire

Report: https://doi.org/10.6028/NIST.TN.2135

NIST Camp Fire Website:
https://www.nist.gov/el/fire-research-division-73300/wildland-urban-interface-fire-73305/nist-investigation-california