Camp Fire – Fire Progression Timeline

International Association of Fire Chiefs

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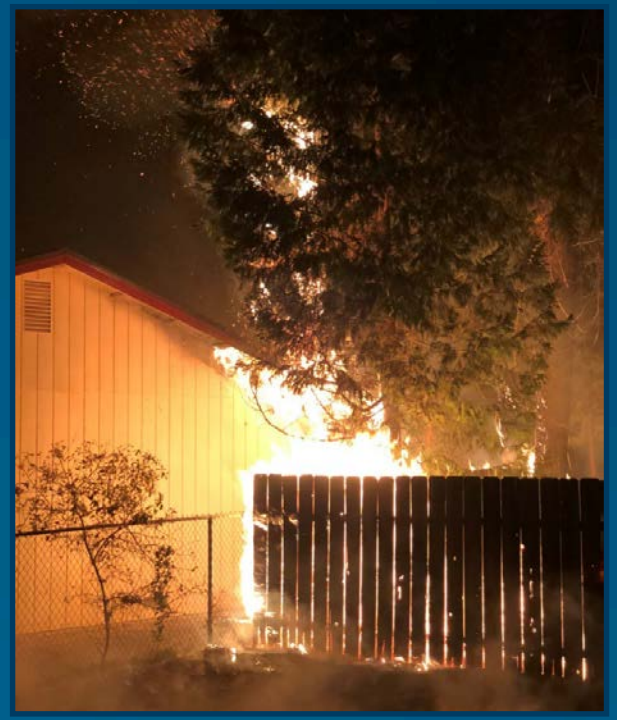


Photo courtesy of CALFIRE, used with permission

April 29, 2021

192 Contributors — THANK YOU!

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

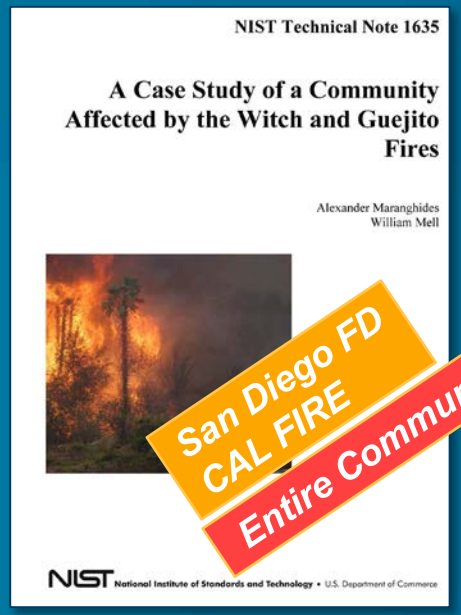
Presentation Themes

- ***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
- ***Not a unique event***
  - how many other communities are in a similar situation?

Previous NIST Case Studies and WUI Scale

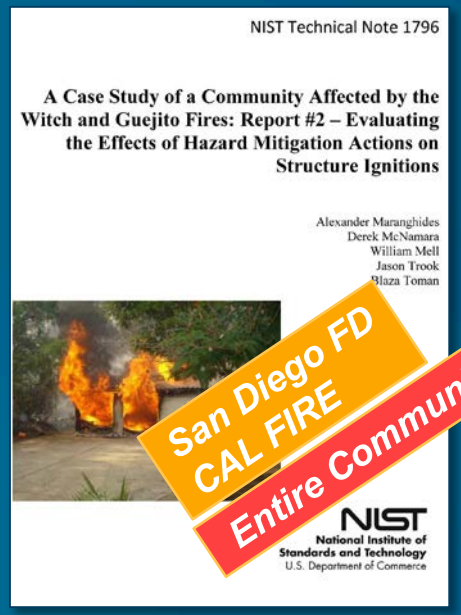
NIST National Institute of Standards and Technology U.S. Department of Commerce

NIST TN 1635 (Witch #1)



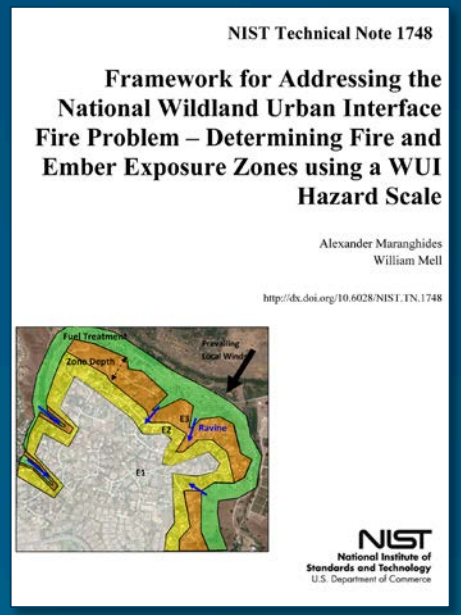
- **Timeline reconstruction**
- **Defensive actions**
- Structure ignitions
- Methodology for future developments

NIST TN 1796 (Witch #2)



- **Exposure quantification!!!**
- Defensive actions
- Effectiveness of mitigation

NIST TN 1748 (WUI Exposure Scale)



- **Exposure scale framework**
- Linking exposure to building construction through codes and standards

Previous NIST Case Studies and WUI Scale

NIST National Institute of Standards and Technology U.S. Department of Commerce

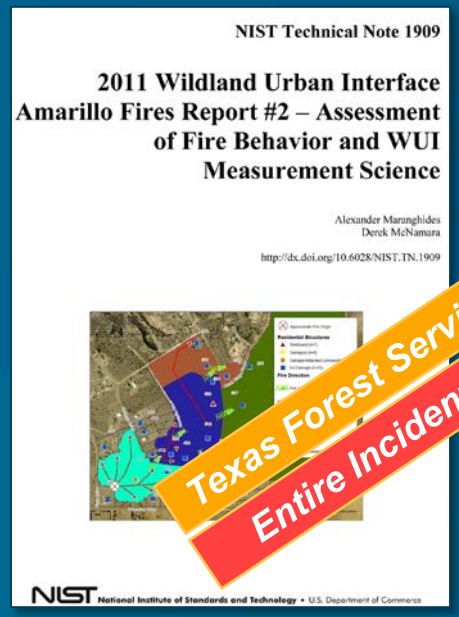
NIST TN 1708 (Amarillo #1)

Texas Forest Service

Entire Incident

- **Deployment methodologies**
- Damage Assessment Summary

NIST TN 1909 (Amarillo #2)

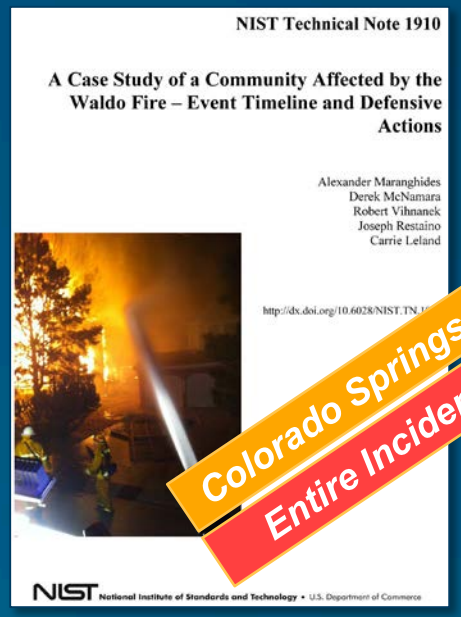


Texas Forest Service

Entire Incident

- **“Area/Neighborhood” Case Studies**
- Fire behavior

NIST TN 1910 (Waldo)

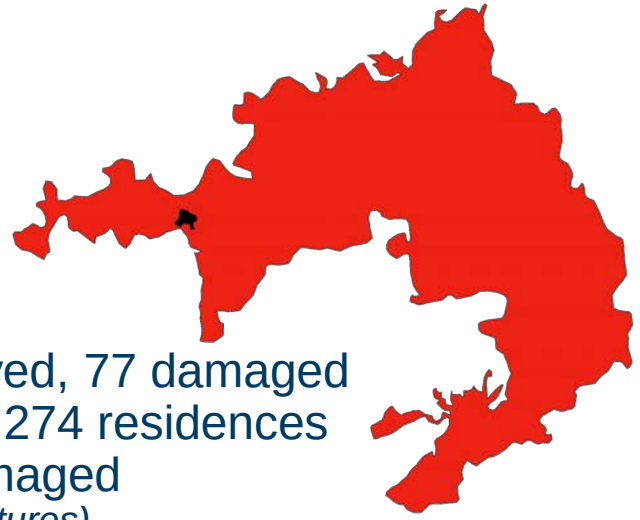


Colorado Springs FD

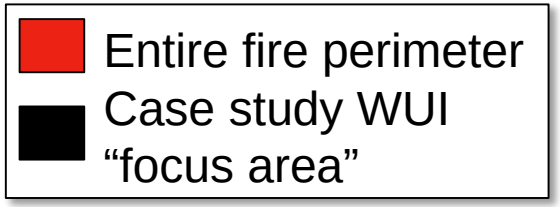
Entire Incident

- **Defensive actions**
- Timeline reconstruction
- Fire behavior

Adaptable Methodology – NIST Case Study Scales

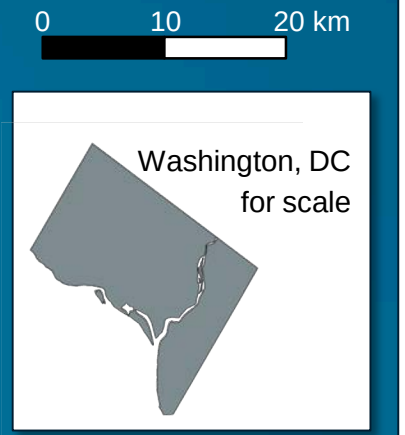


- **Witch Fire**
  - Overall: 1125 destroyed, 77 damaged
  - Focus: 1 community, 274 residences
  - 74 destroyed, 16 damaged
    (primary residential structures)



- **Tanglewood Complex**
  - Focus: entire WUI, entire fire, parcel-level data
  - 35 destroyed, 10 damaged

- **Waldo Canyon Fire**
  - Focus: entire WUI, parcel-level data
  - 344 destroyed, 103 damaged

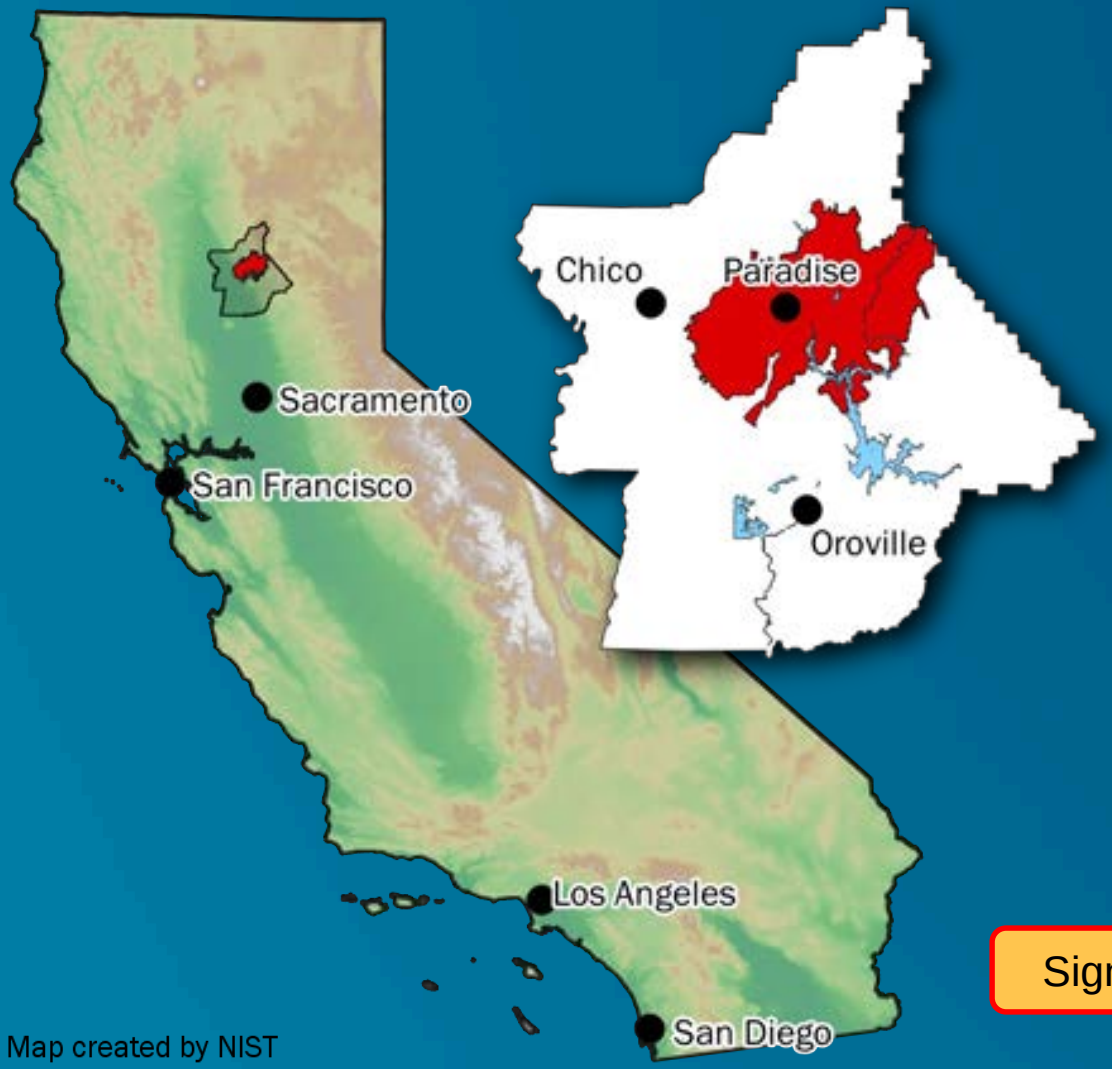


- **Camp Fire**
  - Overall: 13696 dest.
    489 damaged
  - Focus: entire WUI (intermix), community-level data

Camp Fire Overview

losses | statistics

Camp Fire Location



Map created by NIST
Elevation: USGS | Fire Perimeter: NIFC
Boundaries, Places, Water: U.S. Census Bureau TIGER/Line Shapefiles

2018 Population*

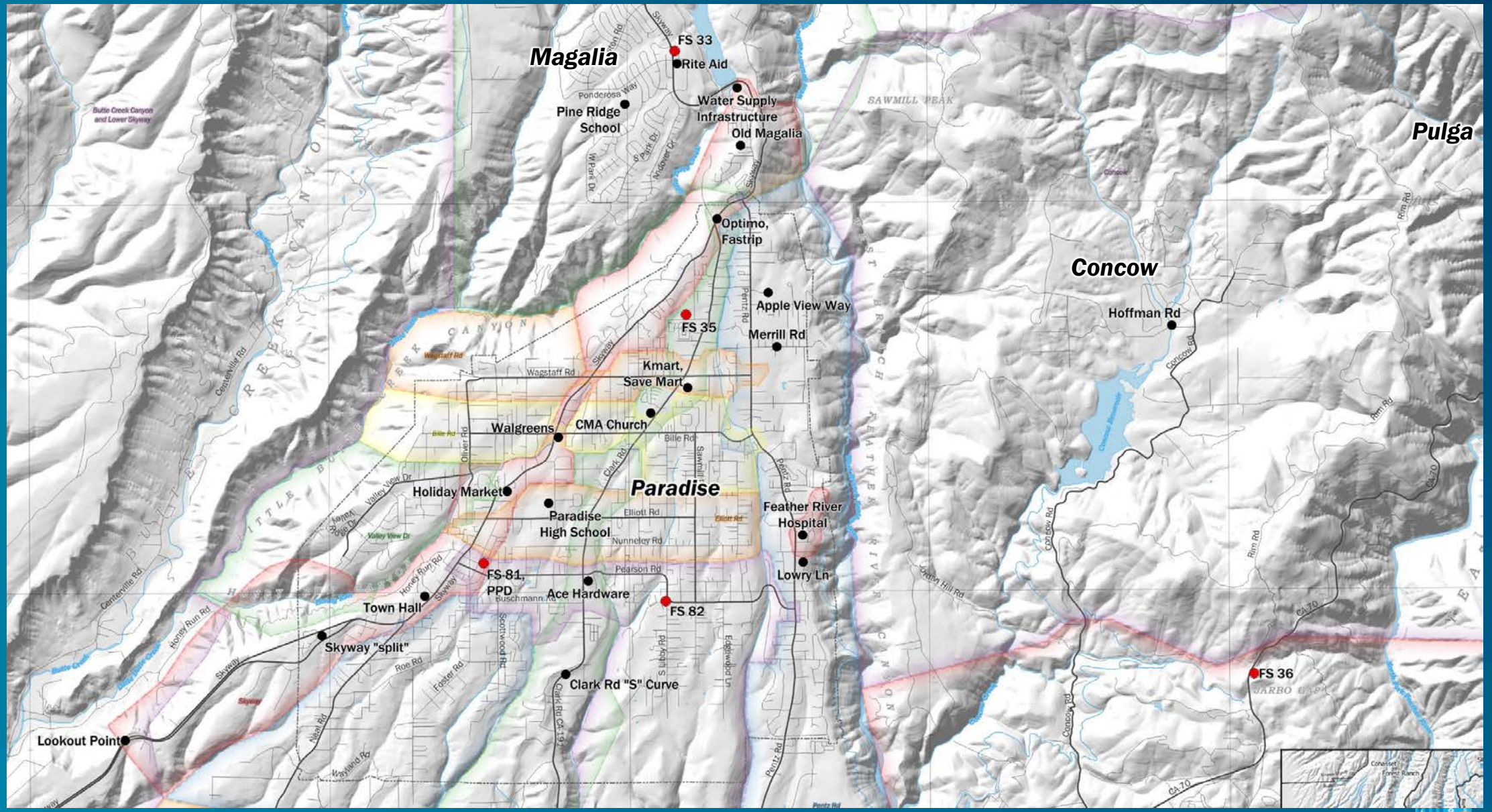
Location	Pop.
Paradise	26 218
Magalia	11 310
Concow	710
Chico (Urban Area)	91 998
Oroville (Urban Area)	41 837
Butte County	227 075

Significant development started during Gold Rush (1850s)

Town incorporated in 1979

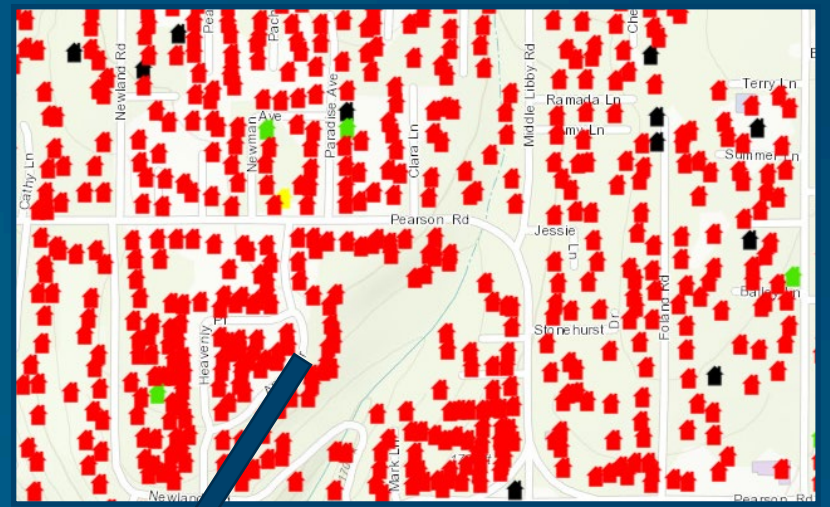
* 2018 ACS 5-year Estimates, US Census Bureau

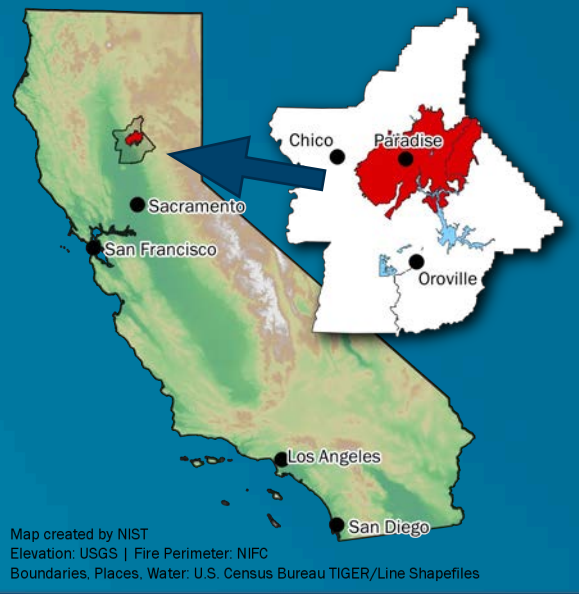
Paradise Points of Interest

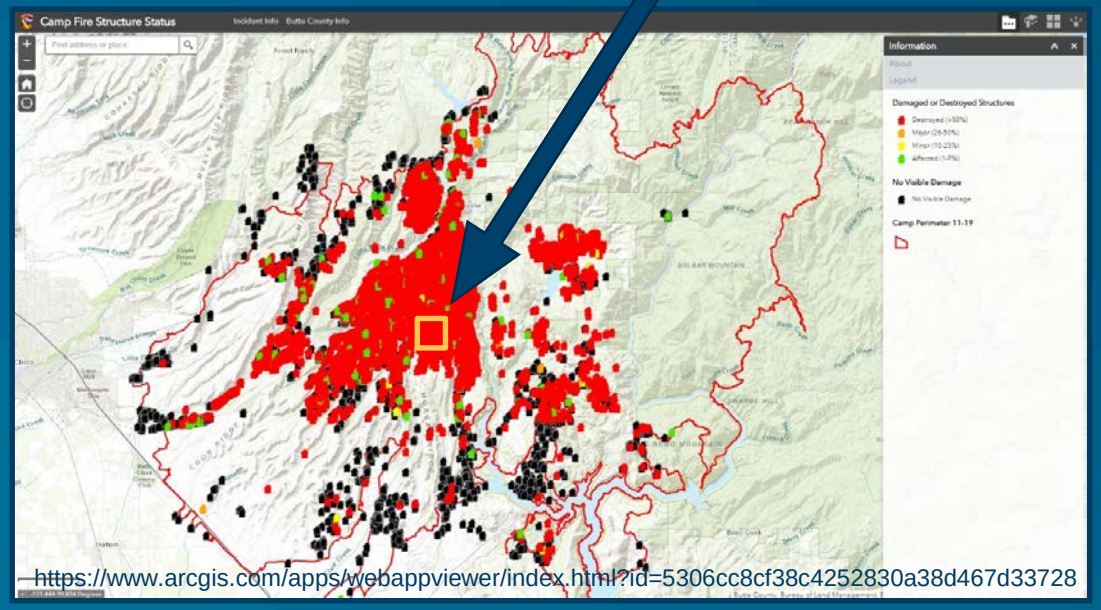


Camp Fire Overview Statistics

- *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







https://www.arcgis.com/apps/webappviewer/index.html?id=5306cc8cf38c4252830a38d467d33728

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.

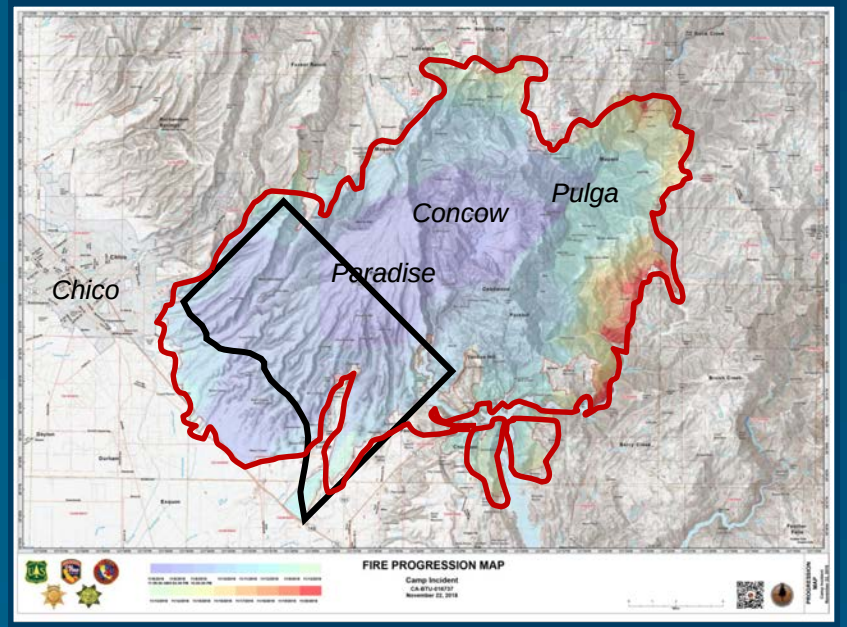
NIST Camp Fire Case Study

case-study plan | research questions

Why The Camp Fire?

- 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



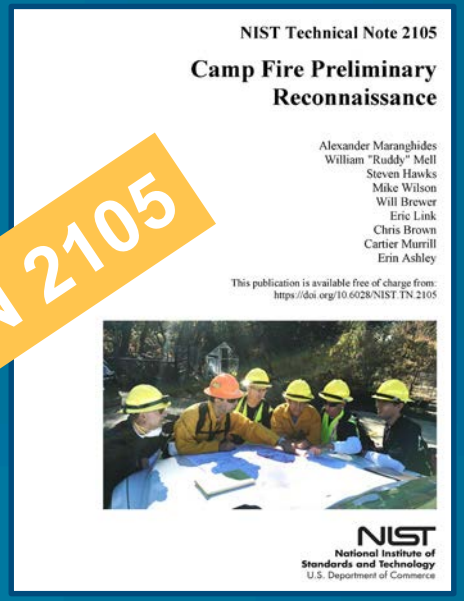
Camp Fire ~ 4× Washington, D.C. area

The NIST Camp Fire Case Study

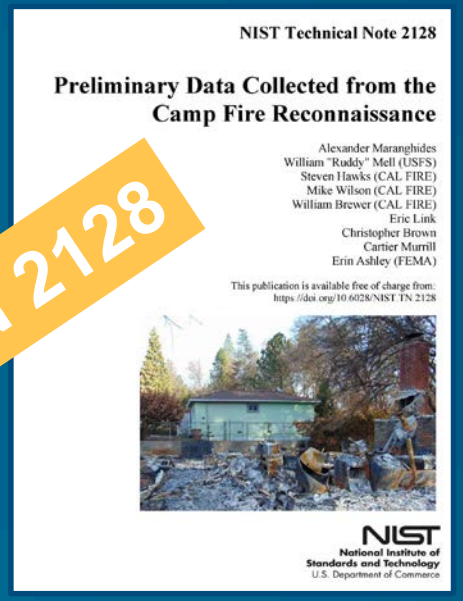
- ✓ Report #1: Camp Fire Preliminary Reconnaissance
- ✓ Report #2: Preliminary Data Collected from the Camp Fire Reconnaissance
- ➡ ***Report #3: Fire Progression Timeline***
- • Report #4: Notification, Evacuation, Temporary Refuge Areas, and Burnovers
- • Report #5: Emergency Response and Defensive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

Camp Fire Technical Research

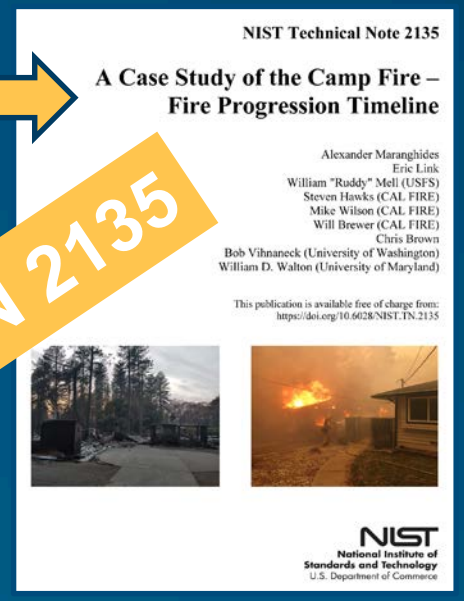
NIST National Institute of Standards and Technology U.S. Department of Commerce



TN 2105



TN 2128



TN 2135

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

Five Research Questions

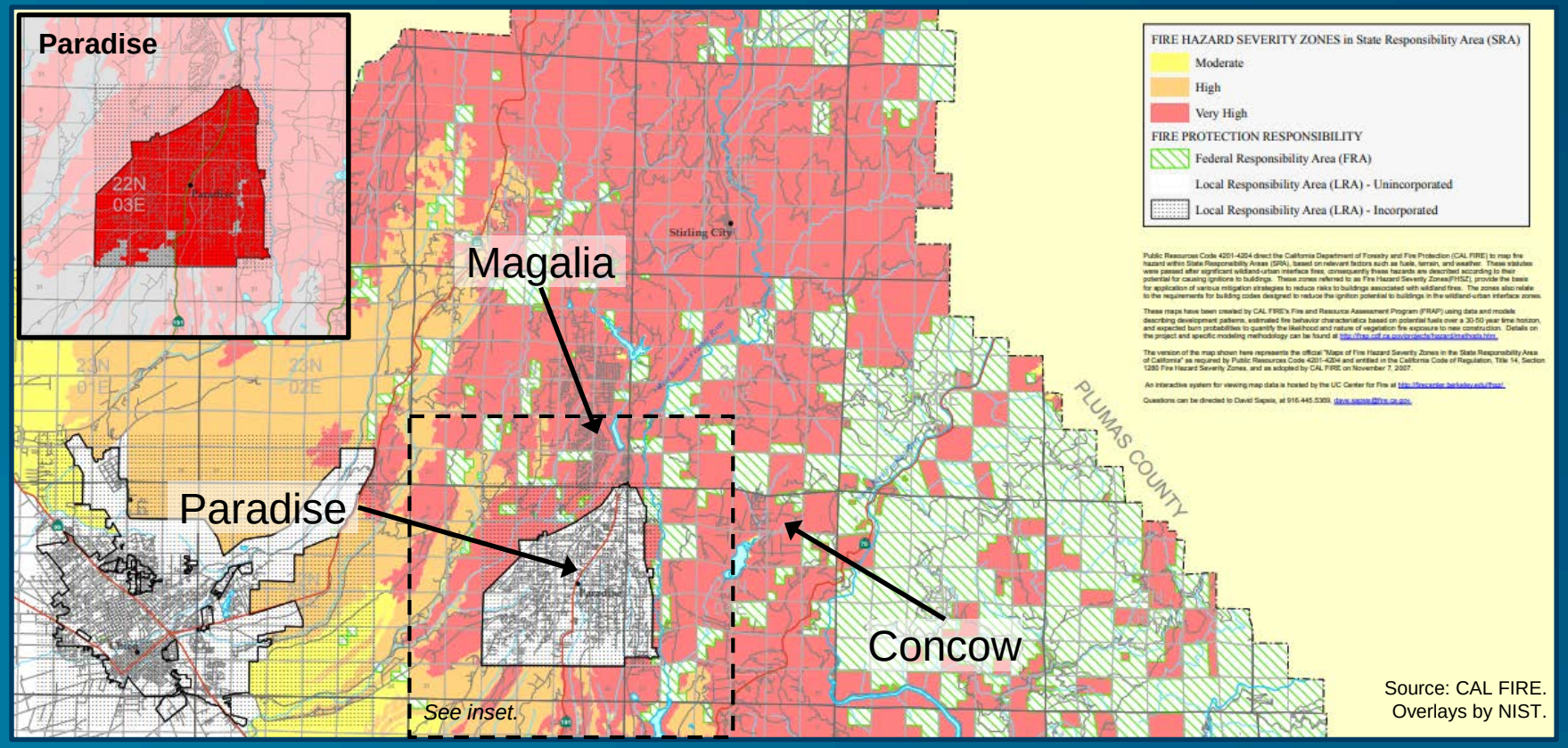
1. *How can a fire event of the scale of the Camp Fire be documented to facilitate the extraction of information for reducing future losses?*
2. *How did the fire spread to and within Paradise?*
3. *What were the primary causes of the extensive devastation?*
4. *What fire spread pathways caused structural ignitions?*
5. *How unique is Paradise as a community at risk of WUI fires?*

Pre-Fire Conditions

wind + drought + topography + fire history

community characteristics

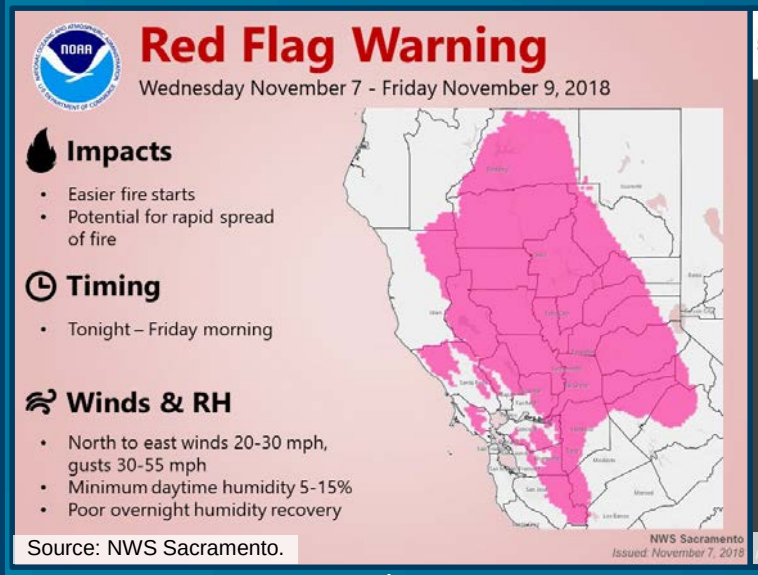
Butte County Fire Hazard Severity



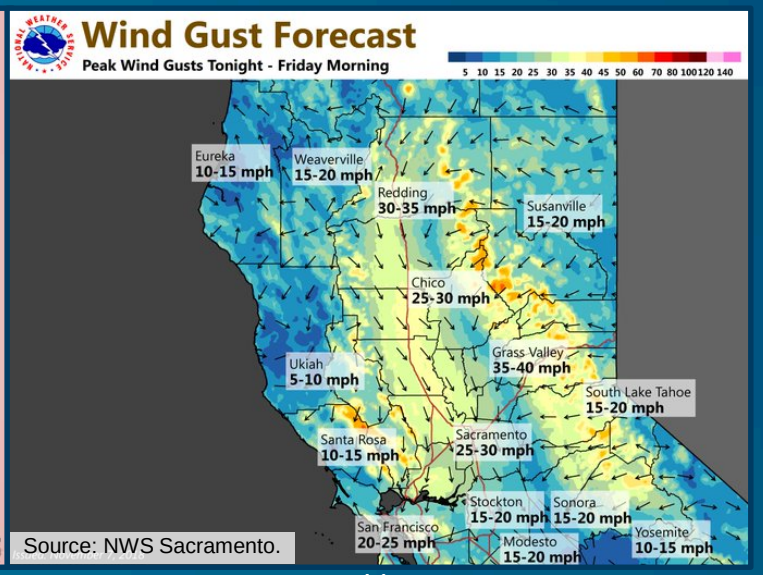
Source: CAL FIRE. Overlays by NIST.

Majority of area Very High Fire Hazard Severity Zone

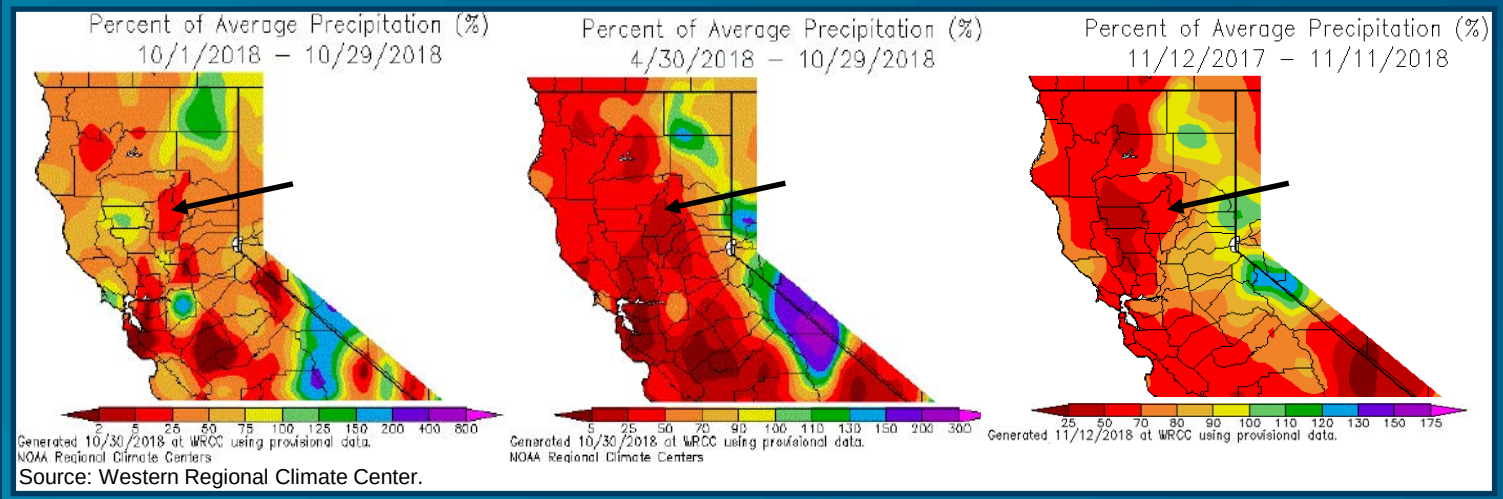
Red Flag Warning and Drought



a)



b)

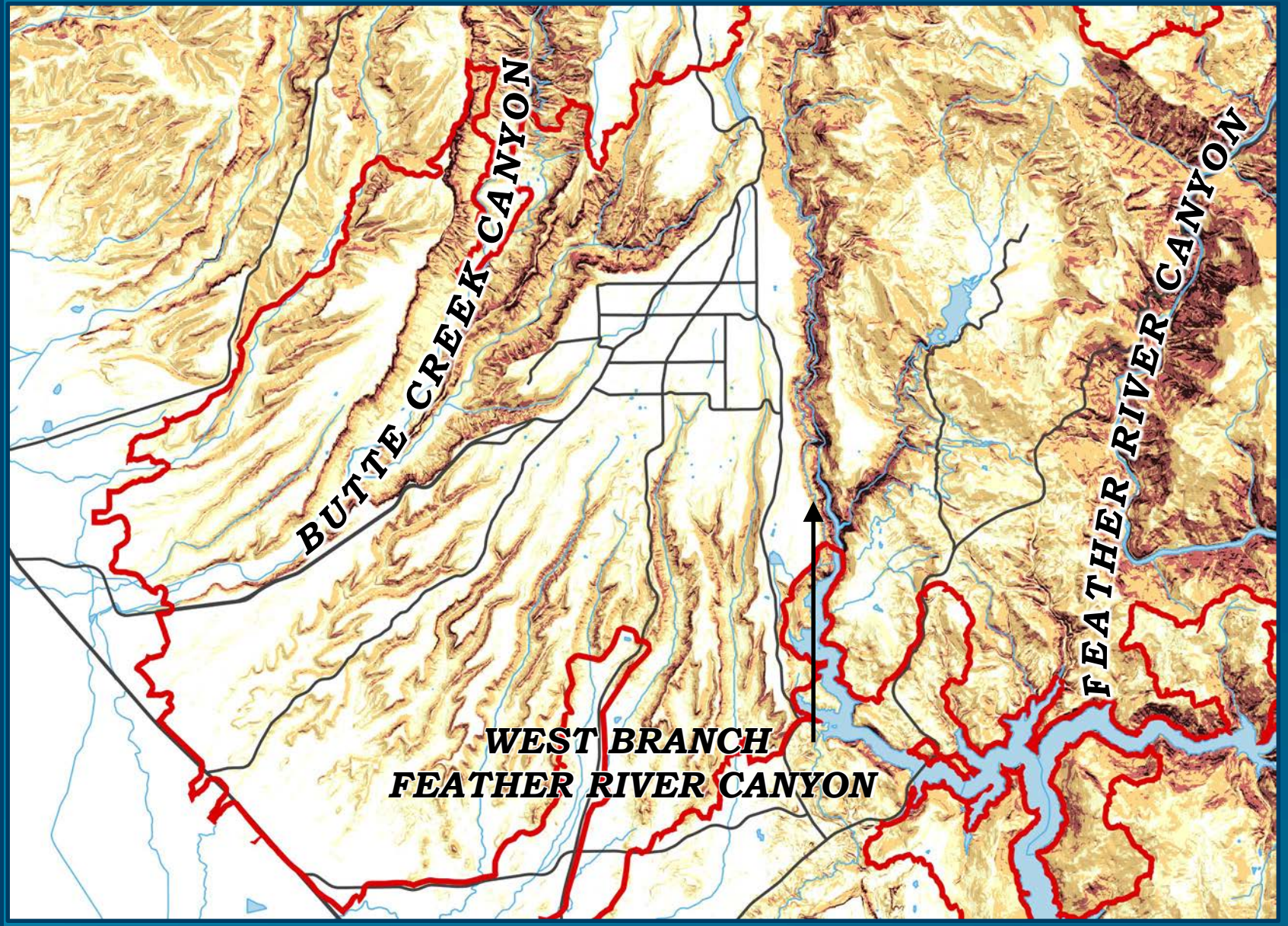


a) 1-month b) 6-month c) 1-year

- Widespread Red Flag Warnings for November 8
- Wind gust forecast showing peak winds exceeding 50 mi/h
- Dry conditions following 200 days without precipitation

NIST Camp Fire Report #3, Figure 7.

Topography



- Significant steep canyons
- Localized wind alignment
- Difficult access
- Restricted egress

gentle	(< 15 %)
moderate	(15 % to 30 %)
steep	(30 % to 60 %)
very steep	(60 % to 90 %)
cliff	(> 90 %)

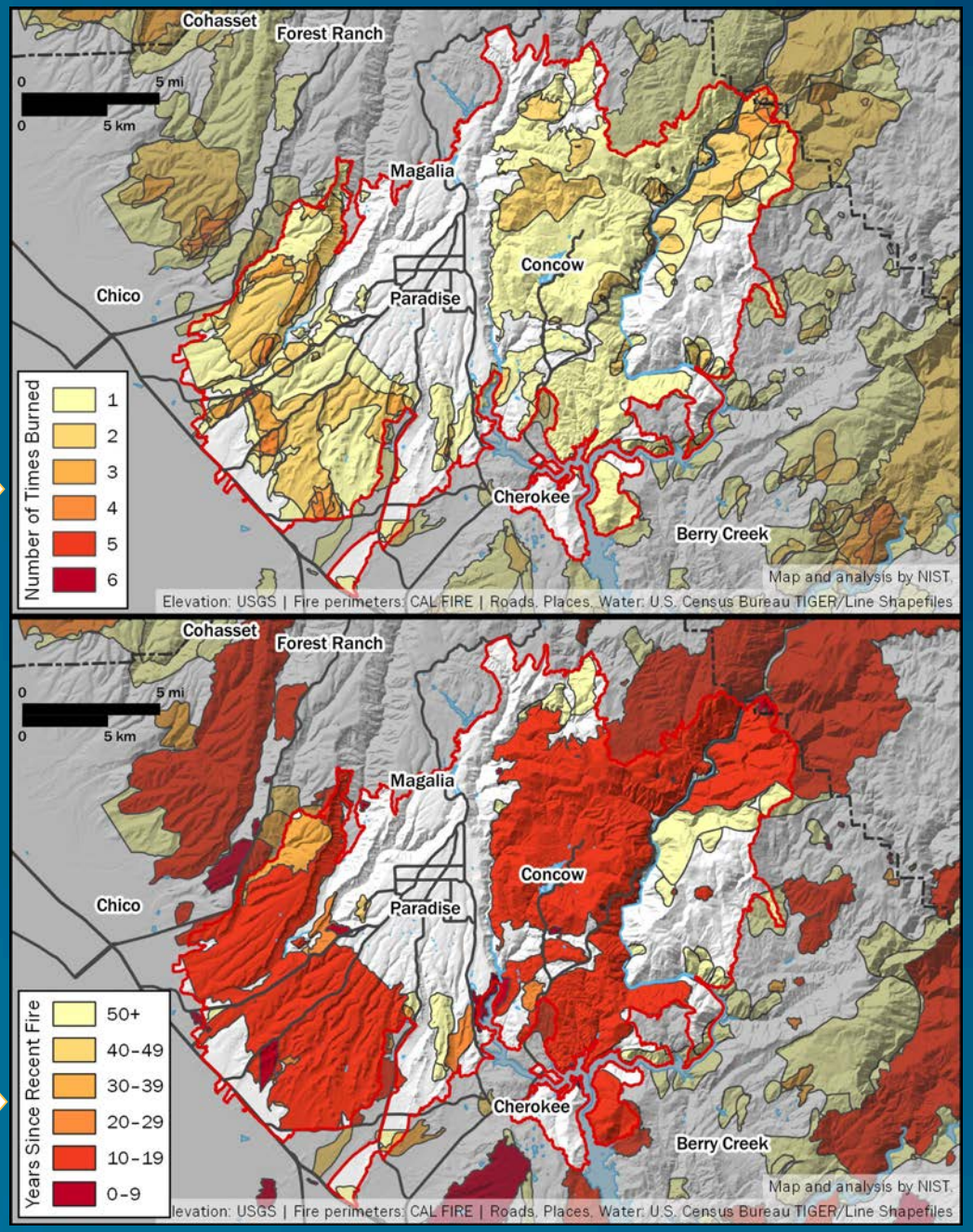
Fire History

Historic fire perimeters in northern Butte County (1911–2018)

Number of times each area has burned.

- 42% had never burned including all area in/around Paradise.
- 17 of 20 prior years had 1 or more fires

Number of years since the last fire.



NIST Camp Fire Report #3, Figure 10.

Population and Housing Density

Location	Pop.	Area km² (mi²)	Pop. Density p/km² (p/mi²)	DINS Struct. Count	Nominal Struct. Density s/ha (s/ac)	Effective Struct. Density s/ha (s/ac)
Paradise	26 218	47.5 (18.3)	552 (1433)	16 520	3.5 (1.4)	6.4 (2.6)
Magalia	11 310	36.3 (14.0)	312 (808)	3466[a]	6.4[a] (2.6)	8.2 (3.3)
Concow	710	72.0 (27.8)	10 (26)	684	0.1 (0.04)	0.6 (0.25)

[a] Only the fire-impacted southern portion of Magalia was included in structure damage inspection data; the entire structure count is unavailable. Area was truncated at the extent of available data.

10+ fold range in effective structure density

NIST Camp Fire Report #3, Table 2.

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)

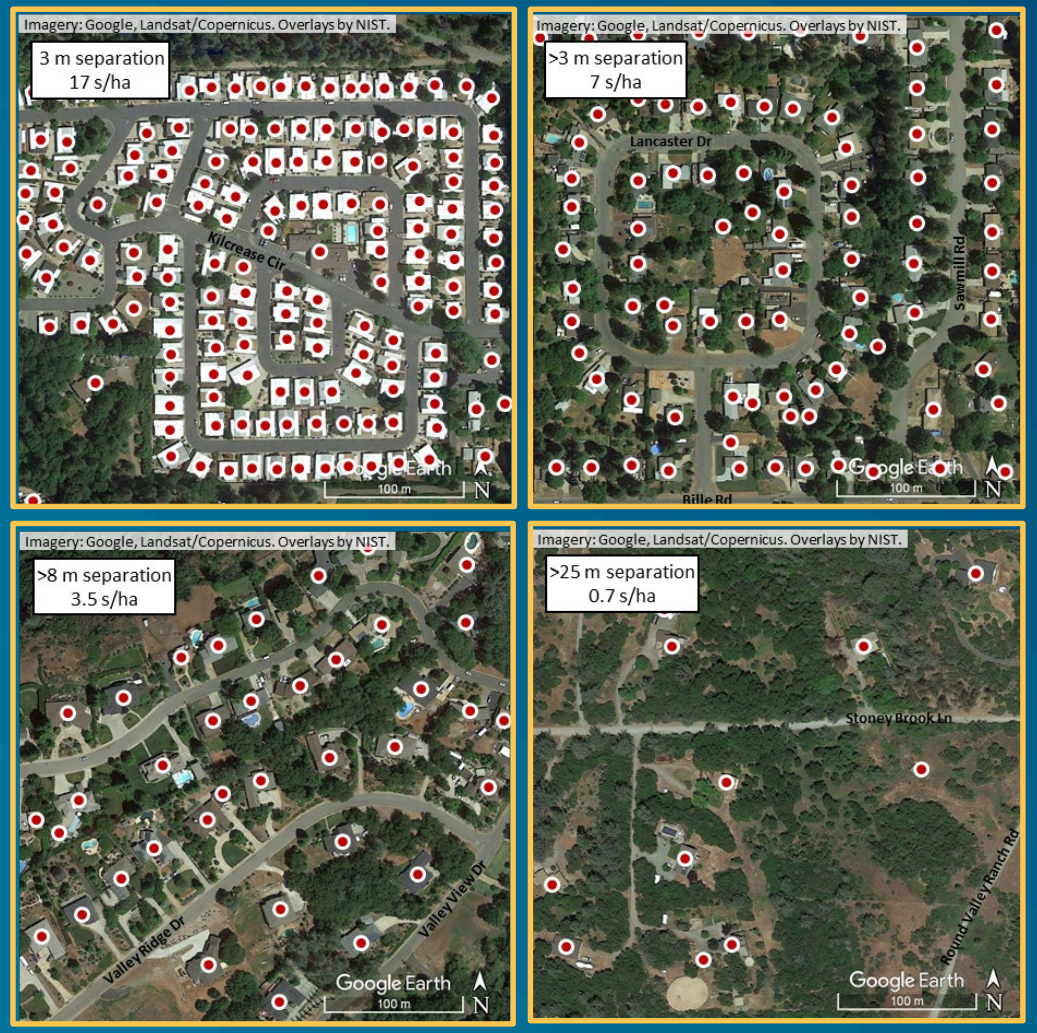
- 3 m (10 ft) separation
- 2.9 structures / acre

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.

Preparedness

Community Preparedness

1. Communities did have multiple programs in place to increase awareness of and reduce fire hazards associated with WUI fires.
2. The Town of Paradise did have an emergency notification and evacuation plan.
3. Paradise Public Works staff had received training in how to respond to a WUI fire.
4. Infrastructure was specifically addressed in pre-fire preparations.

Preparedness

Infrastructure and Firefighting Preparedness

1. Communication battery backup updated day before fire.
2. Water systems (PID and Del Oro) at full capacity.
3. Fire fighting staffing at increased level (Locally and regionally) – more in report #5.

Fire Progression

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

Incident Commander Account

Detailed account of event from IC perspective, including:

- Resource requests
- Fire location
- Fire behavior
- Evacuation orders
- Life safety
- Response orders
- Multi-agency coordination

IC Technical Discussion
06:31 First dispatch by/under power lines, dispatch B2118, P2121, T2107, E2176, E2161, E2167, E2186, E2182, E2162, Company 67, WT37, WT67, TD2140, TD2142, BFC2, BFC3. These were all sent up to NOPS.
06:44 First engine confirms fire off Camp Creek Road, 35 mi/h sustained wind.
06:44 ECC places request for 15 additional engines, 4 dozers, 2 water tenders, and 4 strike teams of hand crews.
06:45 Received call at home. BC informed me of the incident. Cool morning 40 °F. Fire appears on Flea Mountain camera.
06:54 E2161 request a mandatory evacuation order for Pulga and stage resources at Scooters.
06:55 ECC called BCSO and requested Mandatory Evacuation order for Pulga.
07:02 Duty Chief calls. IC send him to Concow.
07:10 Duty Chief calls back, reports flames visible from Hwy 149.
07:14 B2118 assumes IC.
07:21 Camp IC – “Pulga has been evacuated. If you could make notifications, request representative to Scooters. Have the Sheriff respond to Camelot area for evacuations.”
07:22 Camp IC – “Request evacuation warning for the Concow area – working on exact area and warning/order.”
07:22 ECC called BCSO requesting mandatory evacuation warning for Concow Immediately.
07:26 Camp IC – “shut down Hwy 70 and standby for resource order. Close Hwy 70 from Pentz to Belden.”
07:30 Requests to early up all aircraft - Paradise burning not being considered at that time.
07:32 EVAC warning Pentz Rd west side.
07:33 Resource order for an additional 15 engine strike teams, 15 hand crew strike teams, 10 dozer strike teams, with appropriate overhead.
07:40 T2107 needs 5 engine strike teams on Hoffman Rd can’t get ahold of Camp IC – request relay info.
07:44 ECC takes call at 1900 Drayer Dr/Pentz Rd reporting fire on the Paradise side of canyon – reporting 3 spots.
07:45 At ICP develop incident objectives, box it in: North of Hwy 70, east of Pentz, then west of Pulga and south of Empire Creek. Before objectives are announced on the radio, there are spot fires reported outside the box.
07:44 IC change over to new IC – *for remainder of first day.*
07:45 Camp IC – “We are extending the mandatory evac zone to east of Pentz Rd 3, 8, 14 and everything east of Pentz Rd and everything north of Hwy 70.”
07:46 ECC calls BCSO requesting the above Evacuation Warning. Not thinking spot fires is a crazy issue, spot fires are normal.

NIST Camp Fire Report #3, Table 10.

Fire Progression –Three Levels of Detail

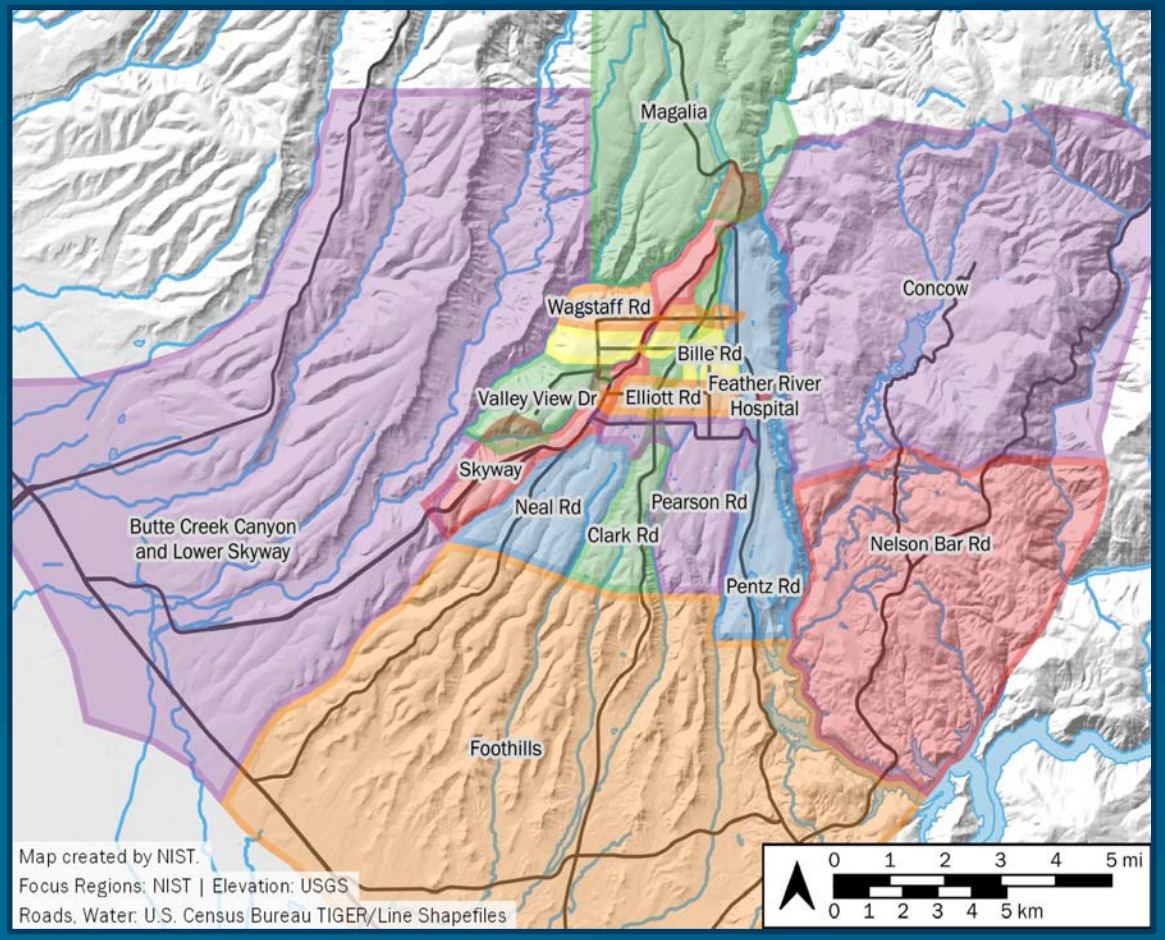
1. ***Overview*** in Executive Summary and report findings/conclusions *(3 pages)*

2. ***Detailed*** fire behavior — by focus regions *(71 pages)*
   - Fire progression described by region and by time
   - 14 large format maps by time *(3 ft x 4 ft)*

3. ***All*** of the data in Appendix F *(113 pages, 8 font)*

Fire Timeline Focus – 15 Regions

1. Detailed Narration
2. Tabulated Highlights
   - Time
   - Description
   - General Location
   - Information Source(s)



Note some regions overlap slightly indicated by relative discoloration.

NIST Camp Fire Report #3, Figure 23.

Concow Fire Progression (1 of 2)

Date	Time Range		Fire Behavior Observations	Location	Source #
11/8	06:25	06:40	First report of vegetation fire via 911. Caller reports fire under electric transmission lines within 6 m (20 ft) of tower, estimated size 30 m × 30 m (100 ft ×100 ft). Others call to report same fire.	West side Feather River, CA Hwy 70 at Poe Dam	911-001-1 911-002-1 911-004-1
11/8	06:45		First engine gets sight of well-established fire, reports difficult access in nearly inaccessible location. Approximately 15 m/s (35 mi/h) sustained winds. Captain declares potential for a major incident.	West side Feather River, CA Hwy 70 at Poe Dam	TD-028
11/8	06:45		Investigators determined a second power line ignition started another fire which was enveloped in the Camp Fire.	Near intersection of Rim Rd and Concow Rd	VTD-28
11/8	06:45		Fire begins threatening structures in Pulga.	Pulga	TD-029
11/8	07:10		Engine reports fire is now 80 ha to 120 ha (200 ac to 300 ac) with rapid rate of spread toward Concow Reservoir.	Pulga	TD-028
11/8	07:15		Fire spread SW from origin and got established in Flea Valley above Pulga.	Pulga	TD-028
11/8	07:20		Wind pushing fire up slope W, WSW; fire extending up slope and well beyond ridge to W	Pulga	TD-028
11/8	07:20		Multiple (5) small spot fires (3 m × 3 m, 10 ft ×10 ft) visible on east facing slopes west of Concow Reservoir.	West side of Concow Reservoir	TD-013
11/8	07:20		Engines attempting access to the north flank of the fire encounter large, a well-established spot fire, 0.1 ha to 0.2 ha (0.25 ac to 0.5 ac).	Rim Rd between Concow and Pulga	TD-005
11/8	07:25		Spot fires are igniting in Concow and homes start to catch fire.	Concow	TD-062
11/8	07:30		Engines responding to Concow encounter 6 m × 6 m (20 ft ×20 ft) spot fire burning upwind, threatening homes.	Concow Rd at Cribbage Ln	TD-013
11/8	07:30		First 911 call reporting active fire in yard.	Concow	911-037-1
11/8	07:30		Spot fires up on Rim Rd have grown to several acres within 10 min, spreading up slope, consuming the draw.	Rim Rd between Concow and Pulga	TD-005
11/8	07:40	07:45	Multiple 911 calls report multiple spot fires just below Sawmill Peak, burning on the Paradise side.	Sawmill Peak	911-048-1 911-058-1
11/8	07:50		Fire is well-established in Concow. Multiple structures are burning, and fire is impacting evacuation.	Concow	911-075-1

NIST Camp Fire Report #3, Table 11.

Caltrans Pulga Maintenance Yard, 07:23

- View of the fire looking north from Highway 70.
- Panorama created from video recording.

NIST Camp Fire Report #3, Figure 24.

Concow Fire Progression (1 of 2)

Date	Time Range		Fire Behavior Observations	Location	Source #
11/8	06:25	06:40	First report of vegetation fire via 911. Caller reports fire under electric transmission lines within 6 m (20 ft) of tower, estimated size 30 m × 30 m (100 ft ×100 ft). Others call to report same fire.	West side Feather River, CA Hwy 70 at Poe Dam	911-001-1 911-002-1 911-004-1
11/8	06:45		First engine gets sight of well-established fire, reports difficult access in nearly inaccessible location. Approximately 15 m/s (35 mi/h) sustained winds. Captain declares potential for a major incident.	West side Feather River, CA Hwy 70 at Poe Dam	TD-028
11/8	06:45		Investigators determined a second power line ignition started another fire which was enveloped in the Camp Fire.	Near intersection of Rim Rd and Concow Rd	VTD-28
11/8	06:45		Fire begins threatening structures in Pulga.	Pulga	TD-029
11/8	07:10		Engine reports fire is now 80 ha to 120 ha (200 ac to 300 ac) with rapid rate of spread toward Concow Reservoir.	Pulga	TD-028
11/8	07:15		Fire spread SW from origin and got established in Flea Valley above Pulga.	Pulga	TD-028
11/8	07:20		Wind pushing fire up slope W, WSW; fire extending up slope and well beyond ridge to W	Pulga	TD-028
11/8	07:20		Multiple (5) small spot fires (3 m × 3 m, 10 ft ×10 ft) visible on east facing slopes west of Concow Reservoir.	West side of Concow Reservoir	TD-013
11/8	07:20		Engines attempting access to the north flank of the fire encounter large, a well-established spot fire, 0.1 ha to 0.2 ha (0.25 ac to 0.5 ac).	Rim Rd between Concow and Pulga	TD-005
11/8	07:25		Spot fires are igniting in Concow and homes start to catch fire.	Concow	TD-062
11/8	07:30		Engines responding to Concow encounter 6 m × 6 m (20 ft ×20 ft) spot fire burning upwind, threatening homes.	Concow Rd at Cribbage Ln	TD-013
11/8	07:30		First 911 call reporting active fire in yard.	Concow	911-037-1
11/8	07:30		Spot fires up on Rim Rd have grown to several acres within 10 min, spreading up slope, consuming the draw.	Rim Rd between Concow and Pulga	TD-005
11/8	07:40	07:45	Multiple 911 calls report multiple spot fires just below Sawmill Peak, burning on the Paradise side.	Sawmill Peak	911-048-1 911-058-1
11/8	07:50		Fire is well-established in Concow. Multiple structures are burning, and fire is impacting evacuation.	Concow	911-075-1

NIST Camp Fire Report #3, Table 11.

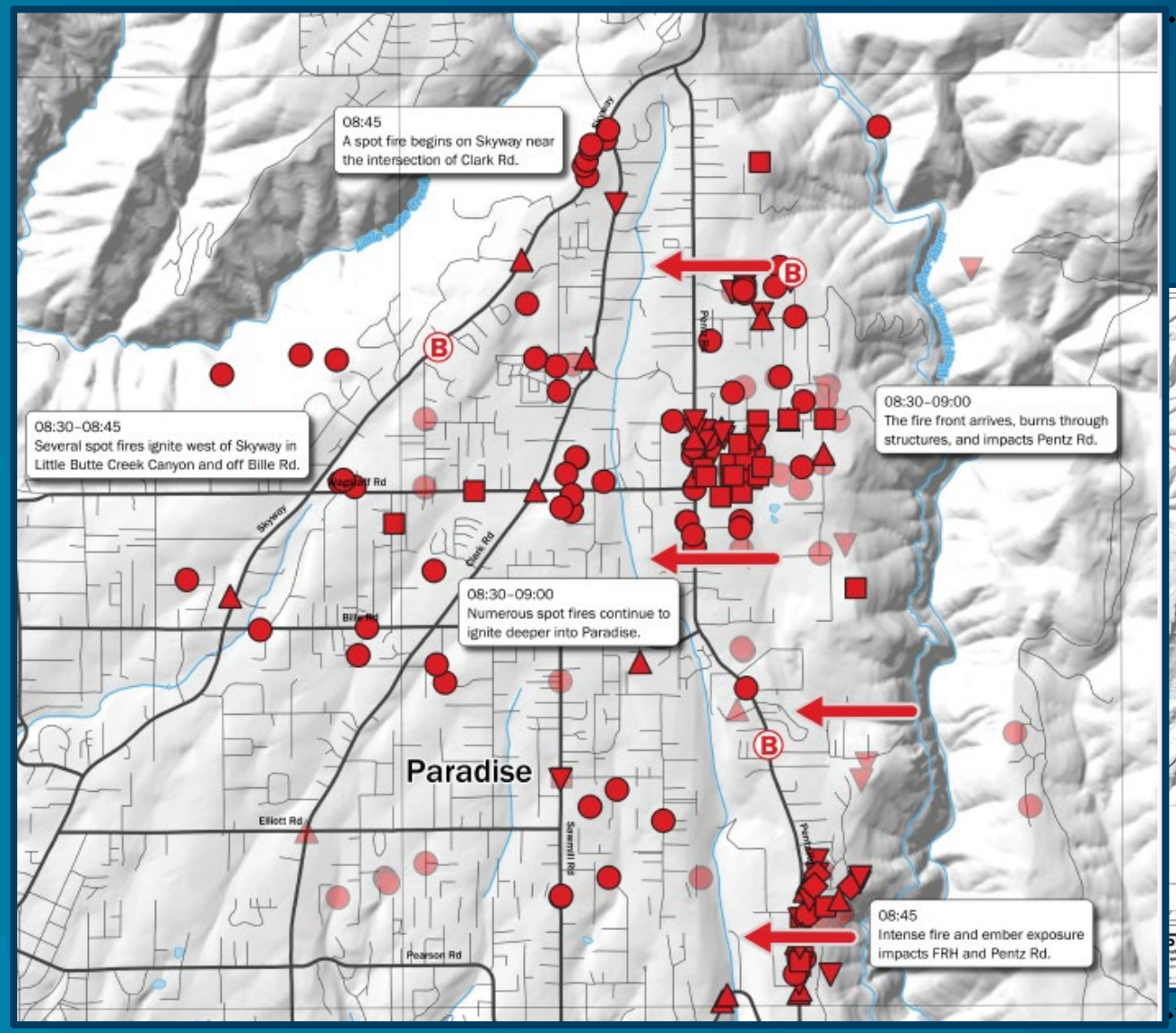
Strong Wind at Rim Road

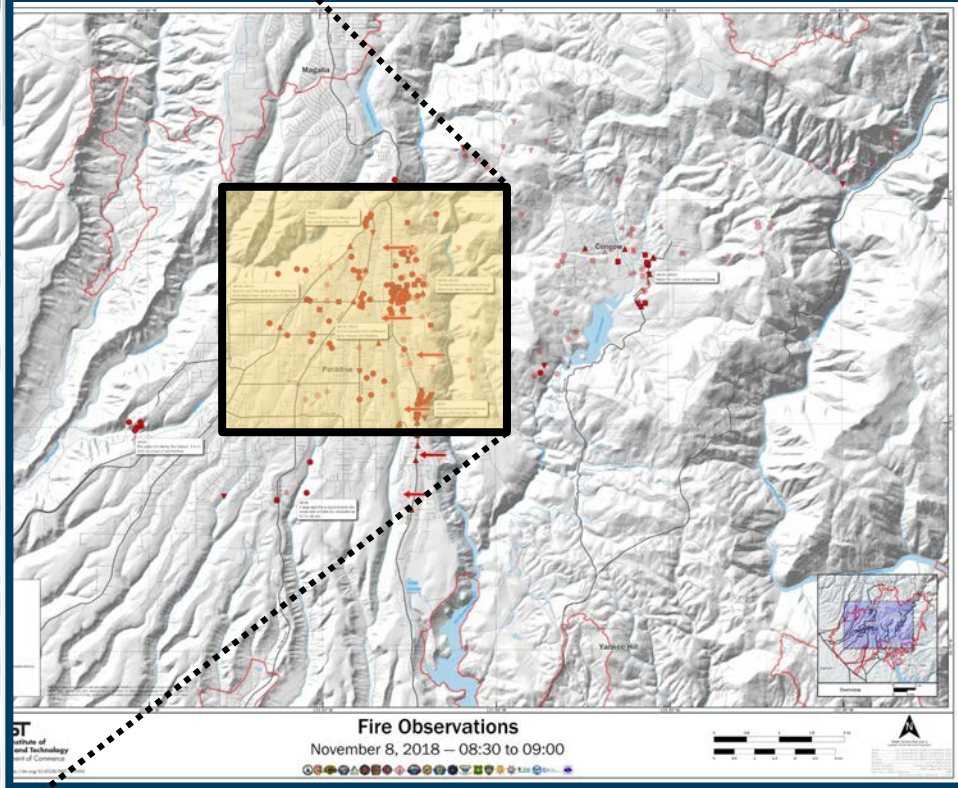
Video courtesy of TD-005, 07:32.
Used with permission.

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

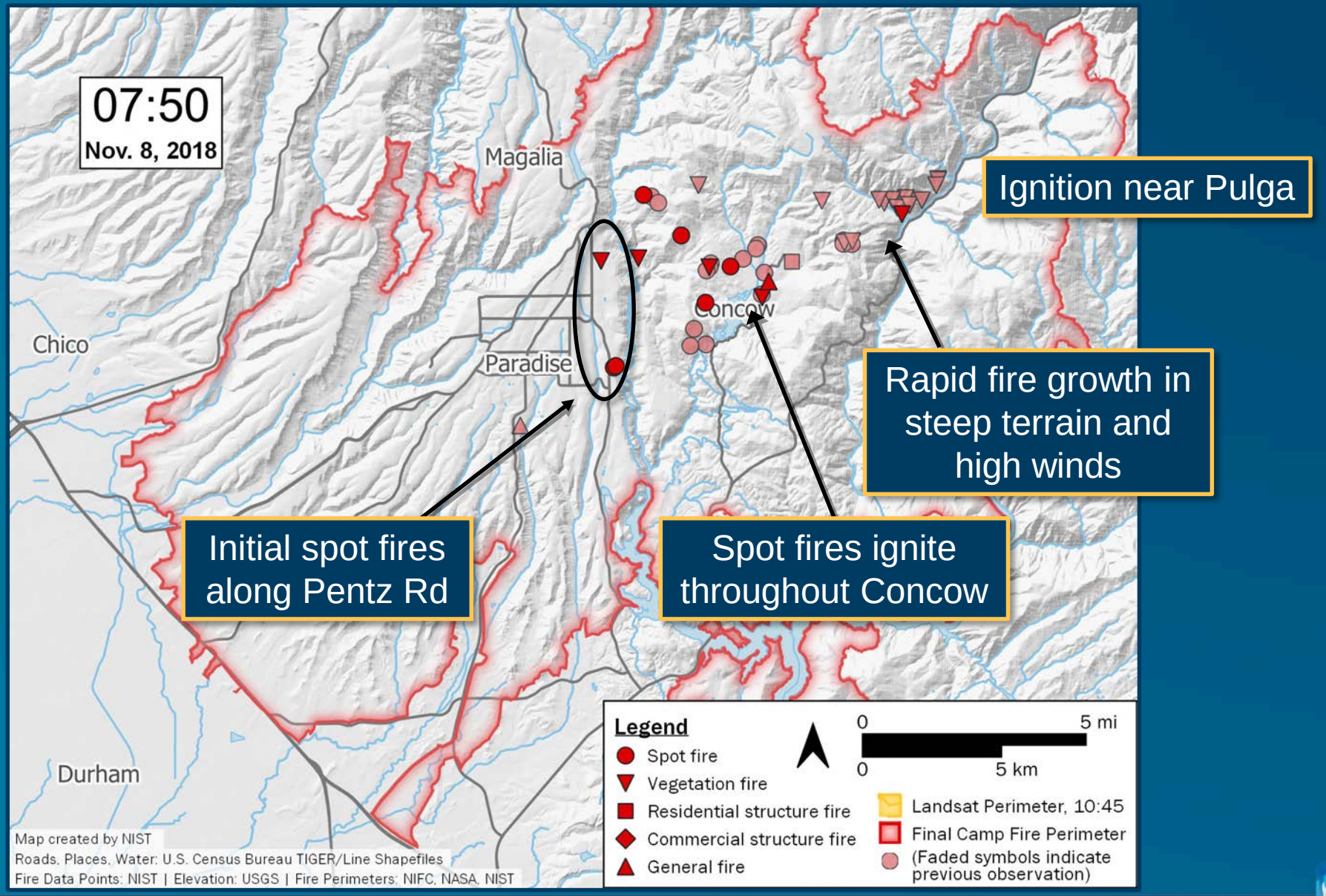
NIST Camp Fire Report #3, Figure 25.

14 E-size Maps (3 ft × 4 ft)

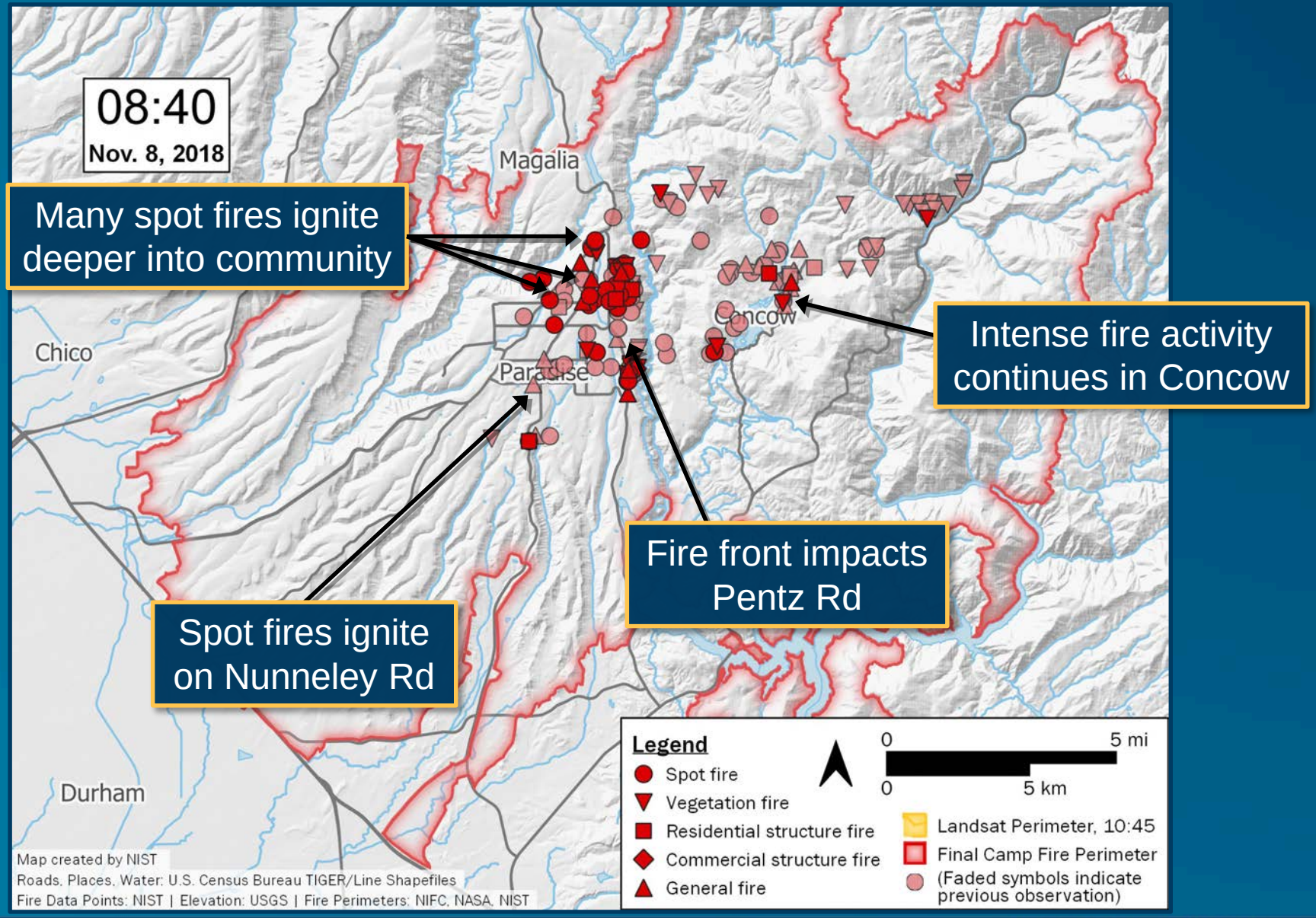




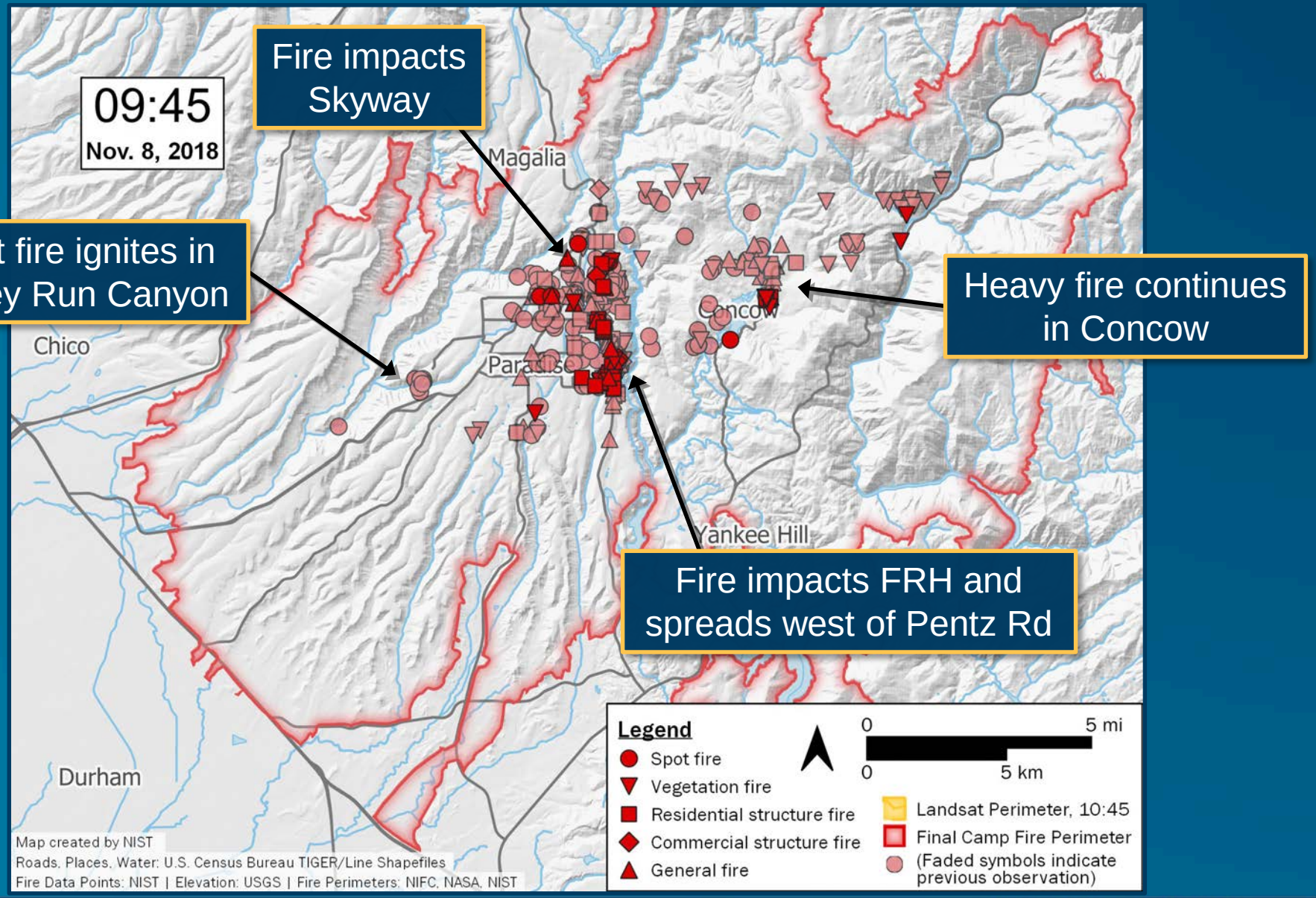
Fire Progression Summary 06:15 to 07:50



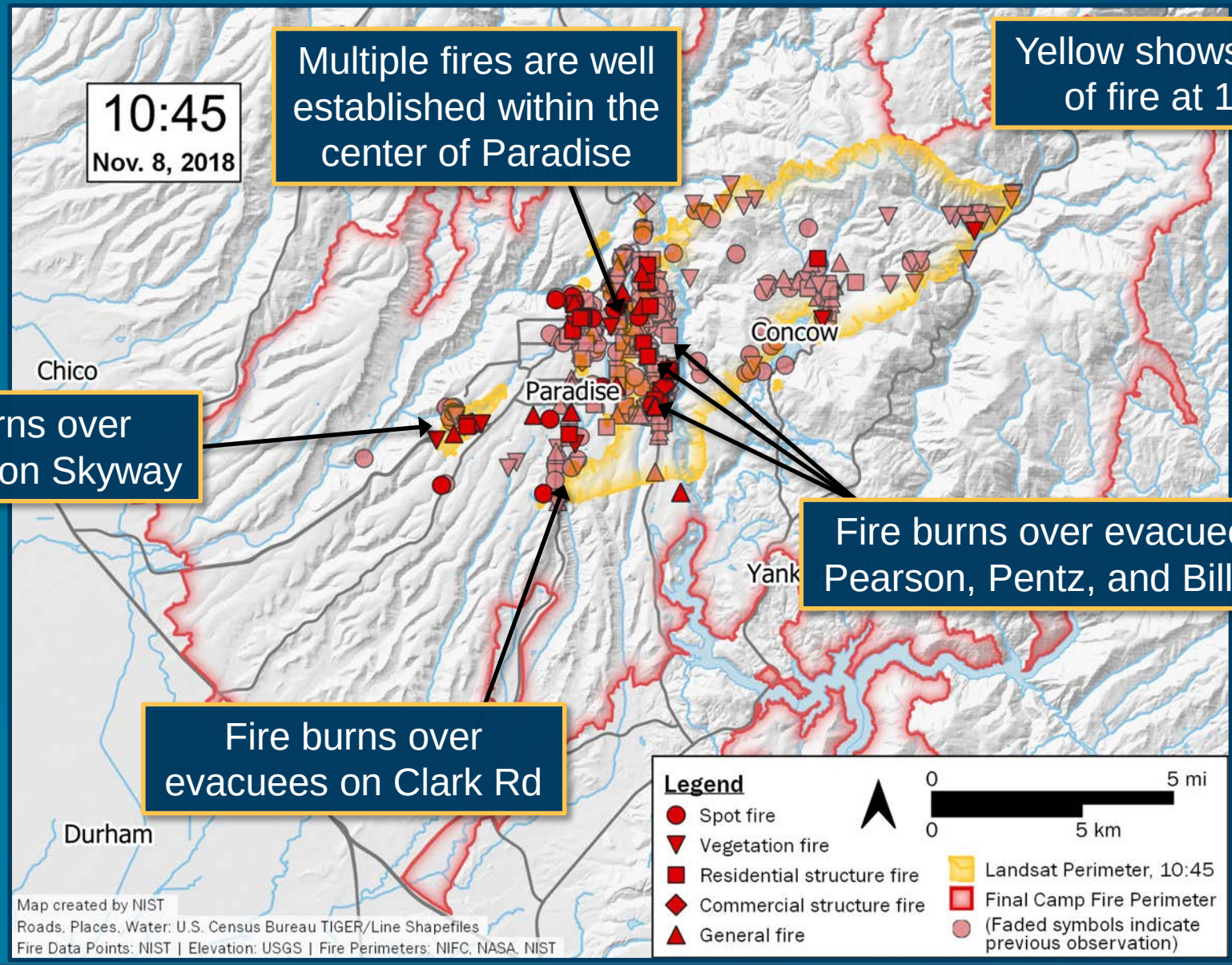
Fire Progression Summary 07:50 to 08:40



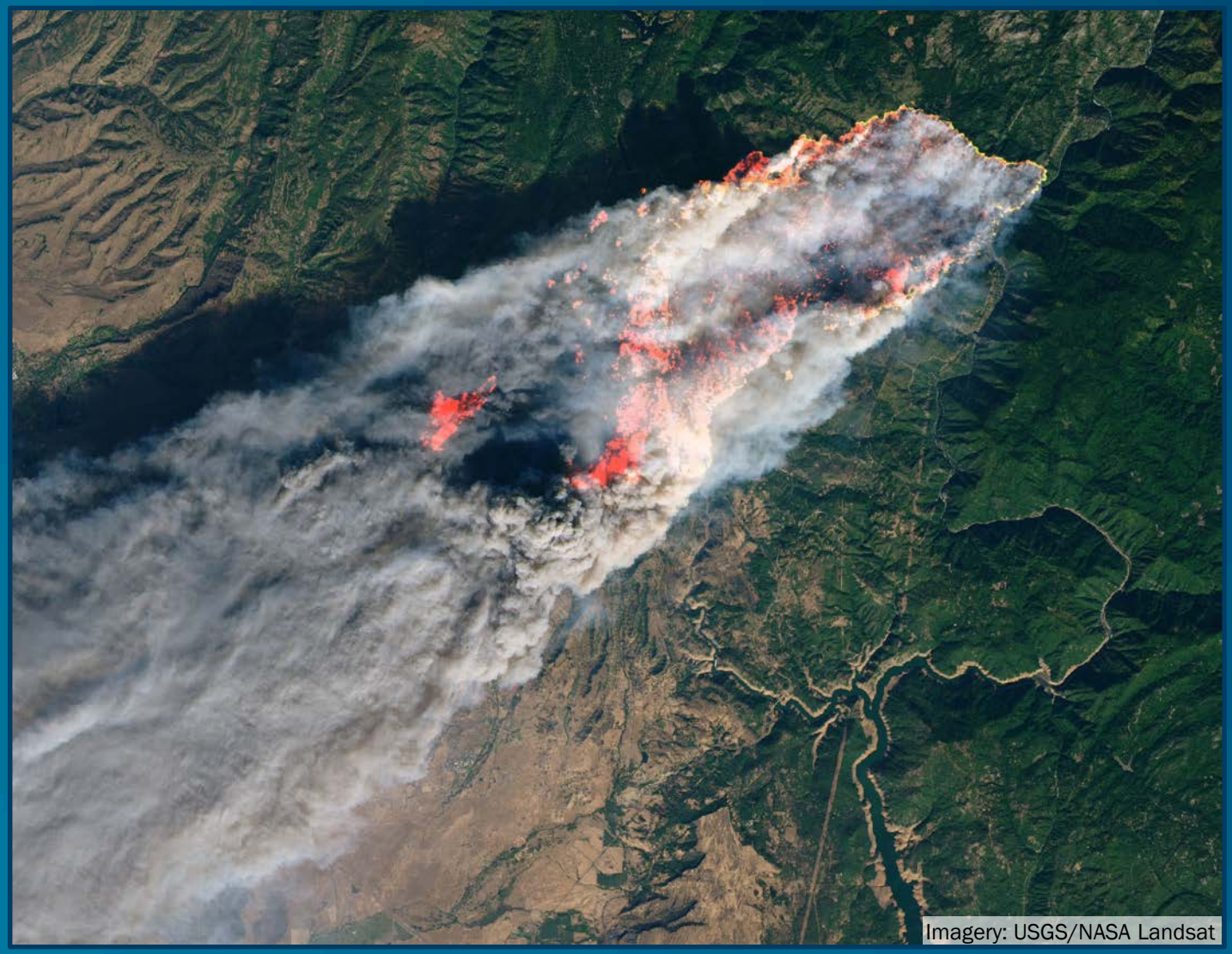
Fire Progression Summary 08:40 to 09:45



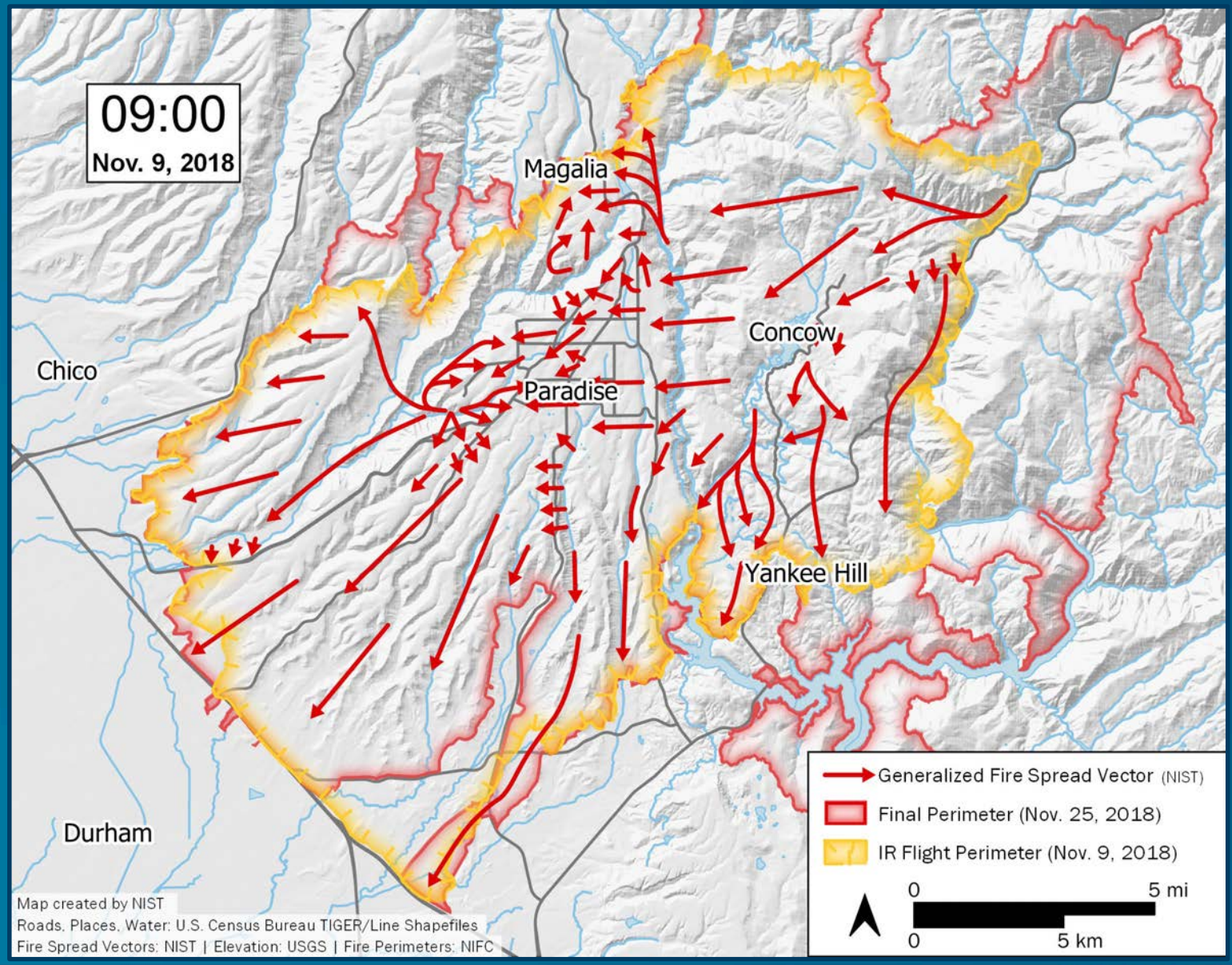
Fire Progression Summary 09:45 to 10:45



Fire Progression Summary by 10:45



Fire Progression Summary (Day 1)



NIST Camp Fire Report #3, Figure 22.

Burnovers

19 documented

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

Burnovers

Report describes identified:

burnovers, entrapments, and "near misses"

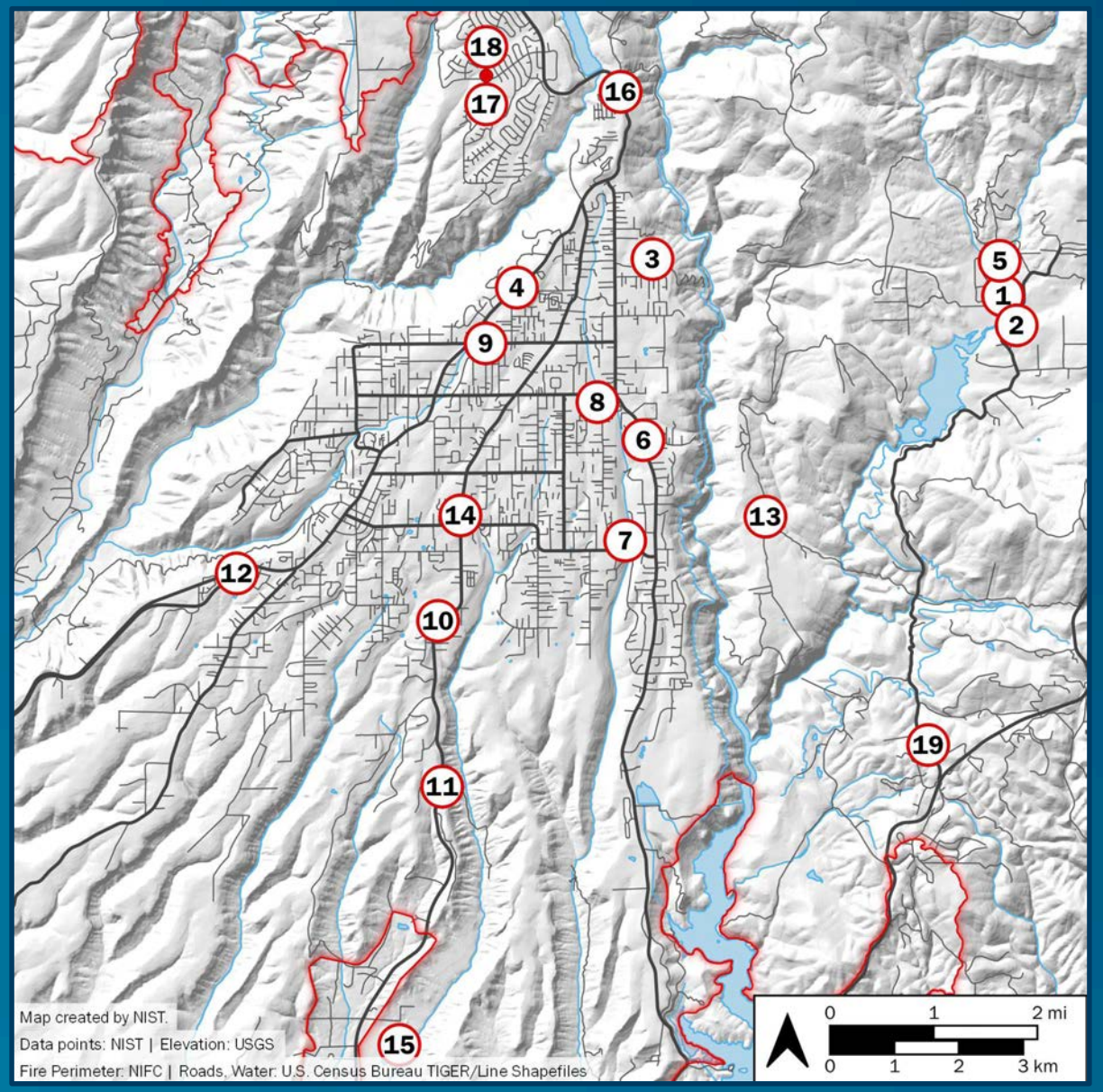
- Unexpectedly caught
- Life-threatening position
- Fire overtakes personnel or equipment
- Escape routes or safety zones are absent, inadequate, or compromised
- May or may not result in injury
- Possible damage to equipment

Source: ViralHog
Used with permission.

Burnovers

- **19 burnover events** were documented
- Occurred throughout the duration of the fire
- Occurred throughout the fire area
- Additional burnovers occurred but were not captured during the data collection process because:
  - no personnel (first responder or civilian) was present to witness the event, or
  - the event was witnessed by first responder(s) and/or civilian(s), but data was not captured because no TD took place with these individuals.

Locations of Documented Burnovers



NIST Camp Fire Report #3, Figure 47.

Identified burnover locations by time of occurrence and risk of injury or death.

ID	Burnover Location	Time	Risk of Injury/Death Category
1	Hoffman Rd	07:50	1
2	Concow Rd	07:50	2
3	Chapman Ln	08:30	1
4	Skyway (upper, between Clark Rd and Wagstaff Rd)	08:30	1
5	Windermere Ln	08:35[a]	1
6	Pentz Rd	08:45	1
7	Pearson Rd	09:15	1
8	Bille Rd	09:25	1
9	Wagstaff Rd	09:30	2
10	Clark Rd / American Way	10:00	2
11	Clark Rd / Airport Rd	10:00	2
12	Skyway (lower, west of Princeton Way)	10:15	2
13	Jordan Hill Rd /Granite Hill Rd	11:30	1
14	Clark Rd / Black Bear Diner	13:10	2
15	Rattlesnake Flats Rd	15:15	1
16	Coutolenc Rd	00:00[b]	2
17	Chestnut Cir	06:00[b]	1
18	Ponderosa Way	07:15[b]	2
19	Concow Fire Station 37	07:15[b]	1

[a] Burnover conditions existed prior to the first recorded observation.
[b] November 9.

NIST Camp Fire Report #3, Table 33.

Burnovers Summary (1 of 2)

ID	Location	Burnover Initiation	Burnover Duration	Road Width (m)	Vegetation Setback (m)	Roadway Length Affected[a] (m)	Impacted Civilian Evacuation (Y if yes)	Fire Shelter(s) Deployed (Y if yes)	TRA Formed (Y if yes)
1	Hoffman Rd	07:50	40 min	3	0–2, more at creek	250	Y	Y	Y
2	Concow Rd	07:50	70 min	7	0–1	1000	Y		
3	Chapman Ln	08:30	n/d[b]	3	0–3	250			
4	Skyway (upper)	08:30	360 min	8	0–10	2600	Y (street was gridlocked)		Y
5	Windermere Ln	08:35[c]	n/d	4	0–2	1100	Y		
6	Pentz Rd	08:45	150 min	8	0–1	1300	Y (street was gridlocked)		Y
7	Pearson Rd	09:15	60 min	11	1–3	800	Y (street was gridlocked)	Y	Y
8	Bille Rd	09:25	140 min	8	0–2	500	Y (street was blocked)		Y
9	Wagstaff Rd	09:30	60 min	8	0–3	500	Y		
10	Clark Rd / American Way	10:00	120 min	11	1–3	700	Y		
11	Clark Rd / Airport Rd	10:00	90 min	9	1	1500	Y		

[a] The roadway segment affected by each burnover was estimated from the technical discussions.
[b] No data
[c] First time of observation. Burnover conditions existed prior to the first recorded observation.

NIST Camp Fire Report #3, Table 34.

Burnovers Summary (2 of 2)

ID	Location	Burnover Initiation	Burnover Duration	Road Width (m)	Vegetation Setback (m)	Roadway Length Affected[a] (m)	Impacted Civilian Evacuation (Y if yes)	Fire Shelter(s) Deployed (Y if yes)	TRA Formed (Y if yes)
12	Skyway (lower)	10:15	90 min	7–20	1–3	1000	Y		
13	Jordan Hill Rd / Granite Hill Rd	11:30	n/d	5	0–4	800	Y		
14	Clark Rd / Black Bear Diner	13:10[c]	n/d	23	3 (structure)	150			
15	Rattlesnake Flats Rd	15:15	15 min	3	0	300			
16	Coutolenc Rd	00:00 (Nov 9)	120 min	7	0–2	3000			Y
17	Chestnut Cir	06:00 (Nov 9)	n/a	9	0–1	150			
18	Ponderosa Way	07:15 (Nov 9)	n/d	12	0–3	400	Y		Y
19	Concow Fire Station 37	07:15 (Nov 9)	n/d	9	0–3	600			Y

[a] The roadway segment affected by each burnover was estimated from the technical discussions.
[b] No data
[c] First time of observation. Burnover conditions existed prior to the first recorded observation.

NIST Camp Fire Report #3, Table 34.

Burnovers Appendix B

Hoffman Road Burnover Details

1. Hoffman Road

Date/Time: November 8, 07:50–08:30

Location: Hoffman Road, Concow

Coordinates: [39.783963, -121.509288]

Related TRA/ Safety Zone: after the Hoffman Rd burnover, civilians went to the Camelot Wildfire Safety Zone

Summary: Fire activity in the form of a large spot was first reported in the Hoffman Rd area at 07:35. Within ten minutes conditions deteriorated dramatically, blocking Hoffman Road between the low water crossing and Concow Road, trapping fire fighters and a convoy of civilians trying to evacuate. Evacuees and fire fighters remained at the low water crossing area as the fire burned over the area. Fire shelters were deployed to shield civilians and fire fighters during rescue operations and civilians took refuge in the creek. When local conditions improved the convoy of vehicles migrated towards the intersection of Hoffman Road and Concow Road.

Time	Observation	Source
08:00	four civilians running WB on Hoffman Rd at low water crossing, beard a bit on fire; clothing is burned; civilians advise road ahead is blocked by fire; civilians jump into creek; visibility 0 m to 2 m (0 ft to 7 ft), dark	TD-013
08:00	park on low water crossing; 10 to 15 vehicles of civilians trying to evacuate are stuck in line behind, *[west]* up Hoffman Rd	TD-013
08:00	small patch of green between Hoffman Rd and lake, fire all around	TD-013
08:00–08:17	vehicles behind *[in line to the west]* are catching fire; TD-027 goes to evacuate people from vehicles using fire shelters as shields, 4 trips back and forth to grab people; cannot make it back to all vehicles; hard to breathe	TD-013
08:00–08:25	28 to 30 civilians in the creek at the rock wall; 4 to 5 vehicles are burning; wind is from the north	TD-013
08:00–08:25	3 or 4 homes fully involved; propane tanks exploding	TD-013
08:15–08:29	dozer gains access to clear Hoffman Rd, pushing cars off roadway	TD-008
08:15–08:30	head *[toward Hoffman Rd on Concow Rd]* with a couple engines following; most intense fire conditions; flames horizontal over Hoffman Rd; had to reverse back out of there, engines had difficulty *[turning around on narrow road]*, total bottleneck in S-curve	TD-110

Time	Observation	Source
08:15–08:30	trees torching down Hoffman Rd, not safe to go down there to get to TD-013	TD-110
08:17–08:27	plan to get to Camelot Wildfire Safety Zone; stuff all people into 8 vehicles, leave behind the burning vehicles; 2 civilians in front seat *[of fire pickup truck]* plus 3 in the back seat and TD-027 in the bed camper shell (total of 7 people in pickup); takes maybe 40 min to 60 min from leaving Hoffman Rd to arrive at Camelot Wildfire Safety Zone	TD-013
08:23–08:31	Concow Rd at Hoffman Rd; dozer coming up Hoffman Rd, meet with TD-013 and evacuees; confirm power is dead, and clear powerlines off Concow Rd with bolt cutters; fire right up against road; significant 13 m/s to 18 m/s (30 mi/h to 40 mi/h) wind	TD-062

Topography: low concrete road fording across a creek that feeds into Concow Reservoir, road passes along flat ground

Roadway width: 3 m to 3.5 m (10 ft to 12 ft)

Vegetation setbacks: 0 m to 2 m (0 ft to 6 ft) setback on road, more at creek crossing

Duration: 40 min

Extent of burnover (length of road affected): 250 m (0.15 mi)

Fire direction across road: from northeast to southwest

Wind intensity: estimated 13 m/s to 18 m/s (30 mi/h to 40 mi/h) from north

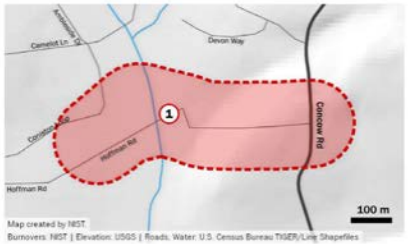
Fuels: brush / trees

Fire behavior: surface fire, torching trees, visible flames across road or portion of road

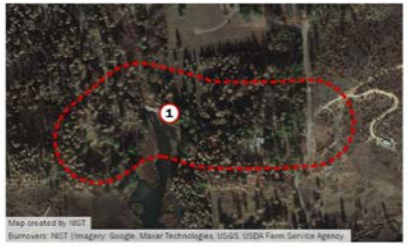
Related TD: TD-005, TD-007, TD-008, TD-013, TD-027, TD-062, TD-103, TD-110, TD-137

Related streets or keywords: Concow Rd, Concow Creek, Hoffman Rd, Concow Reservoir

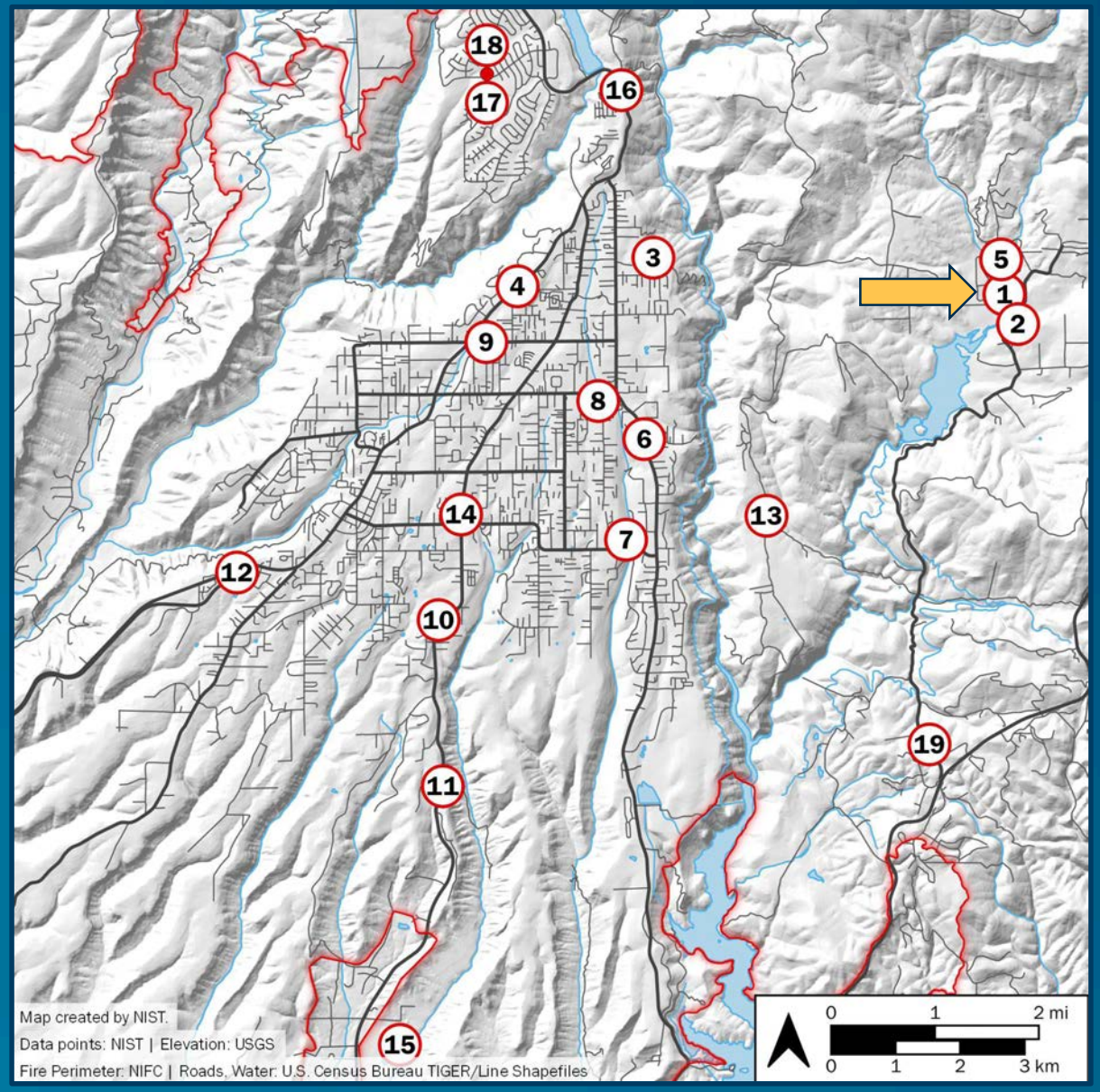
Street map:



Satellite view:

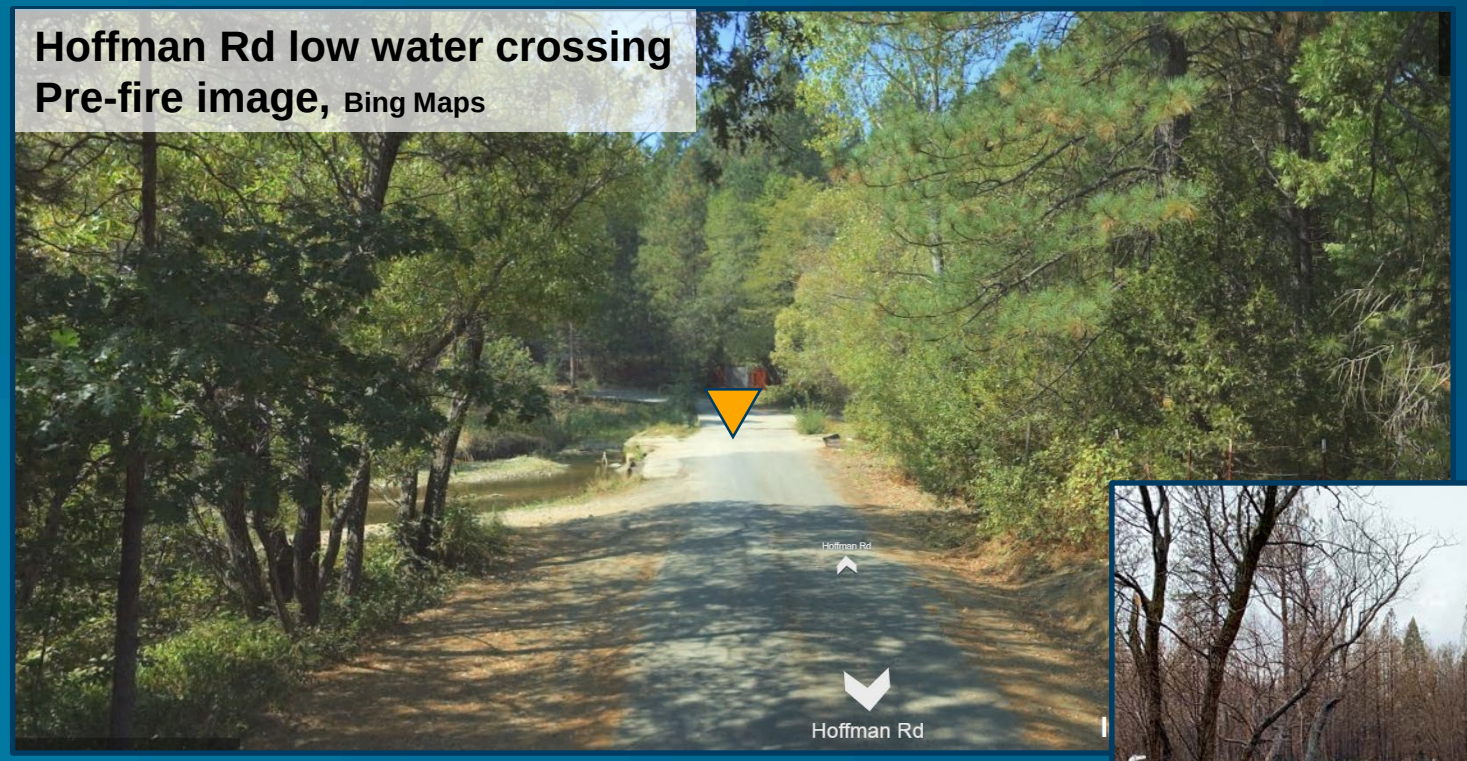


Burnover #1: Hoffman Rd



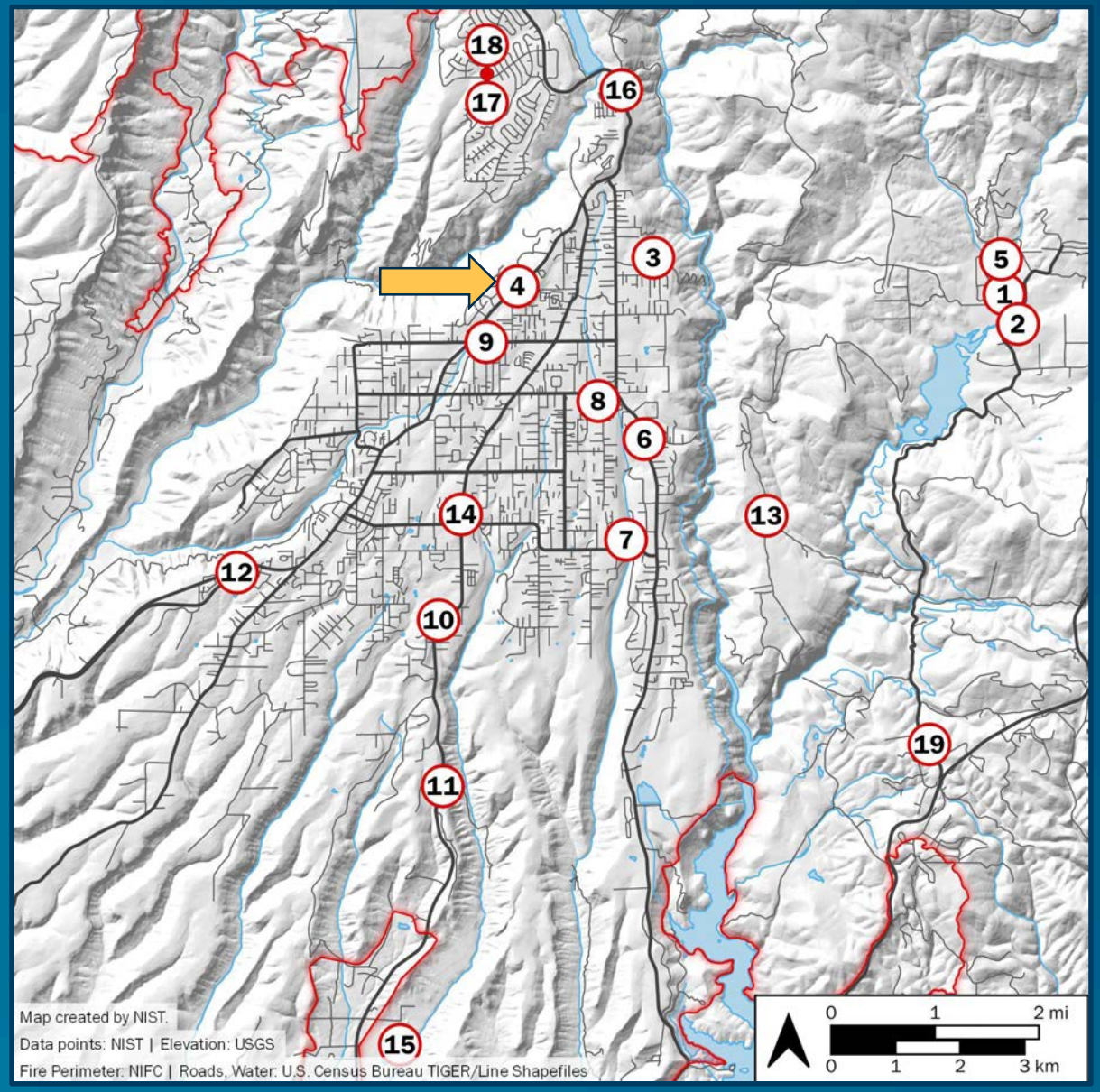
NIST Camp Fire Report #3, Figure 47.

Burnover #1: Hoffman Rd



- Rapid expansion of fire
- Vehicles, vegetation, structures burning
- Trees and fire blocking roadway
- Approx. 30 civilians took refuge in creek

Burnover #4: Upper Skyway



NIST Camp Fire Report #3, Figure 47.

Burnover #4: Upper Skyway

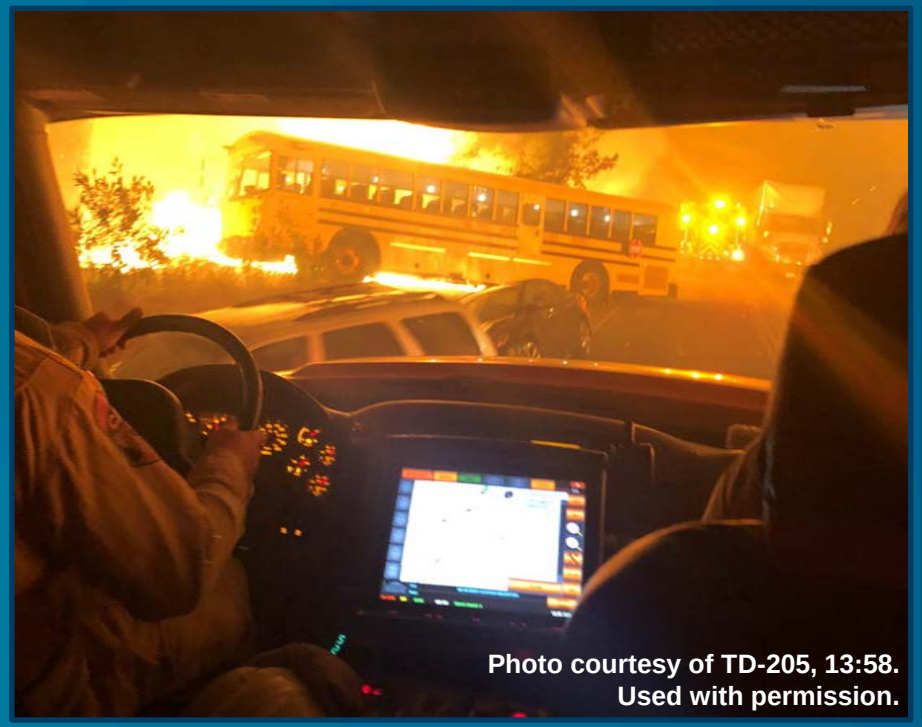
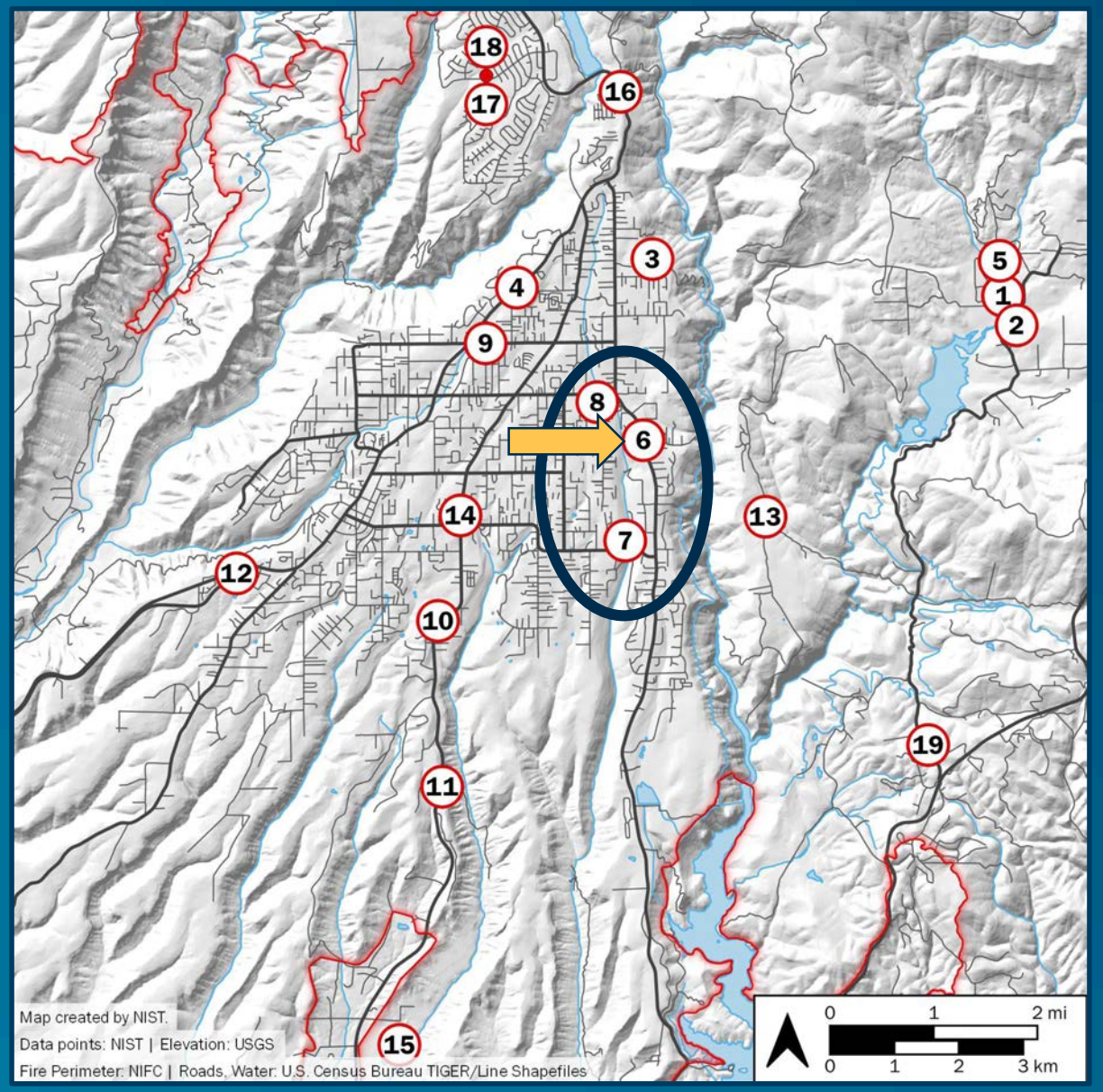


Photo courtesy of TD-205, 13:58. Used with permission.

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

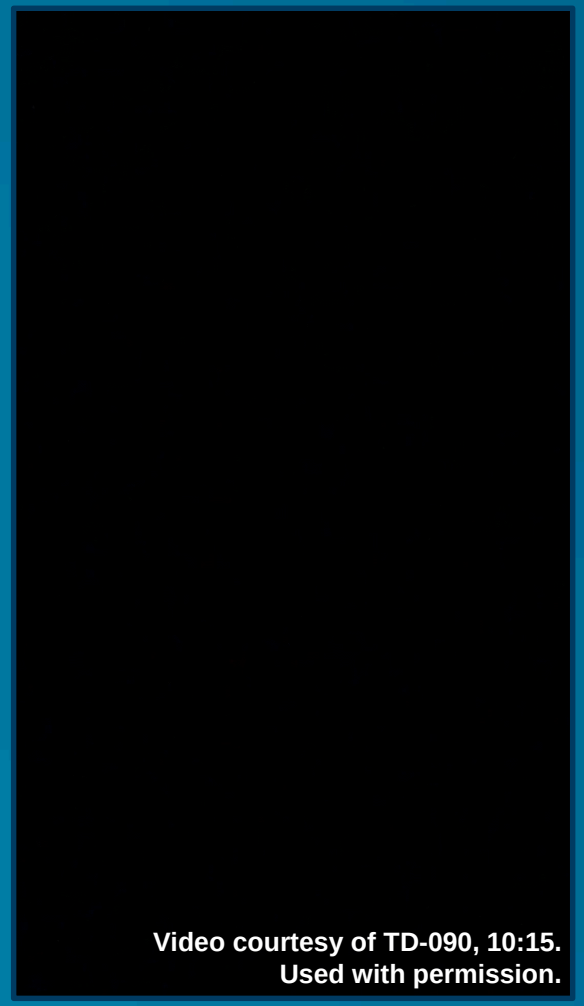
- Prolonged period of hazardous conditions
- Rapid spread of initial spot fires
- Standstill traffic
- Abandoned vehicles burning in roadway
- Prevented evacuation from points north

Burnover #6: Pentz Road



NIST Camp Fire Report #3, Figure 47.

Burnover #6: Pentz Road



Video courtesy of TD-090, 10:15. Used with permission.

Zero visibility, on foot, re-directing traffic

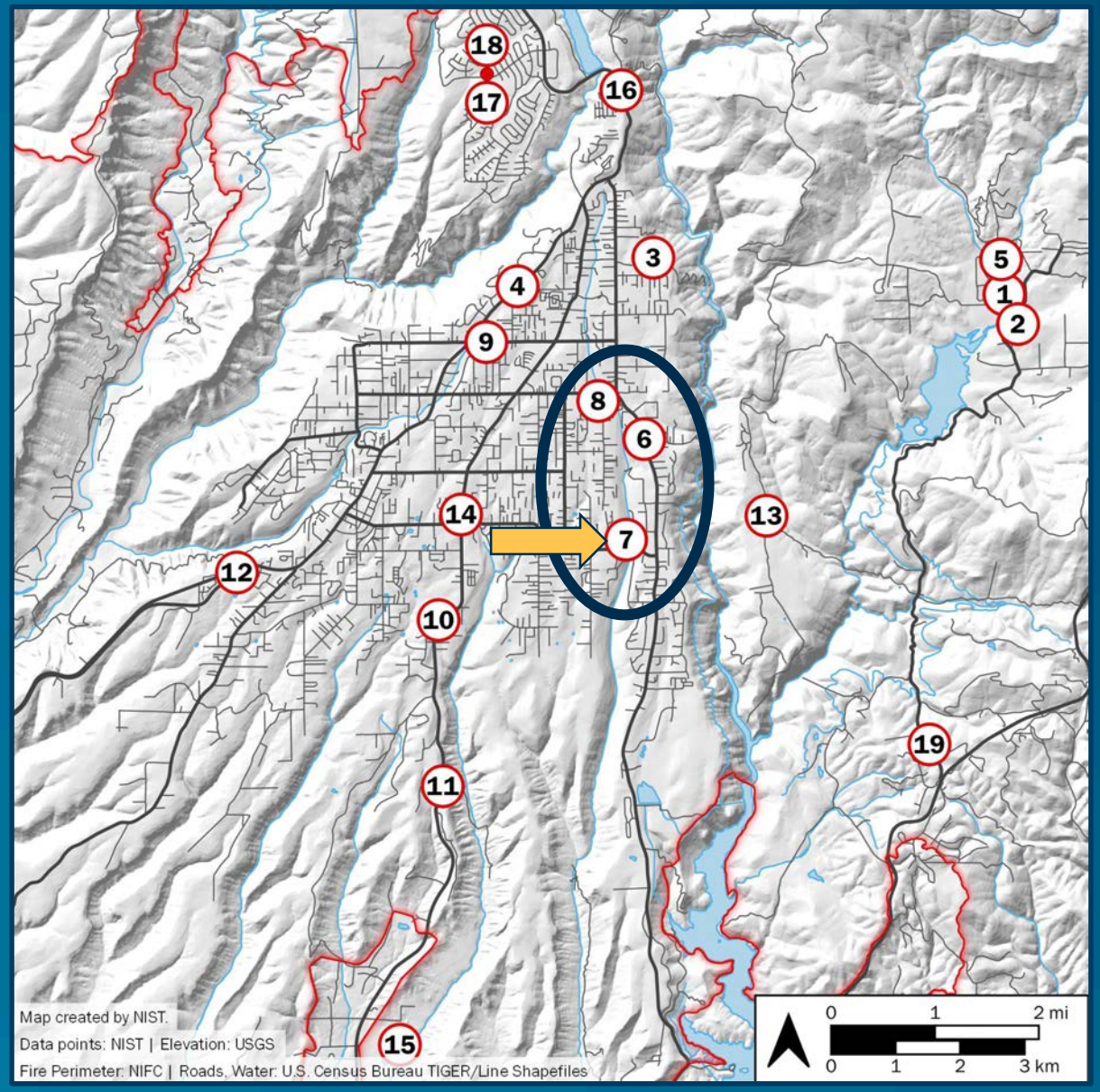
- Widespread spot fires
- Standstill traffic
- Zero visibility
- Burning vegetation, structures, and vehicles along roadway
- Multiple civilian rescues
- Shelter-in-place and traffic redirection

Video courtesy of TD-090, 10:50. Used with permission.

Conditions south of hospital after burnover

NIST Camp Fire Report #3, Figure 48.

Burnover #7: Pearson Road



NIST Camp Fire Report #3, Figure 47.

Burnover #7: Pearson Road

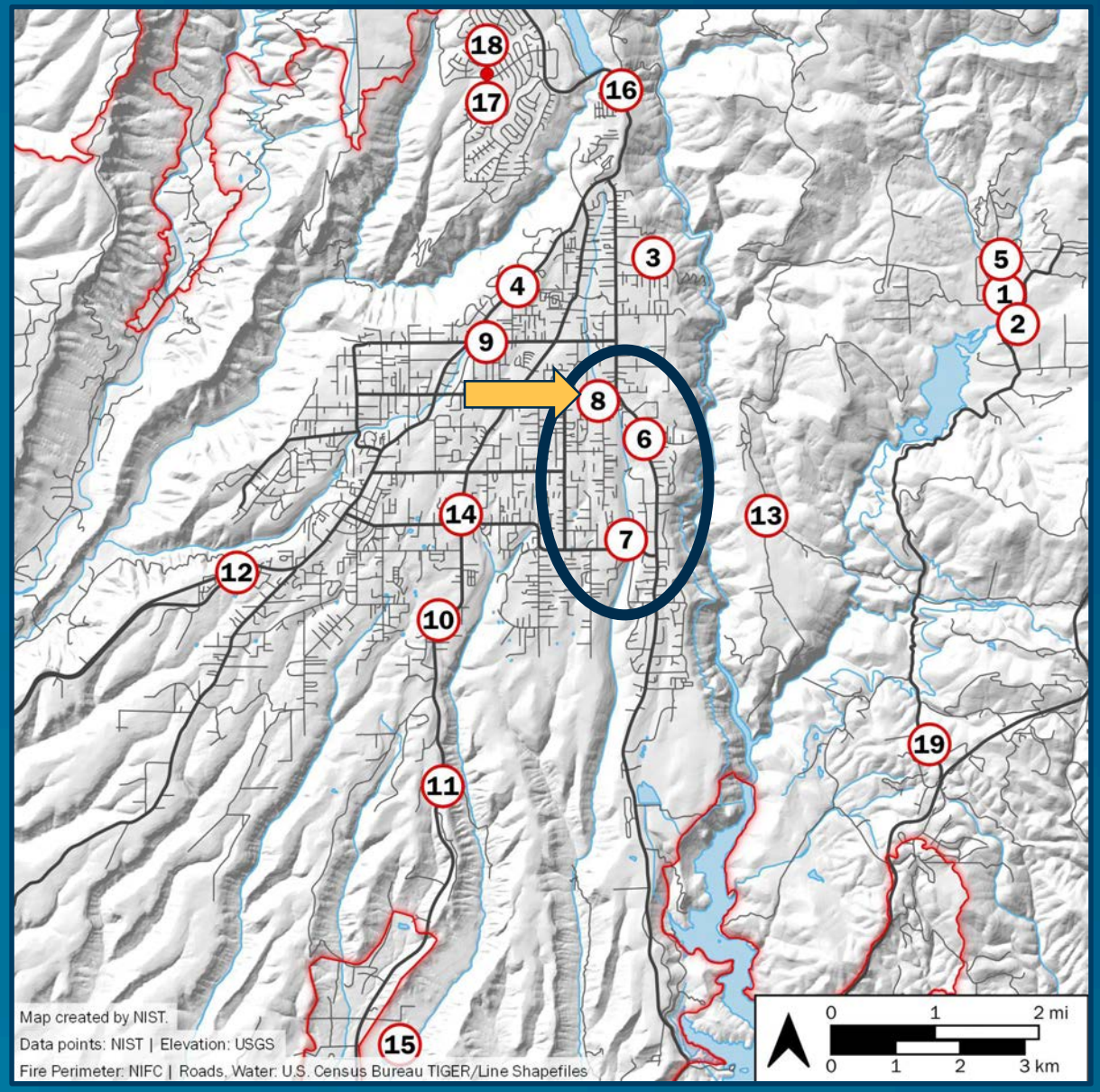

Photo courtesy of TD-122, 09:40. Used with permission.


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

- Standstill traffic
- Intense vegetation fire in drainage near Stearns Rd and Hilbe Dr
- Igniting vehicles and structures
- Fire engines and dozers assisted civilians into temporary refuge area

NIST Camp Fire Report #3, Figure 36.

Burnover #8: Bille Road



NIST Camp Fire Report #3, Figure 47.

Burnover #8: Bille Road

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

- 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.

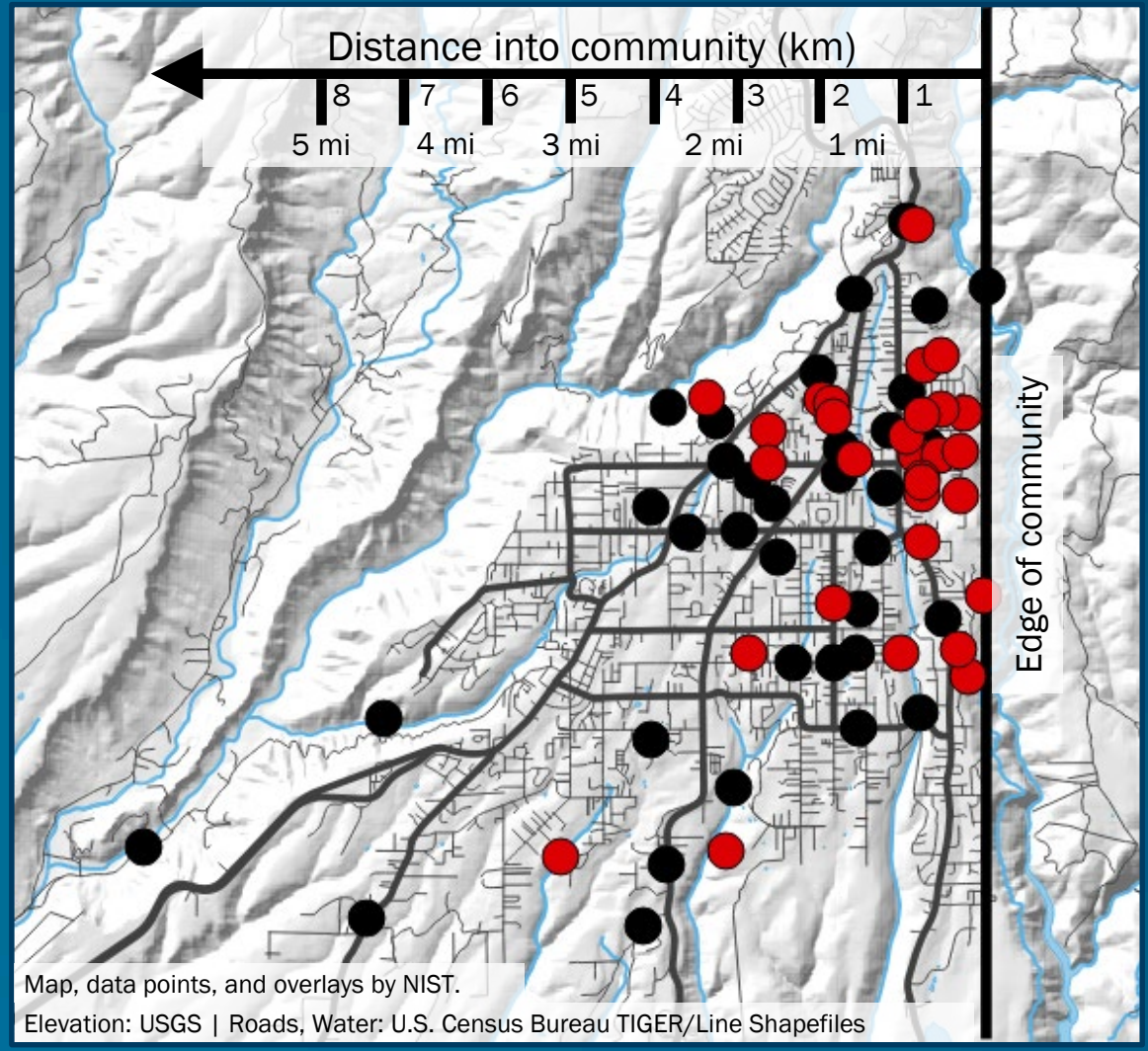
General Fire Behavior

spot fires | structure ignition pathways

Early Spot Fires in Paradise

Spot Fire Ignitions

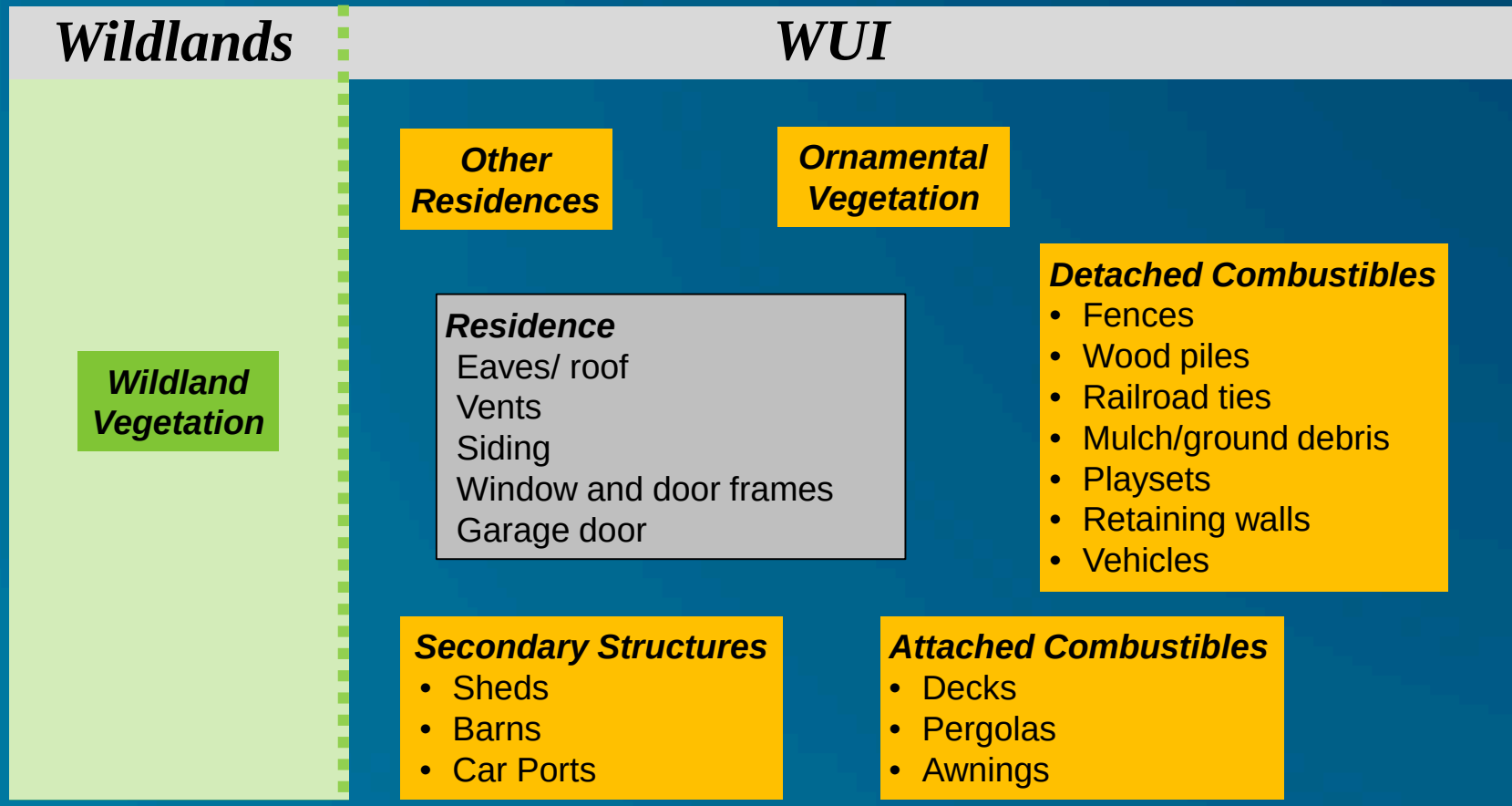
- 07:49 – 08:30 (N=30)
- 08:30 – 10:30 (N=35)



30 identified spot fires within first 40 minutes (red)

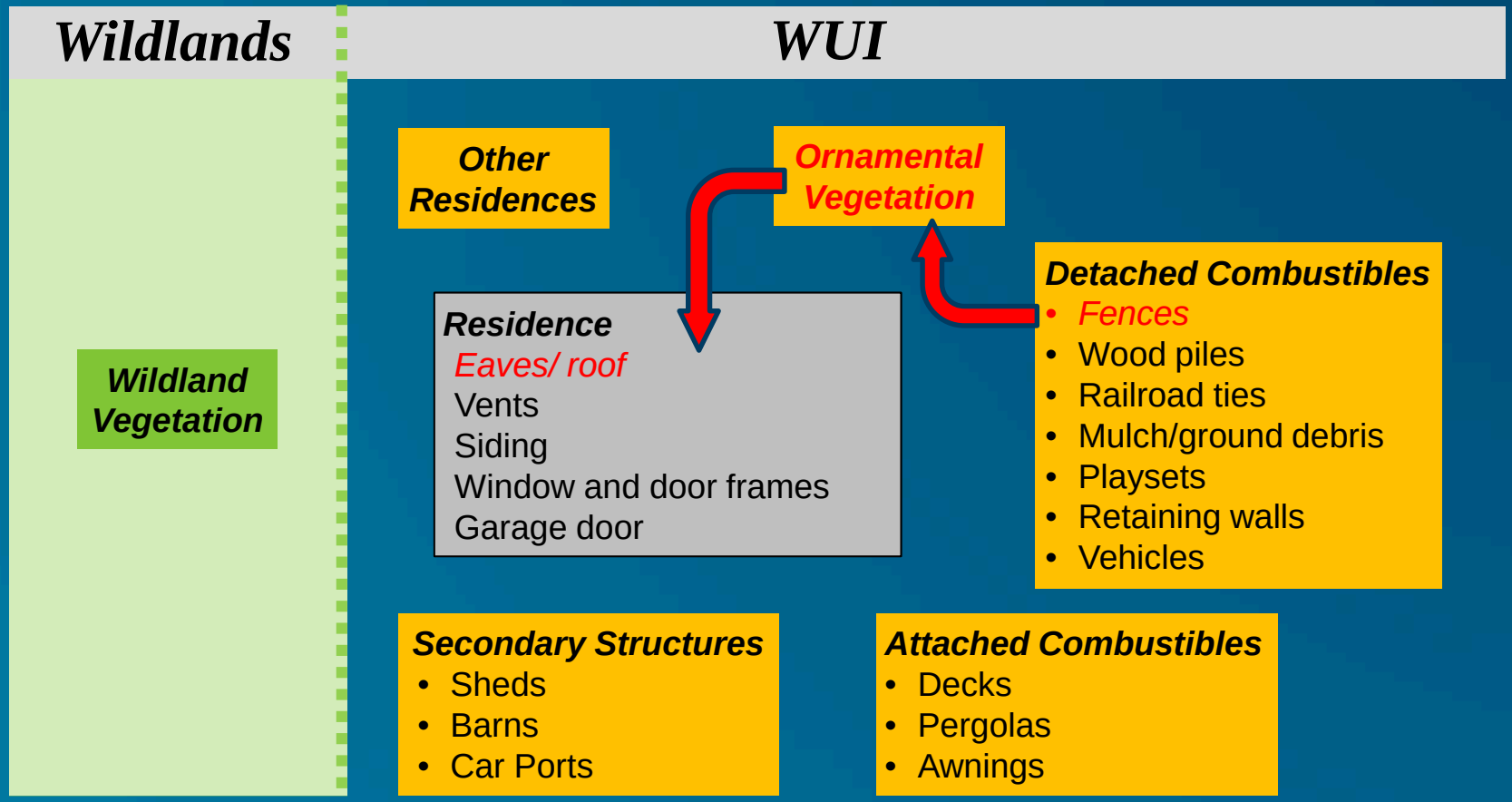
NIST Camp Fire Report #3, Figure 51.

Structure Ignition Pathways



NIST Camp Fire Report #3, Figure 54.

Structure Ignition, Example 1



NIST Camp Fire Report #3, Figure 54.

Structure Ignition, Example 1

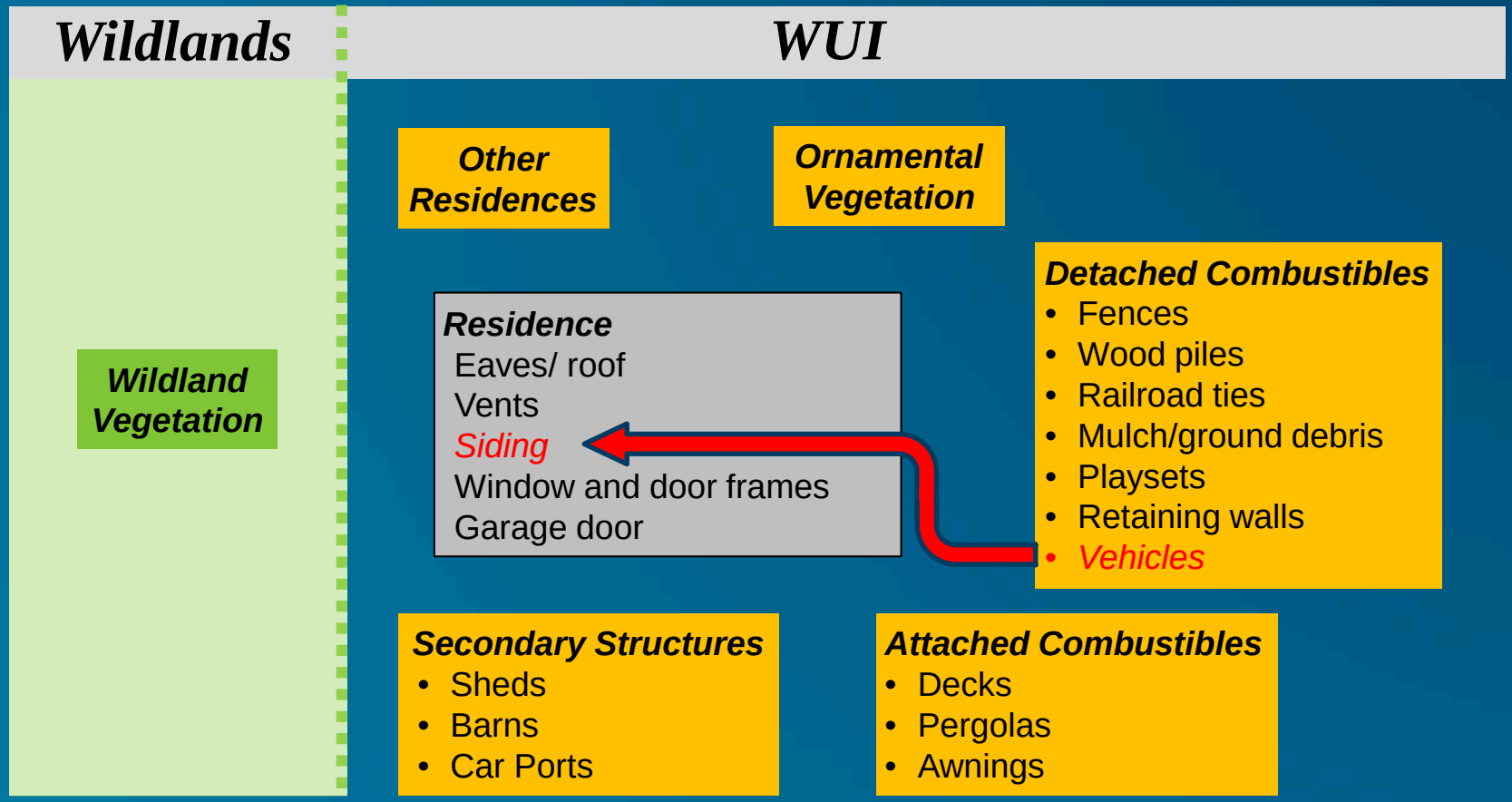
a) t = 0 s

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.

Residential Structure Ignition Pathways Identified by Direct Observation

Data Source	Time of Obs.	Location[a]	Building Ignition Pathway	Source to Target Distance	
				m	ft
TD-045	09:10	Chris Ct	Shed to fence to shed to **house**[b]	2.7	9
TD-005	10:20	Canyon View Dr	Bark mulch to **wall** of house (OSB and vinyl)	unknown	
TD-060	11:06	Sweetbriar Ln	Structure ignition via radiation from neighboring structure on fire	11	35
TD-092	13:52	Neal Rd	Burning car to shed to **house**	unknown	
TD-091	14:06	Lewis Ranch Rd	Burning car to side of **house**	1.5–2.4	5–8
TD-091	14:06	Neal Rd	Mulch to **garage**	unknown	
TD-015 TD-017 TD-064 PPD	14:37	Skyway	Fence to **wall** of building	2.4	8
TD-100 TD-101	14:53	Pearson Rd	Commercial structure to commercial structure roof to **eave**	0.7	2
TD-036	14:58	Skyway	Juniper vegetation to **eave**	against house	
TD-108	17:01	Clark Rd	Juniper vegetation to **house**	1.3	4
TD-091	17:09	Neal Rd	Burning bark mulch into **subfloor vents** of house	unknown	
TD-091	17:23	Sutter Rd	8 m × 4 m (26 ft × 13 ft) shed to house **eaves**	2.4	8
TD-044	19:00	Valley Ridge Dr	Fence to boat to **house**	2.7–3.6	9–12
TD-205	20:12	Clark Rd	Boat on fire to **eaves** of house	2.5	8
TD-044	22:30	Valley Ridge Dr	Woodpile to **house**	0.3–0.7	1–2
TD-041	03:20[c]	Dade Ct, Magalia	Fence/ground fuel to tree to **eaves** of house	1.5	5

[a] **Location in Paradise unless noted.**
[b] **Second shed fire resulted in an explosion that caused a firefighter injury.**
[c] **November 9.**

NIST Camp Fire Report #3, Table 35.

Primary Driving Factors

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

Primary Drivers Influencing the Extent of Damage and Destruction

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.

Fuel Ignition Potential

- Dry fuels receptive to ignitions from embers
- "100 % ember ignitions" *[TD-041, TD-079]*
- Numerous spot fires ignited in fine fuels (pine needles, ornamental vegetation) well ahead of the fire front
- In Paradise, ignitions started approximately 30 min to 40 min before the arrival of the fire front

Fuel receptivity within the communities caused the large number of spot fire ignitions.

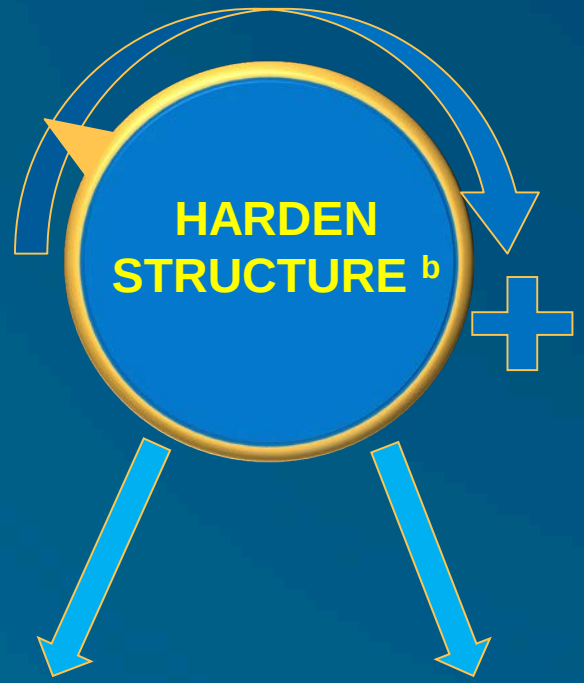
Density of Vegetative and Structural Fuels

- Century-long community growth
  - Wildland-urban intermix developed within wildland vegetation
  - Smaller residential lot sizes
  - Locally low structure separation distances
- No fire history within Paradise and Magalia
  - Long-term accumulation of vegetative fuels
- Post-fire fuel transition to brush and finer fuels in Concow area *[TD-008]*

Density of Vegetative and Structural Fuels – Addressing the Hazard

Displace Fuels

Remove Fuels



Fire Resistant Design

Ignition/Fire Spread Resistant Materials

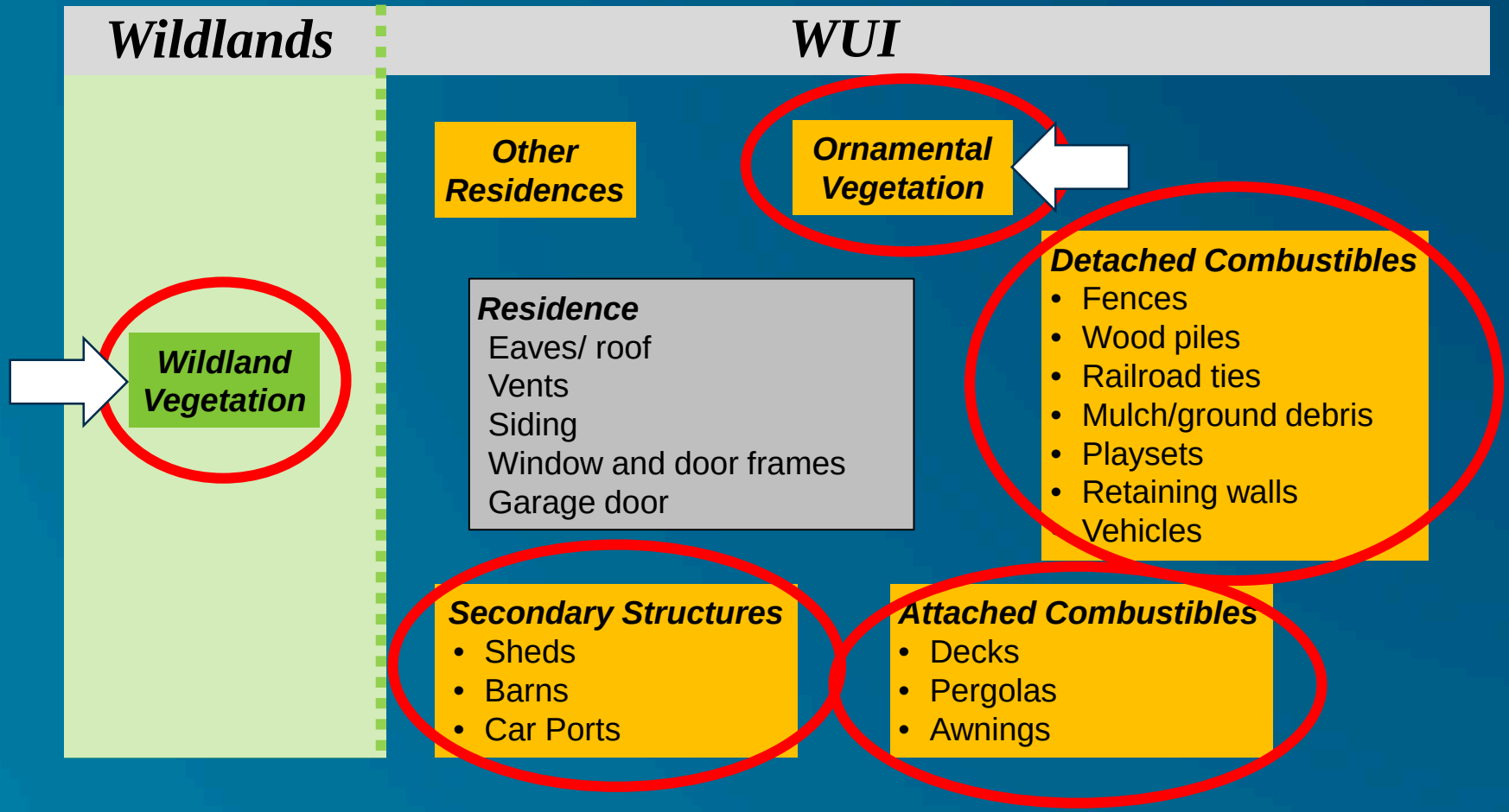
Community Design

Active Systems

a Reduce fire and/or ember exposures

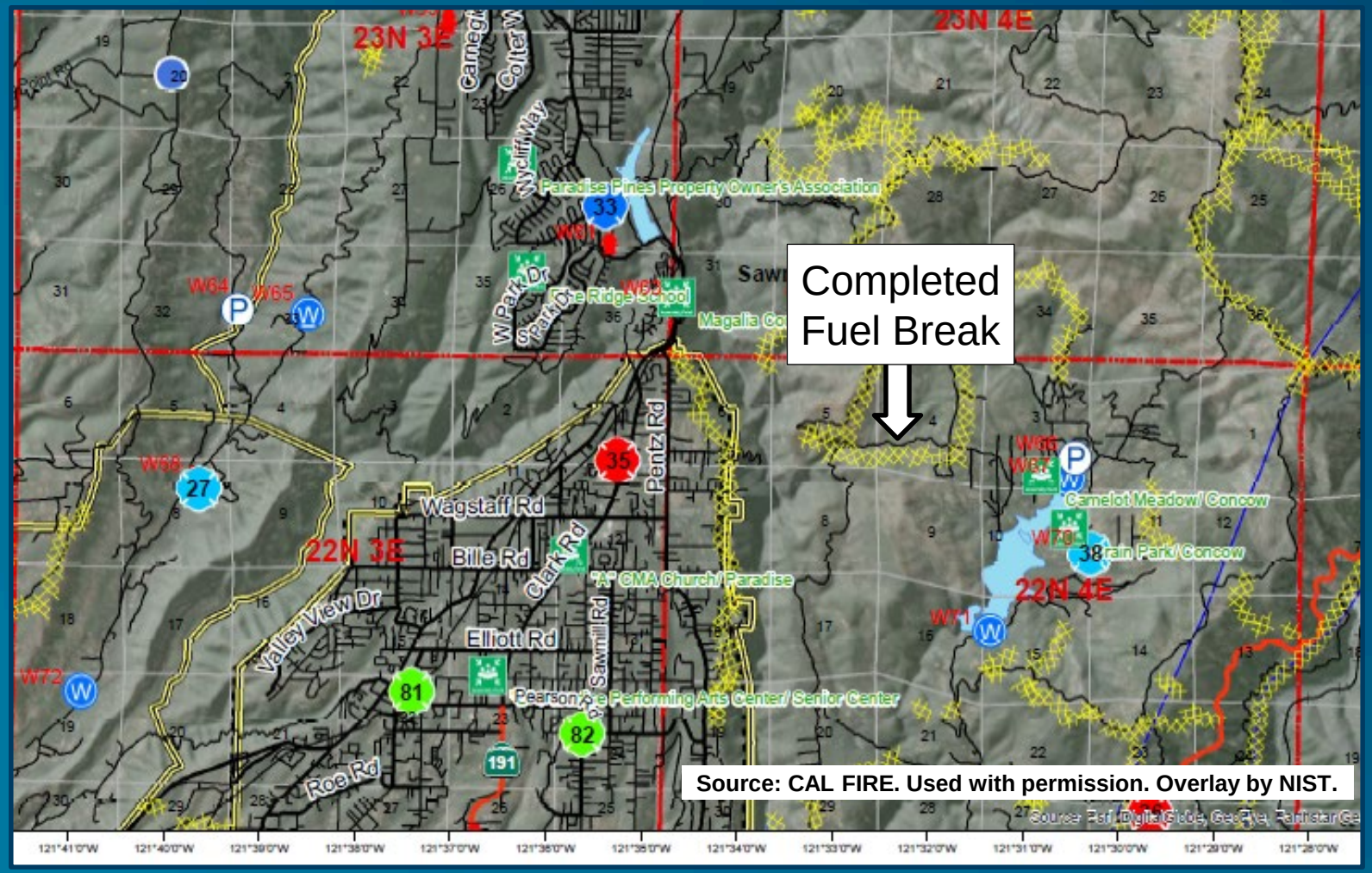
b Hardening for embers and/or fire

Structure Ignition Pathways – Fuels Reduction



NIST Camp Fire Report #3, Figure 54.

Wildland Fire Pre-Plan – Butte County Fire Department



NIST Camp Fire Report #3, Figure 55.

Fuel Treatment Around Critical Infrastructure (Paradise Irrigation District)

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.

Wind and Terrain

- Jarbo Gap is known for its high winds *[TD-003, TD-008]*
- Wind* event + topography + dry fuels
  - Rapid fire growth
  - Fire could not be contained soon after ignition

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

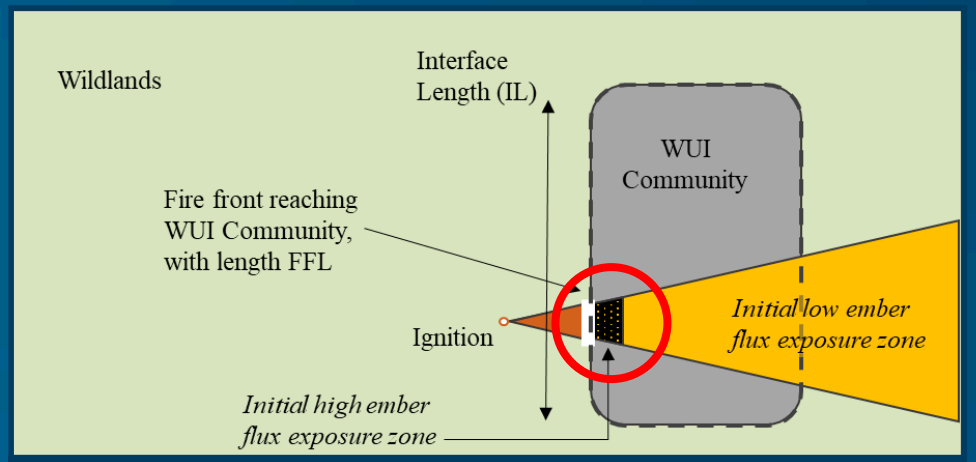
** Wind was not extreme throughout the event (temporally and spatially)*

Extent/Size of Fire Front Reaching the Communities

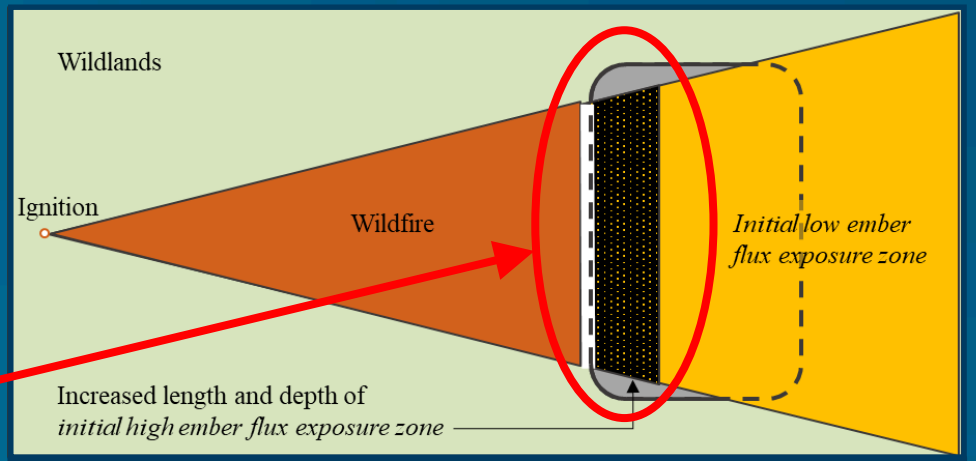
Idealized relationship between ignition location, near or far from WUI Community, and fire front and ember exposures reaching the community.

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.

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

Recommendations

resident and first responder life safety

reduction of structural losses

Recommendations

R1. Characterize fire behavior that leads to burnovers and quantify burnover severity. This information will inform fuel setback guidance for primary egress arteries and provide technical input to evacuation plans. *(Section 10.3, F15, F16, F17, F18)*

R2. Develop technical guidance to quantify parcel level exposures. *(Section 12.2, F20, F21, F22)*

R3. Quantify fire spread within parcels with focus on fire exposures. (*Section 12.2, F20, F21, F22)*

R4. Quantify exposures from adjacent parcels, specifically from neighboring structures, and develop design guidance for structure separation distances. *(Section 12.2, F20, F21, F22)*

R5. Develop methodology to connect field-collected ember data, such as ember flux and size distribution, to laboratory scales and develop worst case ember exposure criteria. *(Section 15.2, F7, F10, F11)*

R6. Develop spacing/hardening cost benefit relationships for high energy release sources (fences, wood piles, sheds, vehicles, RVs, and residences) and target structures (residential and commercial). *(Section 15.2, F20, F21, F22)*

R7. Characterize the relationships among fire history, fuel treatments, and fire behavior. *(Section 14.2, Section 15.1, F5, F6, F7, F8, F9, F10, F11, F12, F13, F17, F19, F21, F22)*

R8. Develop a standardized methodology for assessing the exposures from ornamental vegetation. *(Section 12.2, F20, F21, F22)*

R9. Develop a plant list for vegetation with unacceptably high fire hazard for northern California and other locations with WUI fire risks. (*Section 12.2, F20, F21, F22)*

192 Contributors — THANK YOU!

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

Thank You

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