NIST Presentation

Camp Fire: Fire Progression Timeline

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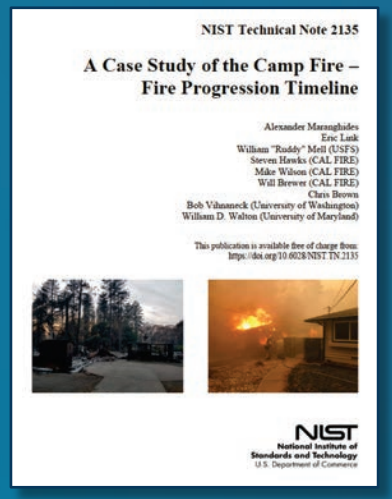
NIST Technical Note 2135

A Case Study of the Camp Fire – Fire Progression Timeline

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Abstract

The Camp Fire ignited on November 8, 2018 in the foothills of the Sierra Nevada in Butte County, California. The first 24 hours were characterized by a fast-moving fire with initial spread driven by high winds up to 22 m/s (50 mi/h) and long-range spotting up to 6.3 km (3.9 mi) into the community. The fire quickly impacted the communities of Concow, Paradise, and Magalia. The Camp Fire became the most destructive and deadly fire in California history, with over 18 000 destroyed structures, 700 damaged structures, and 85 fatalities.

After a preliminary reconnaissance, it was determined that abundant data was available to support an in-depth case study of this devastating wildland-urban interface (WUI) fire to increase our understanding of WUI fire spread, fire behavior, evacuation, and structure response. The methodology guiding the case study and a detailed timeline reconstruction of the fire progression and fire behavior are presented. Over 2200 observations about fire spread and behavior were collected during the case study. Subsequent reports will detail additional aspects of the incident including emergency response and evacuation, and defensive actions and structure response.

This study has identified that Butte County and the Town of Paradise were well prepared to respond to a WUI fire, that the Camp Fire grew and spread rapidly and that multiple factors contributed to the rapid growth and spread of the Camp Fire. Additionally, this study identified the importance of the wildland fire ignition location relative to the community, that multiple parcel-level fire spread pathways caused structure ignitions, and that WUI fire spread impacted the affected communities in multiple ways beyond the destruction of residential and commercial properties.

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

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Including data contributions from:

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The Camp Fire
Paradise, CA

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Photo courtesy of CALFIRE, used with permission

NIST, Who We Are and What We Do

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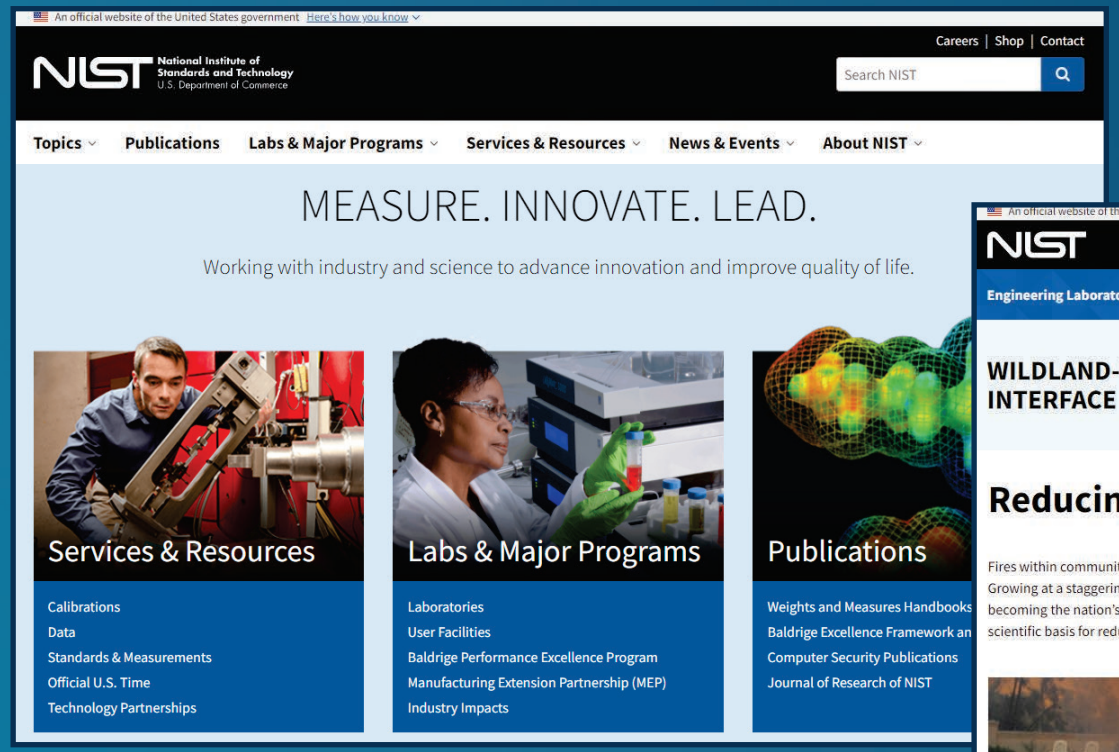

NIST is a Non-Regulatory Federal Agency

WUI Programmatic Goals: Enhance Life Safety and Reduce Fire Losses to Structures and Infrastructure

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

NIST Measurement Science

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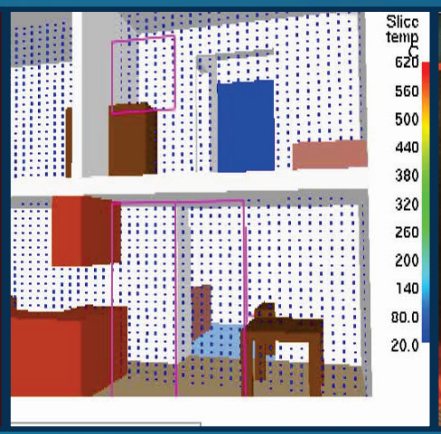
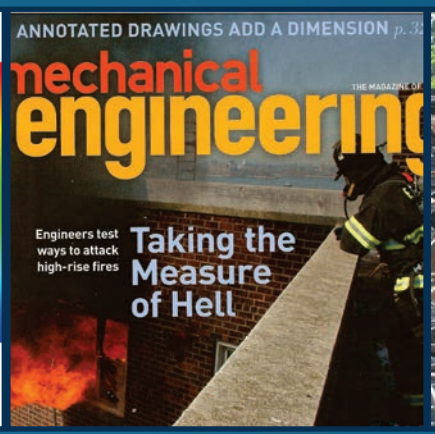
Measurement science supporting the technical basis for:

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





materials **models** **measurements** **investigations** **standards**

WUI Fire Case Studies

- Witch / Guejito Fires (2007) *San Diego, CA*
- Willow Creek / Tanglewood Fires (2011) *Amarillo, TX*
- Waldo Canyon Fire (2012) *Colorado Springs, CO*
- Camp Fire (2018) *Paradise, CA*

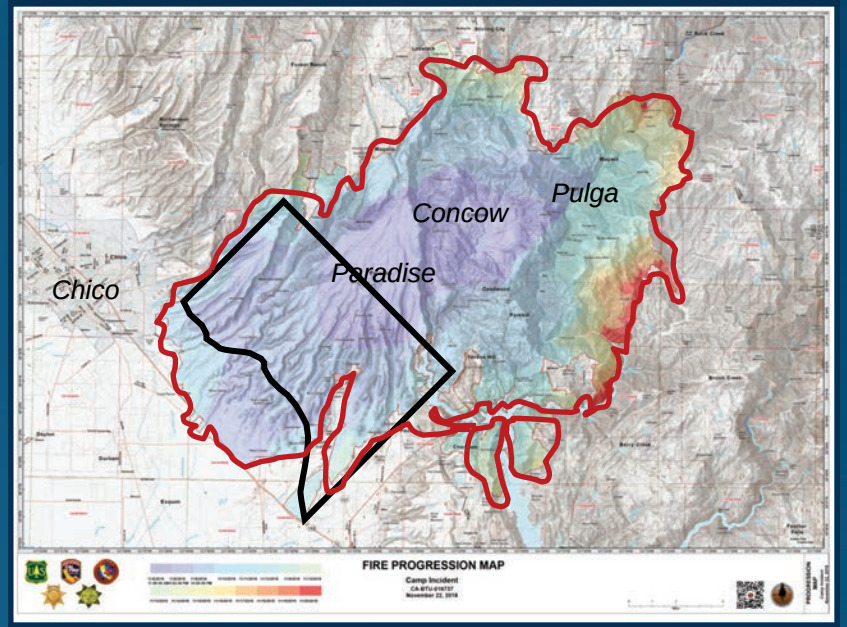
Camp Fire Overview

losses | statistics

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

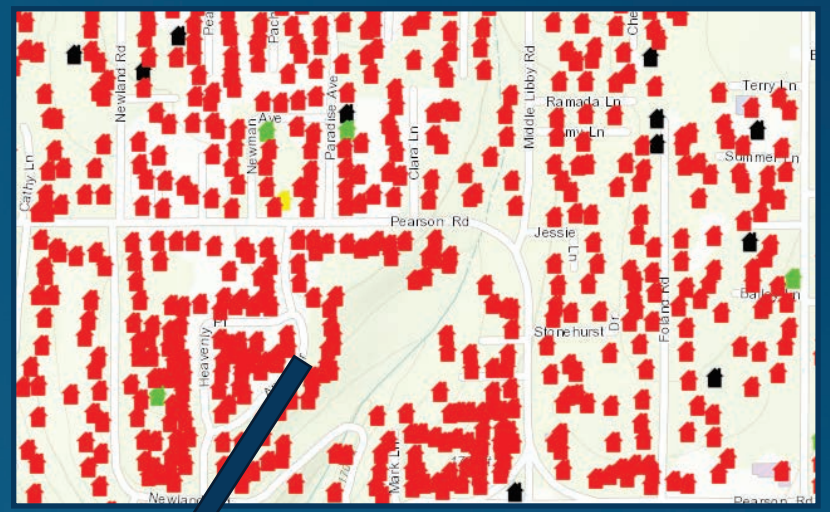
Camp Fire ~ 14 % Butte County area

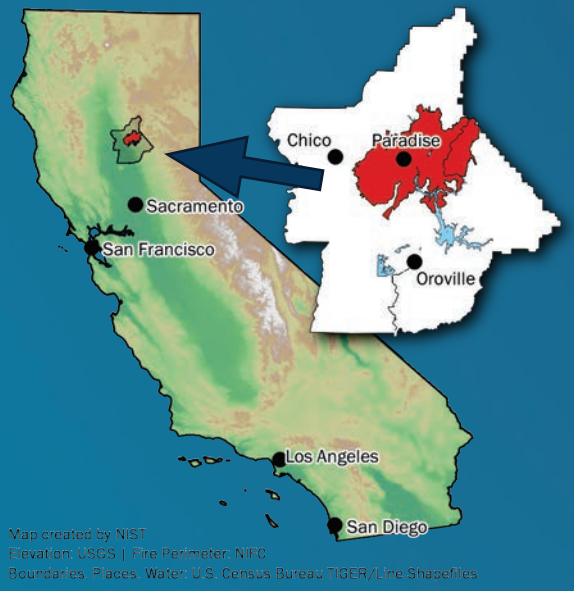


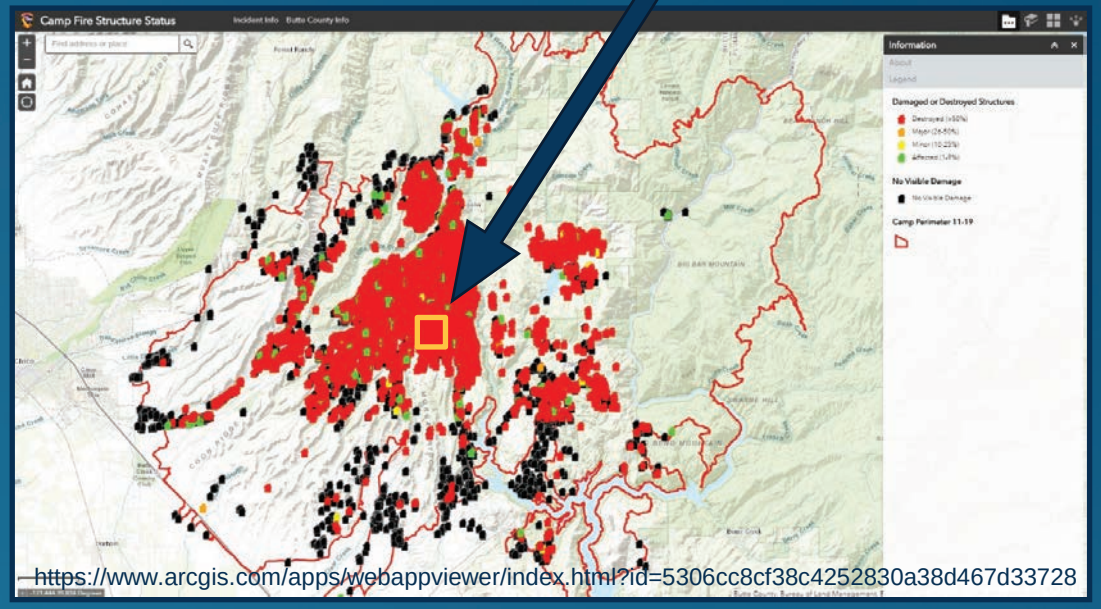
Camp Fire ~ 4× Washington, D.C. area

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

Paradise Points of Interest

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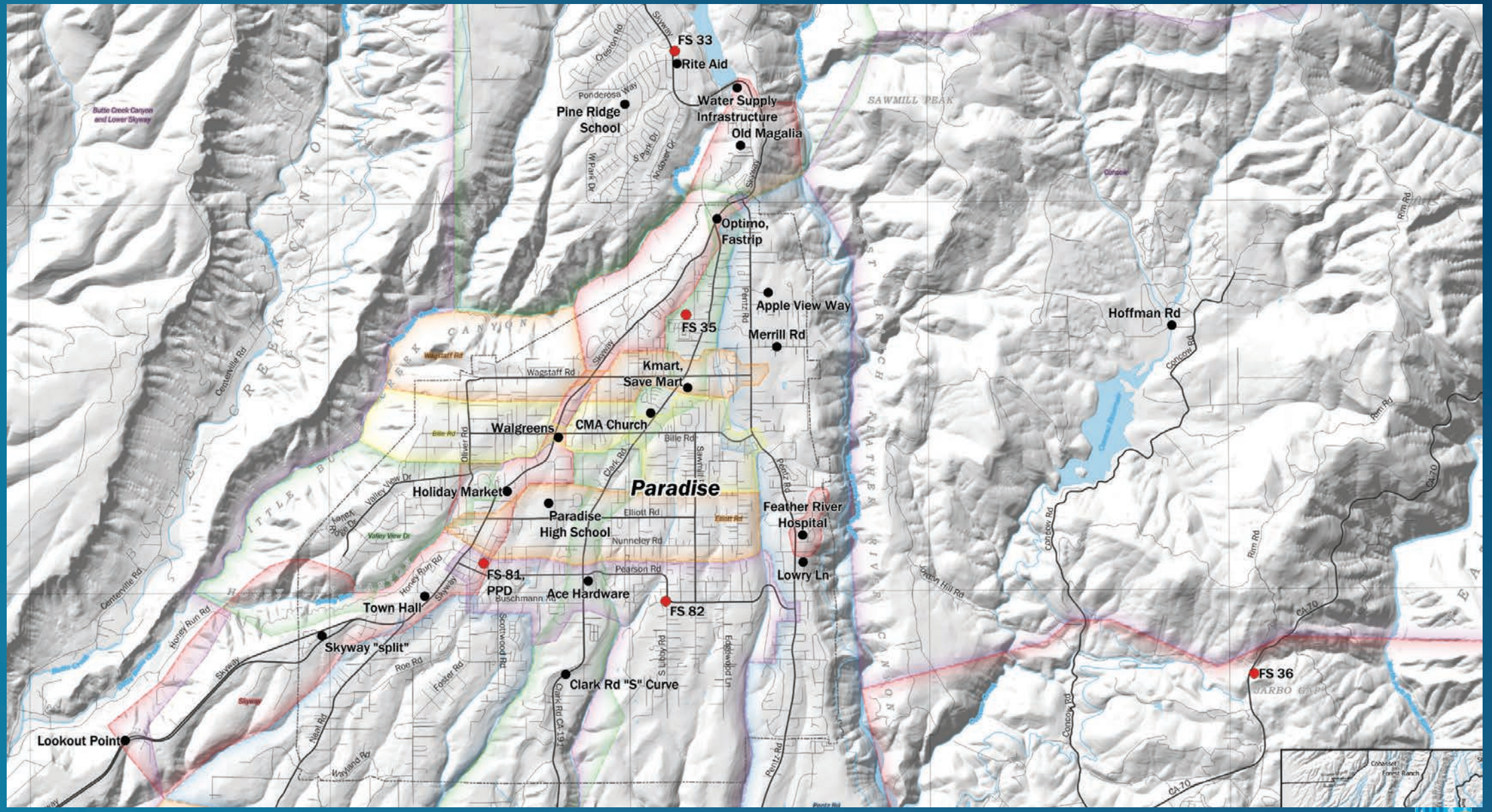


Camp Fire Structure Losses

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

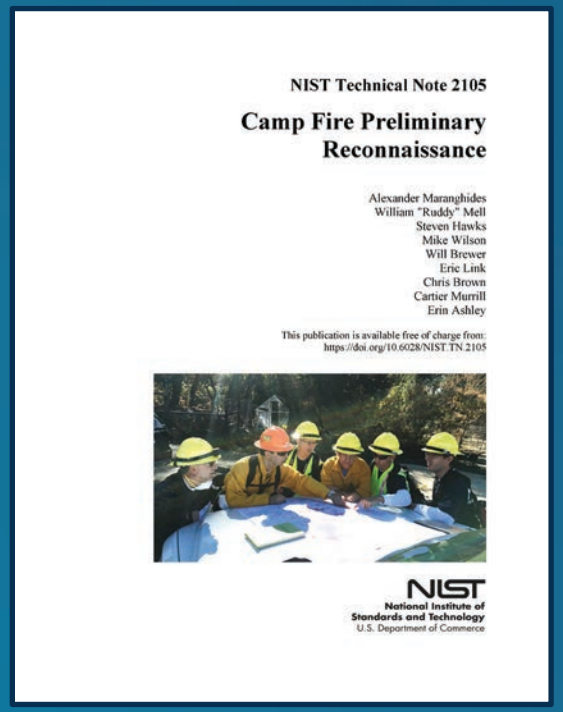
goals* | *contributors* | *research questions

The NIST Camp Fire Timeline Reconstruction

- Goals:
  - Timeline Reconstruction of the Camp Fire
  - Focus on first 24 hours of the fire
- NIST, USFS, FEMA Team was on scene with within eight days of ignition
- Timeline Reconstruction effort is led by NIST
- Joint effort with CAL FIRE, the USFS, FEMA, state and local jurisdictions including the Town of Paradise and Paradise Police Department

The NIST Camp Fire Case Study

- ✓ Report #1: Camp Fire Preliminary Reconnaissance
- ✓ Report #2: Preliminary Data Collected from the Camp Fire Reconnaissance


NIST Technical Note 2105

Camp Fire Preliminary Reconnaissance

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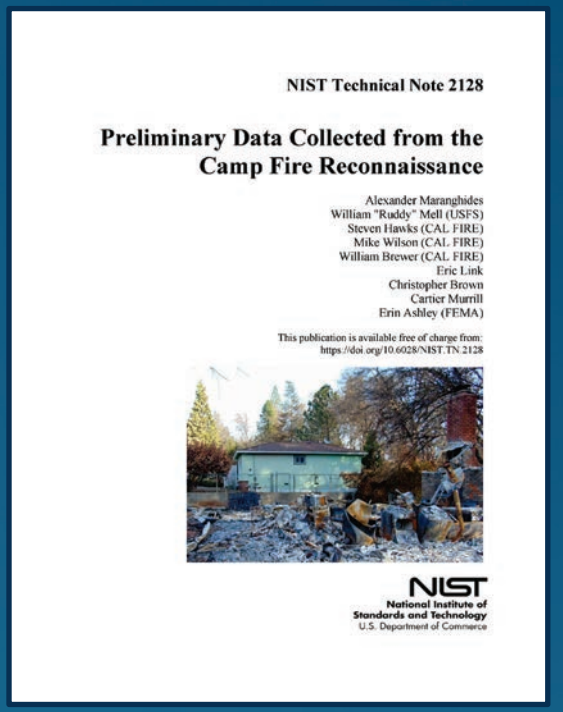
NIST Technical Note 2128

Preliminary Data Collected from the Camp Fire Reconnaissance

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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

Contributors

Camp Fire Reconstruction Phase	Participants	Phase Total
Field Reconnaissance	Alex, Eric, Chris, Cartier, Ruddy, Erin, Steve, Mike, Will, David, DINS, OSFM	10 +
Shadow Team (supporting Field Recon.)	Nicole C, Becky, Sue, Nelson, Jiann, NIST Legal, NIST Library, Judy, Andrew, Carolyn	10
Field Data Collection Logistics	David, Danielle, Colette, Kirk	4
Field Data Collection	Alex, Eric, Chris, Cartier, Ruddy, Erin, Steve, Mike, Will, David, DINS, OSFM	10 +
Technical Discussions	Alex, Eric, Cartier, Lucy, Becky, Ryan, Bob, Nicole L	7
Data Analysis and Integration	Alex, Eric, Chis, Doug	4
Report Writing	Alex, Eric, Chris, Ruddy, Steve, Will, Bob, Doug	8
Report Review	Karen, Kathy, Jiann, Nelson, NIST Legal, Judy, Howard	7
Publication and Public Affairs	Vince, Jonathan, Jennifer	3
Technical Discussion Participants	First Responders, *et al*.	157
	Individual Total	**192 + DINS, OSFM**

Contributors – Technical Discussions

THANK YOU!

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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

Technical Discussion Locations

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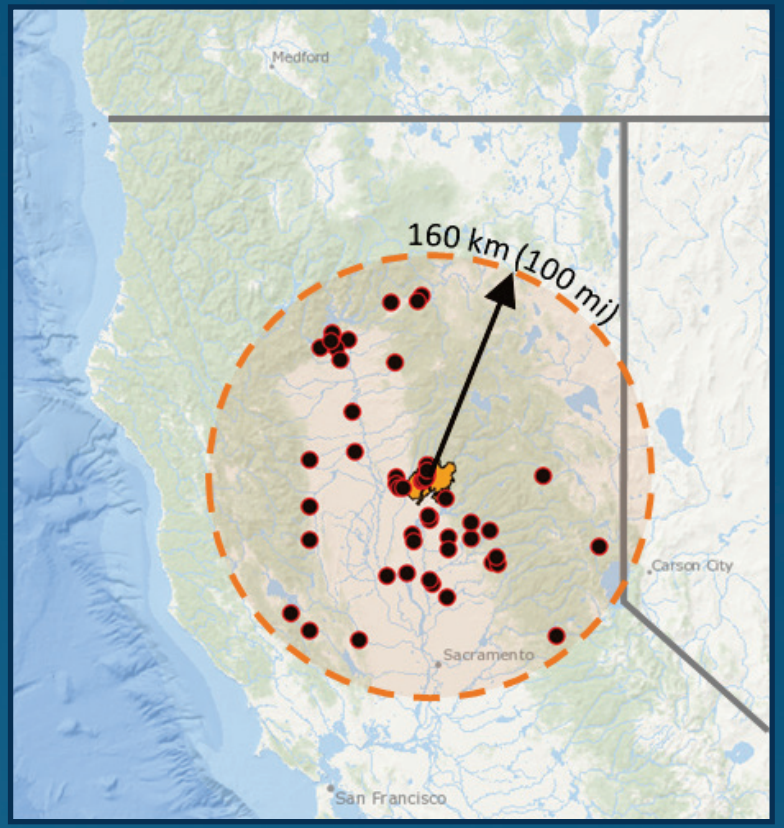
American Medical Response–Shasta County
B-Line Butte Regional Transit
BTU Station 35–Paradise
BTU Station 62–Harts Mill
BTU Station 63–Oroville
BTU–Butte Fire Center
BTU–Unit Headquarters
Burney Fire District Station 17
Butte County Emergency Command Center
Butte County Fire Safe Council
Butte County Fire Station 33–Upper Ridge
Butte County Fire Station 42–North Chico
Butte County Fire Station 44–South Chico
Butte County Fire Station 55–Bangor
Butte County Fire Station 73–Biggs
Butte County Fire Station 74–Gridley
Butte County Sheriff's Office
CAL FIRE–Law Enforcement Division
California Highway Patrol–Chico
Chico Fire Department–Headquarters
Del Oro Water Company
Grass Valley Emergency Command Center
Grass Valley Fire Department Station 2
Linda Fire Protection District
LNU–Brooks Forest Fire Station
LNU–Konocti Conservation Camp
Meridian Fire Protection
National Weather Service
NEU Station 61–Loma Rica
NEU–Dobbins Forest Fire Station
NEU–Nevada City Forest Fire Station
Nevada County Consolidated Fire District
Northern California Geographic Area Coordination Center
Olivehurst Fire Department
Paradise Fire Station 81–Paradise Fire Department
Paradise Irrigation District
Paradise Police Department
Shasta County Fire Station 33–Bella Vista
Shasta Lake Fire Protection District
SHU Station 14–Burney
SHU Station 22–Shingletown
SHU Station 58–Shasta
SHU Station 75–Hillcrest
South Lake County Fire Prot. Dist. Station 63–Hidden Valley
Sutter County Fire Department Station 6–Sutter
TGU Station 12–Corning
TGU Station 1–Red Bluff
TGU–Elk Creek Station
TGU–Paskenta Station
Town of Paradise
Town of Paradise–Department of Public Works
USFS CA-ENF–Pacific Ranger District, Pollock Pines
USFS CA-MNF–Stonyford Work Center
USFS CA-PNF–Beckwourth Ranger District, Blairsden
USFS CA-PNF–Challenge Visitor Center, Challenge
USFS CA-PNF–Feather River Ranger District, Oroville
USFS CA-TNF–Truckee Ranger District, Truckee
USFS CA-TNF–Yuba River Ranger District, Camptonville
Wheatland Fire Authority



Locations of TDs across northern California.

THANK YOU!

NIST Camp Fire Report #3, Figure 11.

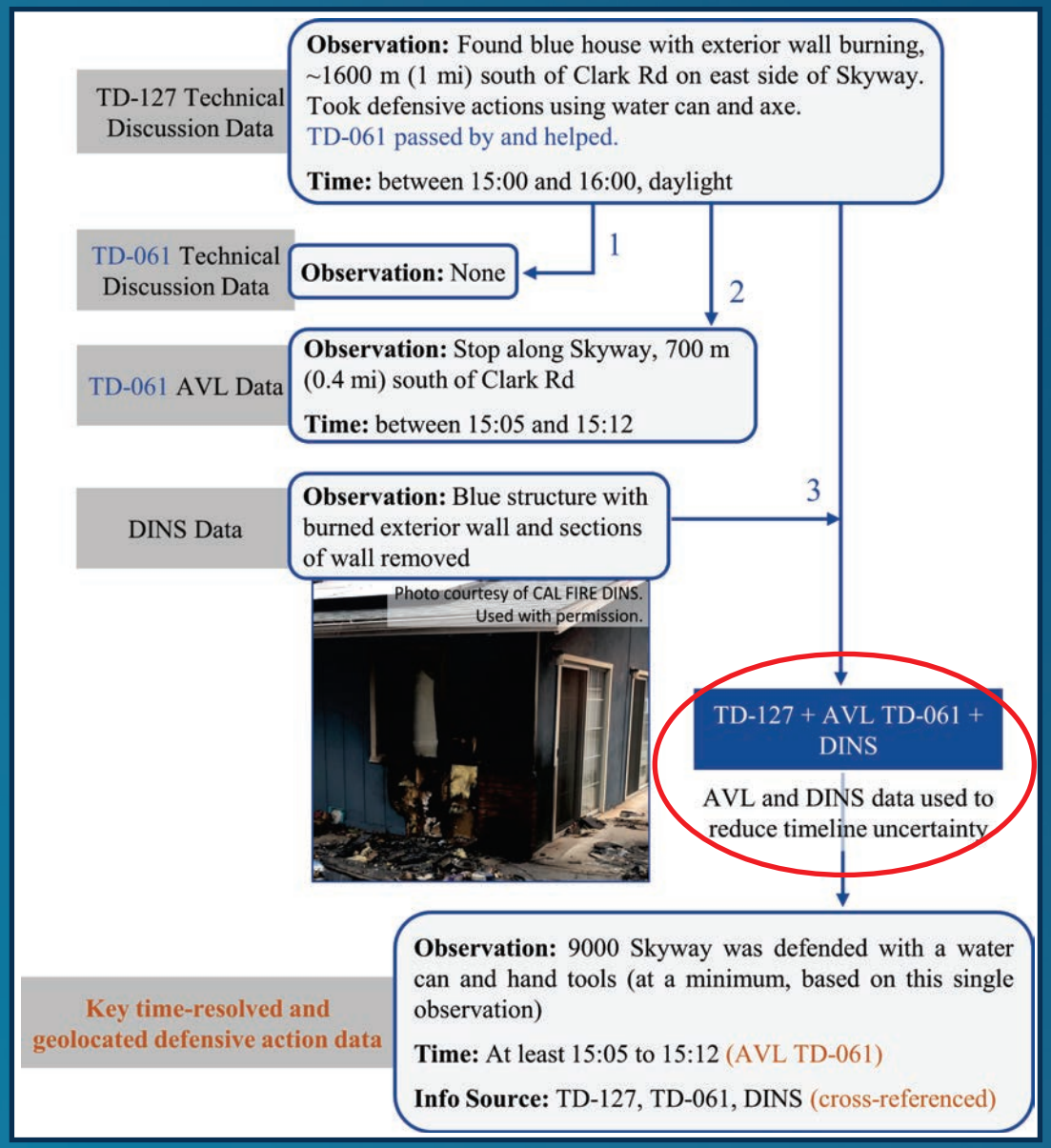
Five Research Questions

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?*

Methodology

0. Pre-plan deployment
1. Integrate with IC and DINS
2. Field data collection
3. Technical Discussions
   - Fire
   - Evacuation / notification
   - Defensive actions
4. Data Integration
5. Analysis / Summarization

Methodology



Cross-referenced, integrated, and supplemented observations

Increased detail

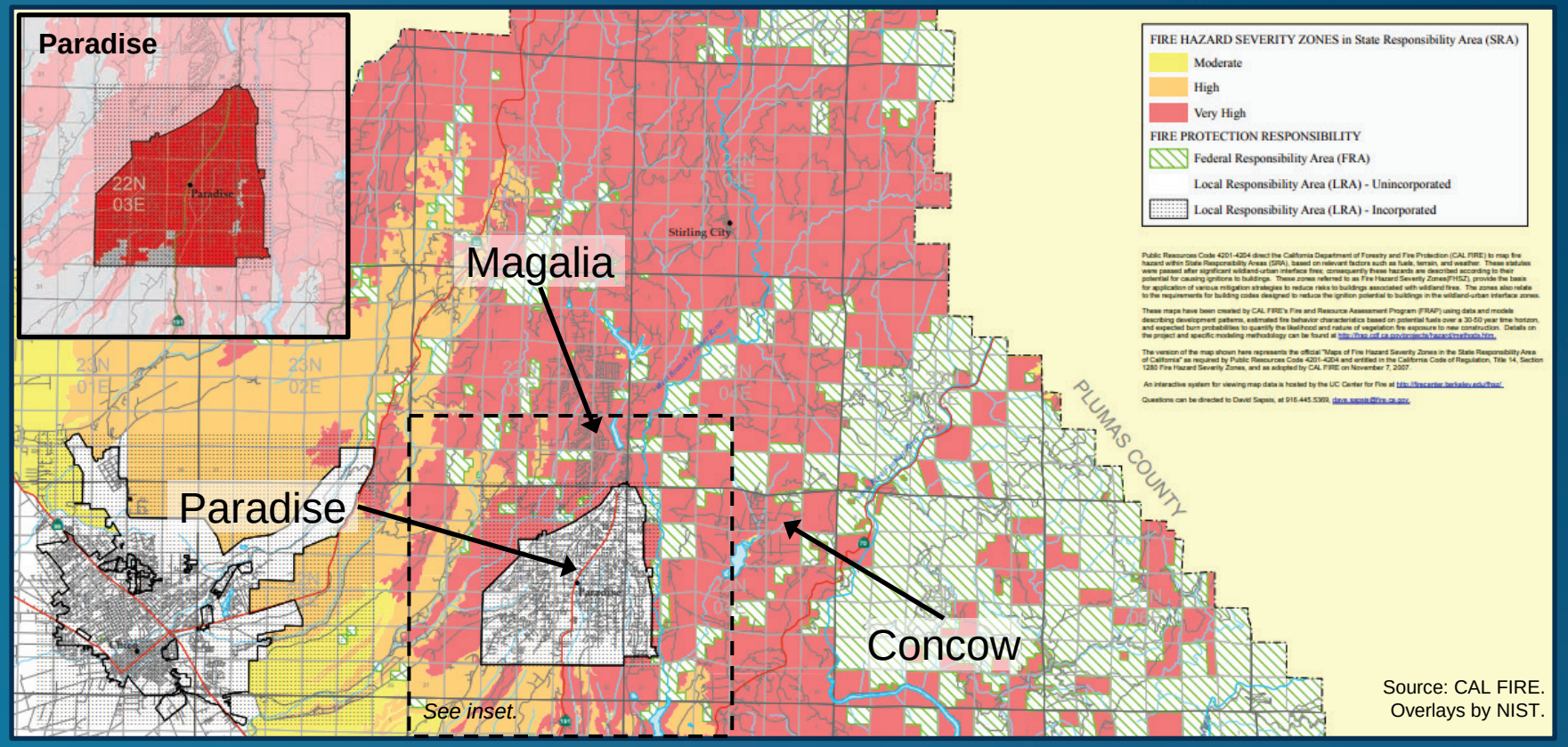
Reduced uncertainty

NIST Camp Fire Report #3, Figure 14.

Pre-Fire Conditions

wind + drought + topography + fire history

Butte County Fire Hazard Severity

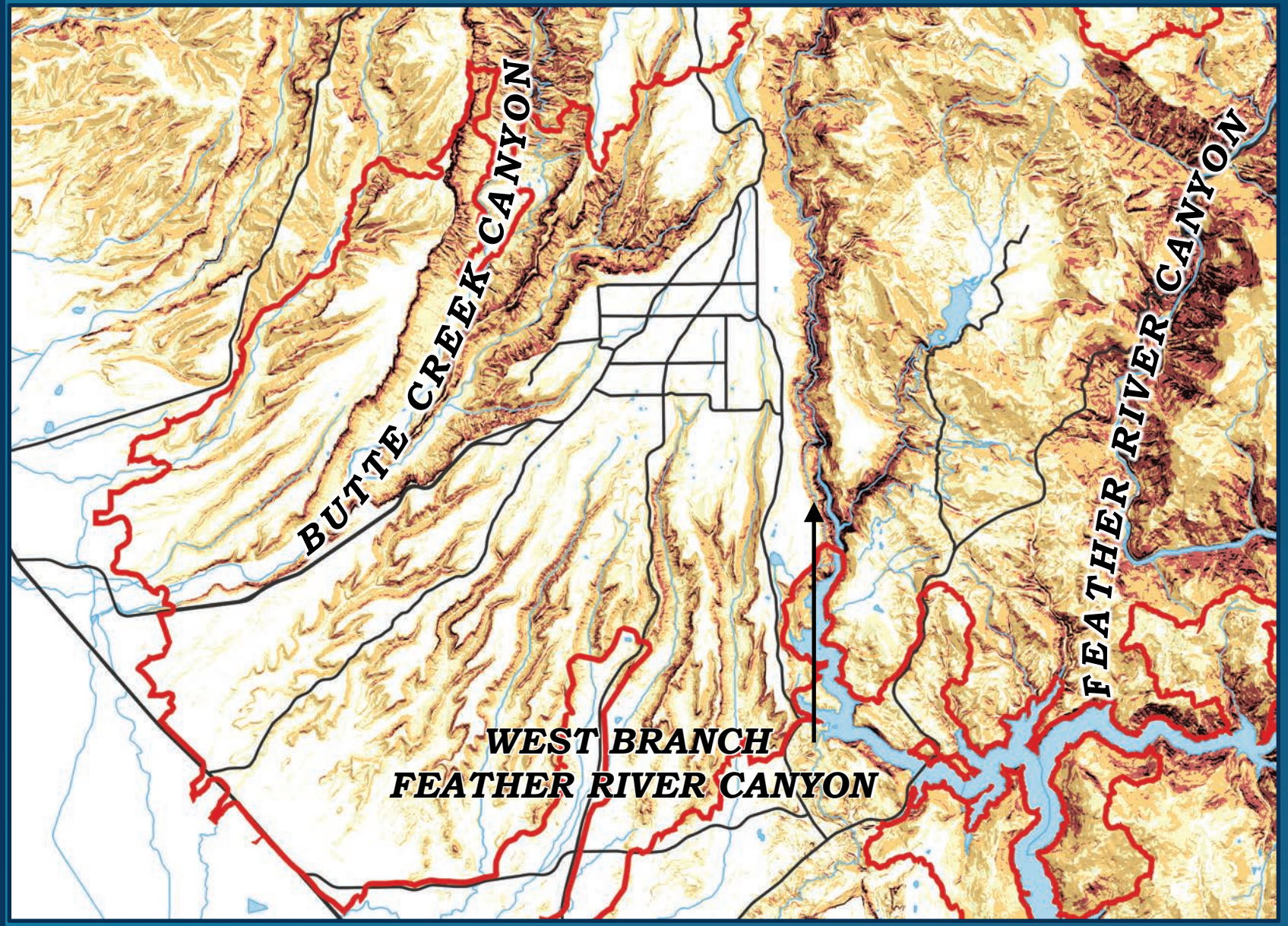


Source: CAL FIRE. Overlays by NIST.

Majority of area Very High Fire Hazard Severity Zone

NIST Camp Fire Report #3, Figure 3.

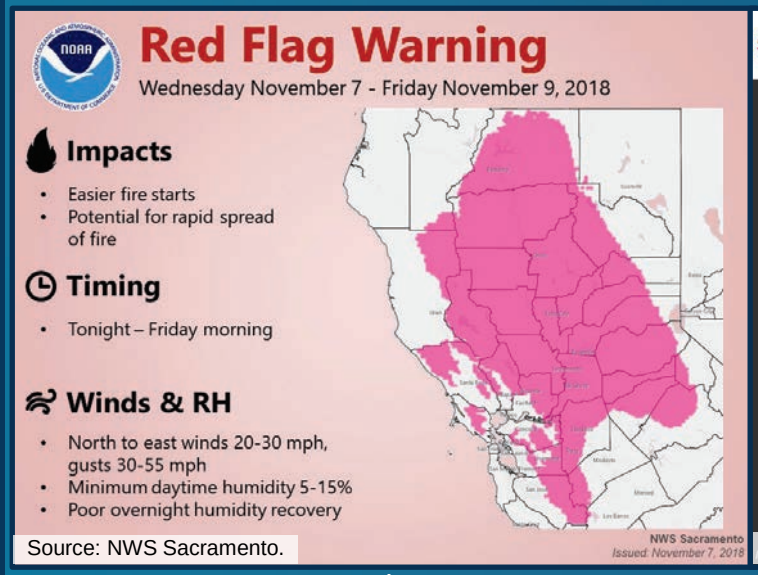
Topography



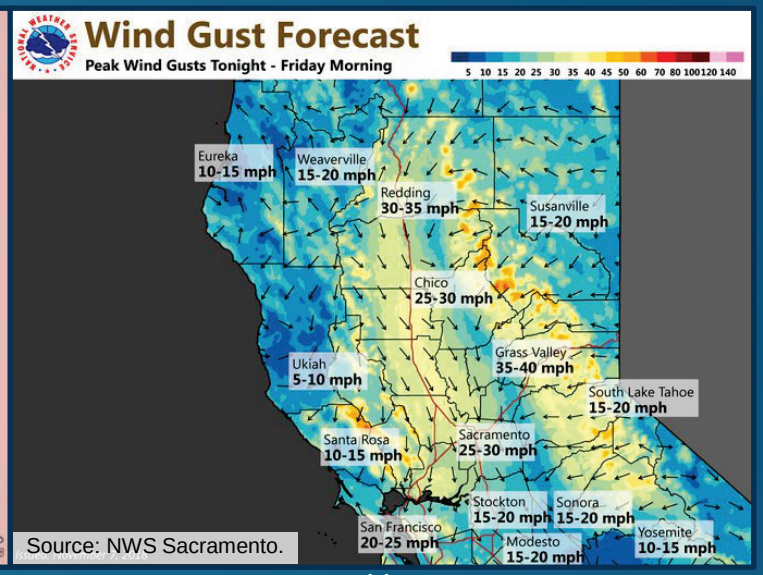
- Significant steep canyons
- Localized wind alignment
- Difficult access
- Restricted egress

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

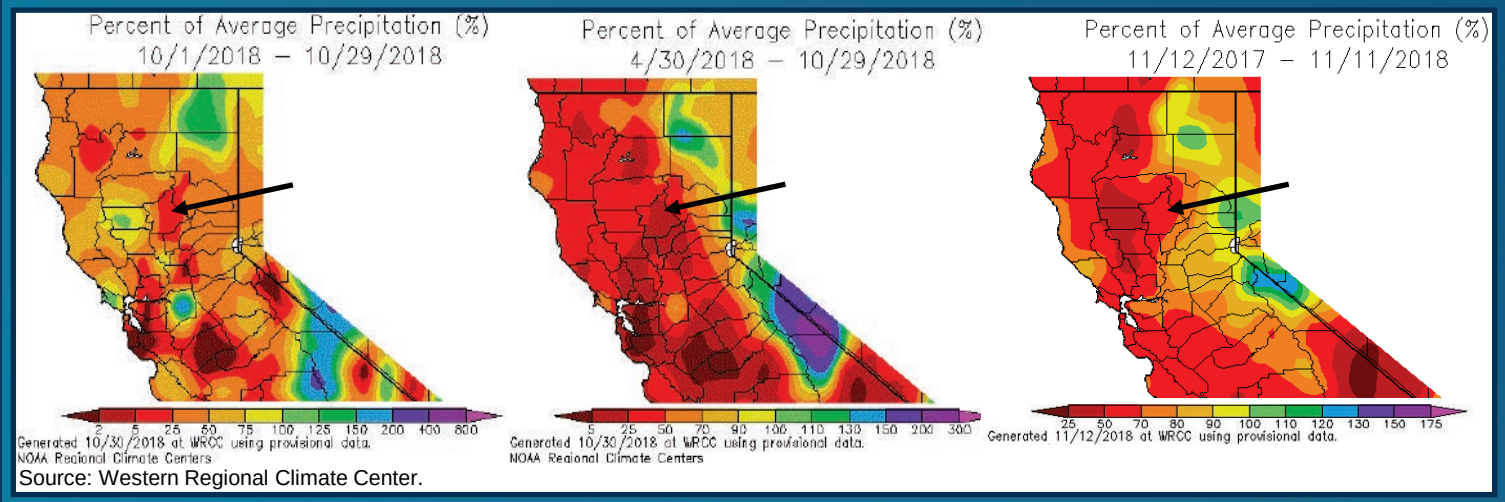
Red Flag Warning and Drought



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.

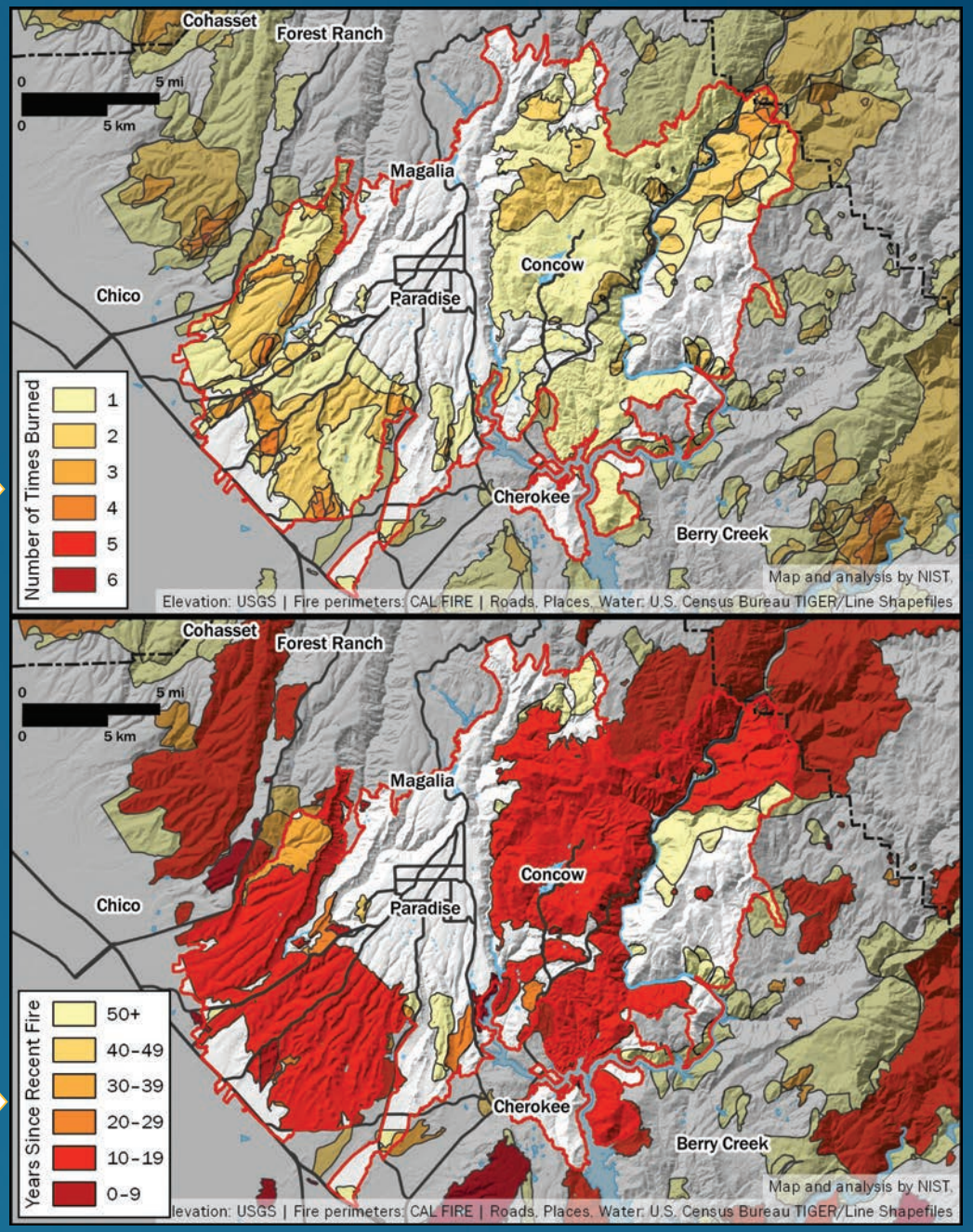
Fire History

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.



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NIST Camp Fire Report #3, Figure 10.

engineering laboratory

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.

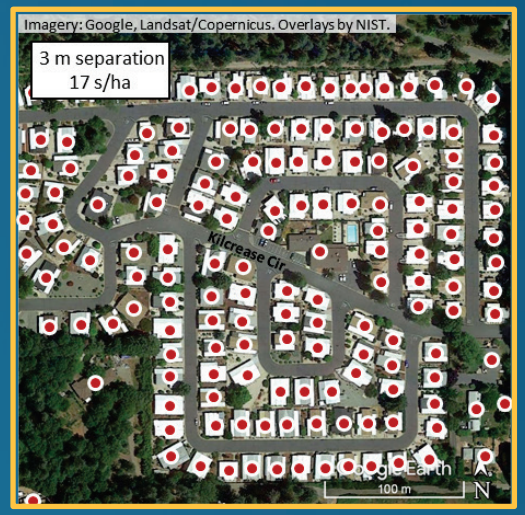
10+ fold range in effective structure density

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

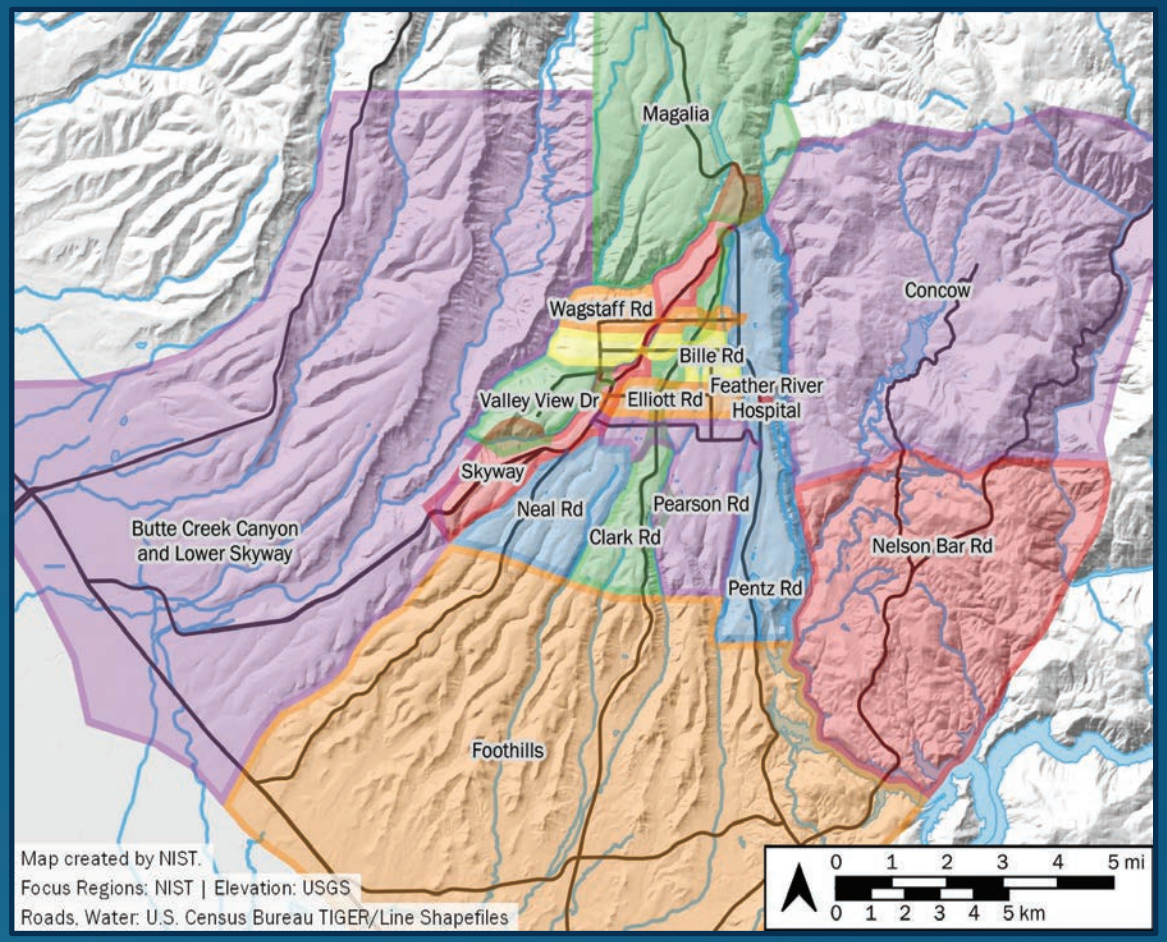
1. ***Overview*** in Executive Summary and report findings/conclusions *(3 pages)*

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.

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.

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.

Concow Fire Progression (2 of 2)

Date	Time Range		Fire Behavior Observations	Location	Source #
11/8	08:00	08:30	Hoffman Rd burnover event (see Section 10.3). Heavy fire is burning in the Hoffman Rd area, blocking the road. Civilian evacuation impacted.	Hoffman Rd	TD-013
11/8	08:00	08:30	Concow Rd burnover event (see Section 10.3). Flame front too intense to pass, burning vehicles in road. Crown, timber, 3 m to 4.5 m (10 ft to 15 ft) brush burning; 18 m to 24 m (60 ft to 80 ft) flames.	Concow Rd near Cribbage Ln	TD-008
11/8	08:15		Intense fire conditions, embers blowing across roadway, trees torching, fire up against roadway.	Concow Rd between Hoffman Rd and Cribbage Ln	TD-110
11/8	08:30		Most structures in Camelot are already burning.	Concow	TD-062
11/8	08:30		Fire burning the hills on the west side of Concow Reservoir.	West side of Concow Reservoir	TD-115
11/8	09:20	10:00	Head of fire is hung up on east side of Concow Reservoir, burning to the north of Ishi Tr. Spot fires are igniting in pine and leaf litter 1.6 km (1 mi) ahead of fire front.	Concow Rd near Ishi Tr	TD-013 TD-090 TD-115
11/8	11:00		Fire is intensifying, moving south, burning both sides of Concow Rd near Jeffrey Pine Ln.	Concow Rd near Jeffrey Pine Ln	TD-062
11/8	11:20	11:40	Intense fire is burning on the ridge and in the canyons near Jordan Hill Rd. Flame lengths of 30 m to 45 m (100 ft to 150 ft) observed. Engines looking for civilians must drive through fire to escape to Concow Rd.	Jordan Hill Rd and Granite Ridge Rd	TD-031 TD-062
11/8	12:00	14:00	South flank of the fire reaches the south end of Concow Reservoir in the early afternoon.	Concow	TD-027
11/8	12:00	12:30	At the heel, fire is backing into wind burning in steep terrain in the canyons near the origin. Numerous small spots are igniting from rollout down the hill.	West side of Feather River near Caltrans yard, CA Hwy 70.	TD-008 TD-028 TD-108
11/8	12:00	23:00	At some point after noon fire crossed Hwy 70. Later at night, began making runs along the canyon to the southwest.	CA Hwy 70, 5 km to 8 km (3 mi to 5 mi) north of Jarbo Gap	TD-013 TD-028
11/9	00:30		Fire gets well established 1.6 km to 3 km (1 mi to 2 mi) below Station 36. Engines drive through fire on Hwy 70 to return to Station 36 for structure prep.	CA Hwy 70, 1.6 km to 3 km (1 mi to 2 mi) north of Jarbo Gap	TD-028 TD-029

NIST Camp Fire Report #3, Table 11.

Paradise Fire Progression (Pentz Rd)

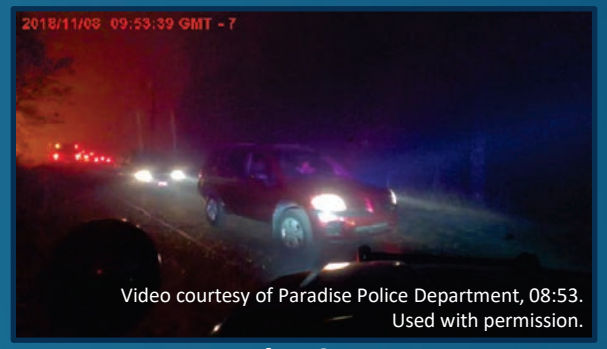
- Initial impact on Paradise was primarily focused along the Pentz Road corridor.
- Pentz Road is divided into five separate regions:
  - Apple View Way to Dean Road,
  - *Merrill Road to Wagstaff Road,*
  - Bille Road to Feather River Hospital (FRH),
  - FRH to Pearson Road, and
  - Pearson Road to Kunkle Reservoir.

Merrill Road Area

Date	Time Range		Fire Behavior Observations	Location	Source #
11/8	07:50	08:10	Multiple 911 calls report widespread spot fires scattered on the east side of Pentz Rd.	Merrill Rd, Stark Ln and cross streets	911-077-3 911-088-1 911-110-1 911-1026-1 911-1027-1 911-1034-2 911-1040-1 911-1046-4
11/8	08:10	08:20	The number of spot fires in the area continues to increase. Two spot fires have become well-established in grass and manzanita, rapidly spreading and threatening structures.	Merrill Rd, Stark Ln and cross streets	TD-020 TD-022 TD-061 911-1049-8 911-1049-6 911-1048-2 911-1053-4
11/8	08:20	08:40	Spot fire in 0.6 m (2 ft) tall grass field continues to spread west and north, consuming field. Structures begin igniting along Merrill Rd.	Merrill Rd, Stark Ln and cross streets	TD-014 TD-022 TD-043 TD-045 TD-061 TD-143
11/8	08:40	08:50	Fire begins spotting west of Pentz Rd. Mobile Homes in Ridgewood Mobile Home Park are on fire. Heavy fire from the field impacts Pentz Rd.	Pentz Rd between Merrill Rd and Wagstaff Rd	TD-014 TD-042 TD-064 TD-067 PPD-02
11/8	09:00		Fire has burned through Ridgewood and Ponderosa Mobile Home Parks and is impacting Pentz Rd, threatening evacuating vehicles. Spot fires ignite in the Ponderosa Elementary School parking lot.	Pentz Rd and Wagstaff Rd	TD-021 TD-043 TD-067 TD-085 PPD-02 PPD-04
11/8	09:10		Fire impacts structures on Chris Ct from the southeast. Sheds and fences are burning, homes are igniting.	Chris Ct	TD-045
11/8	11:05		Buildings at Ponderosa Elementary School are on fire.	Ponderosa Elementary School	TD-014 TD-015
11/8	12:15		Portable classroom buildings have burned, and the cafeteria is on fire.	Ponderosa Elementary School	TD-021
11/8	12:30		Before 12:30, the mobile home parks are burned down, vegetation has burned through, and the main fire activity in the area is over.	Pentz Rd between Merrill Rd and Wagstaff Rd	TD-043

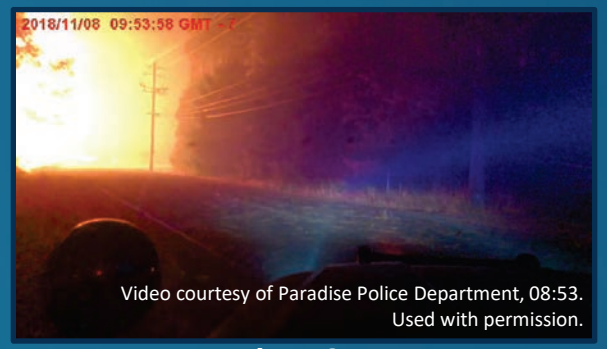
NIST Camp Fire Report #3, Table 13.

Fire Impacts Pentz Road 08:53

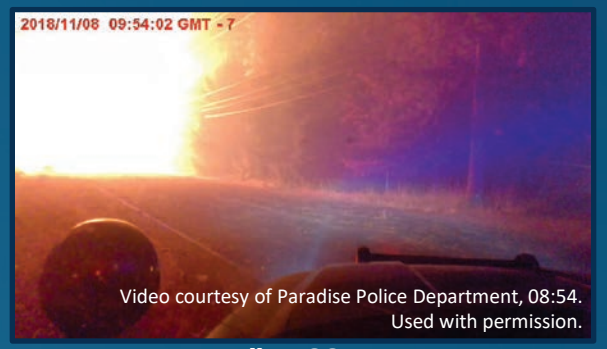


a) *t*=0 s

b) *t*=13 s



c) *t*=19 s



d) *t*=23 s

e) *t*=37 s

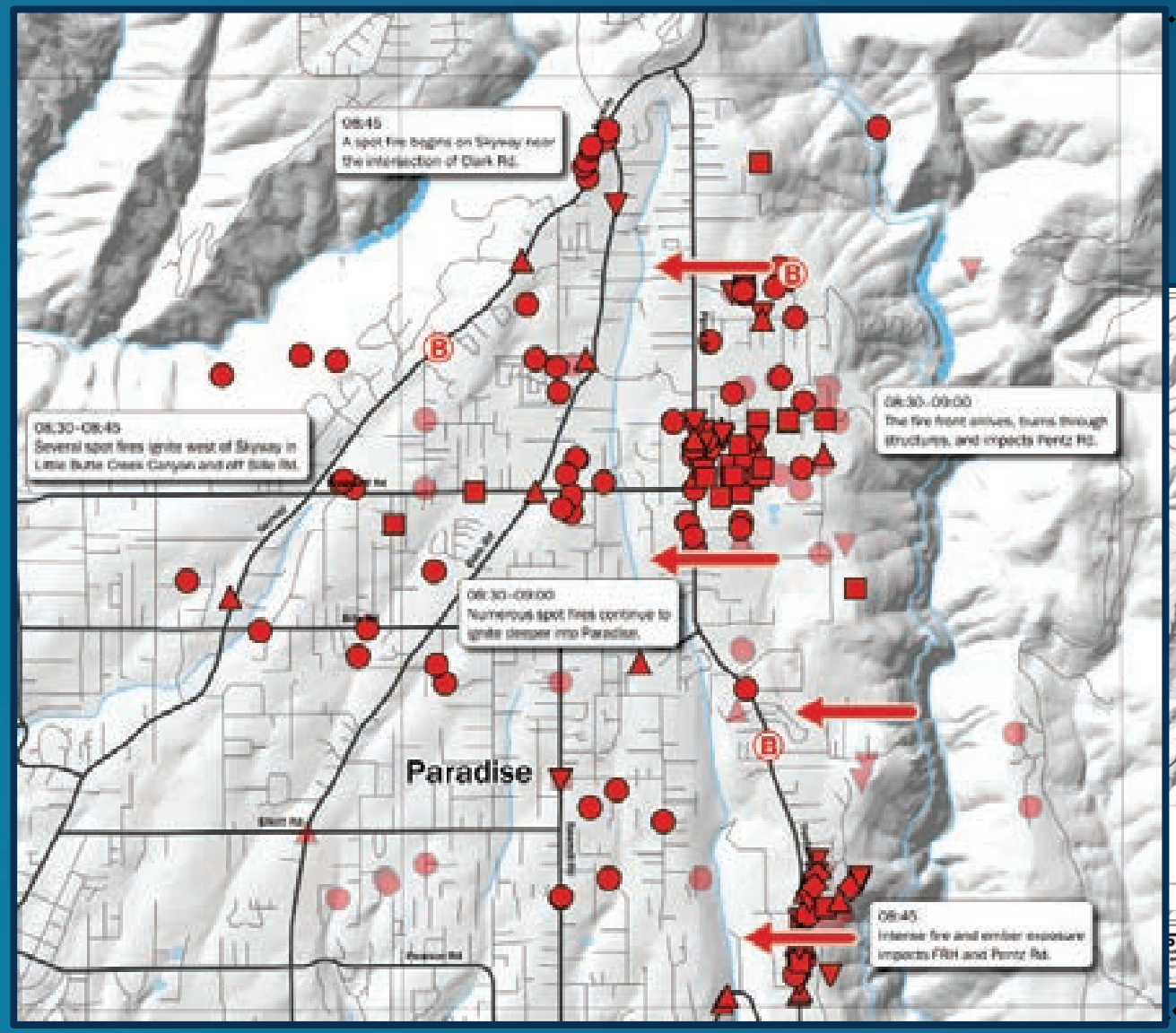
NIST Camp Fire Report #3, Figure 26.

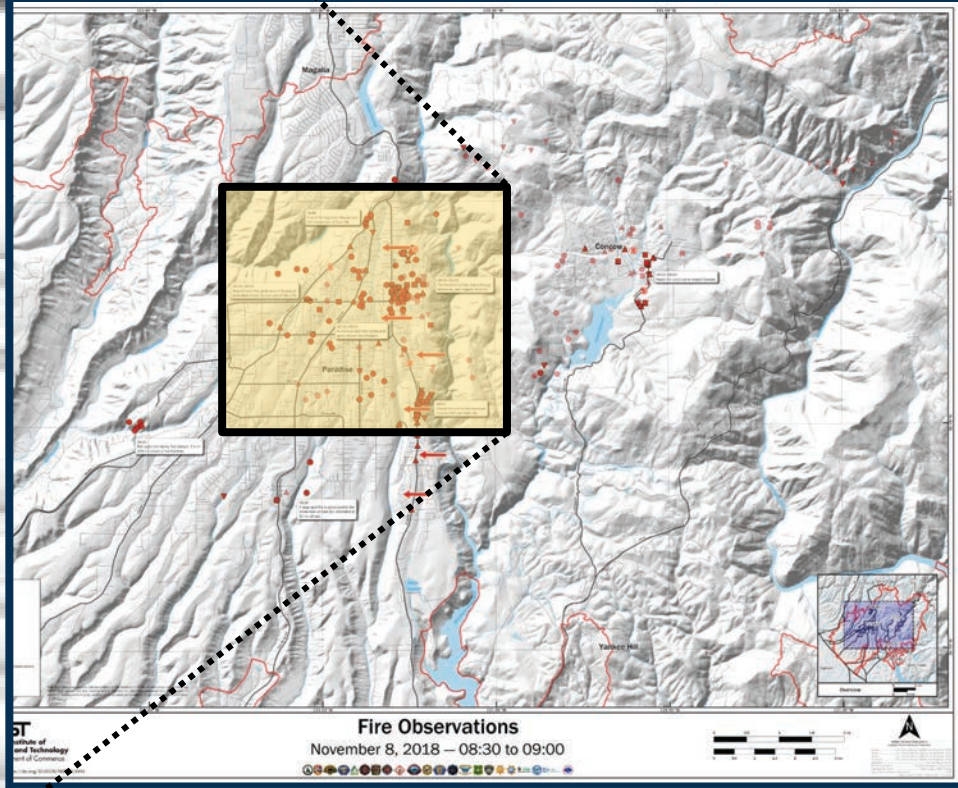
Fire Impacts Pentz Road 08:53

Video courtesy of Paradise Police Department, 08:53.
Used with permission.

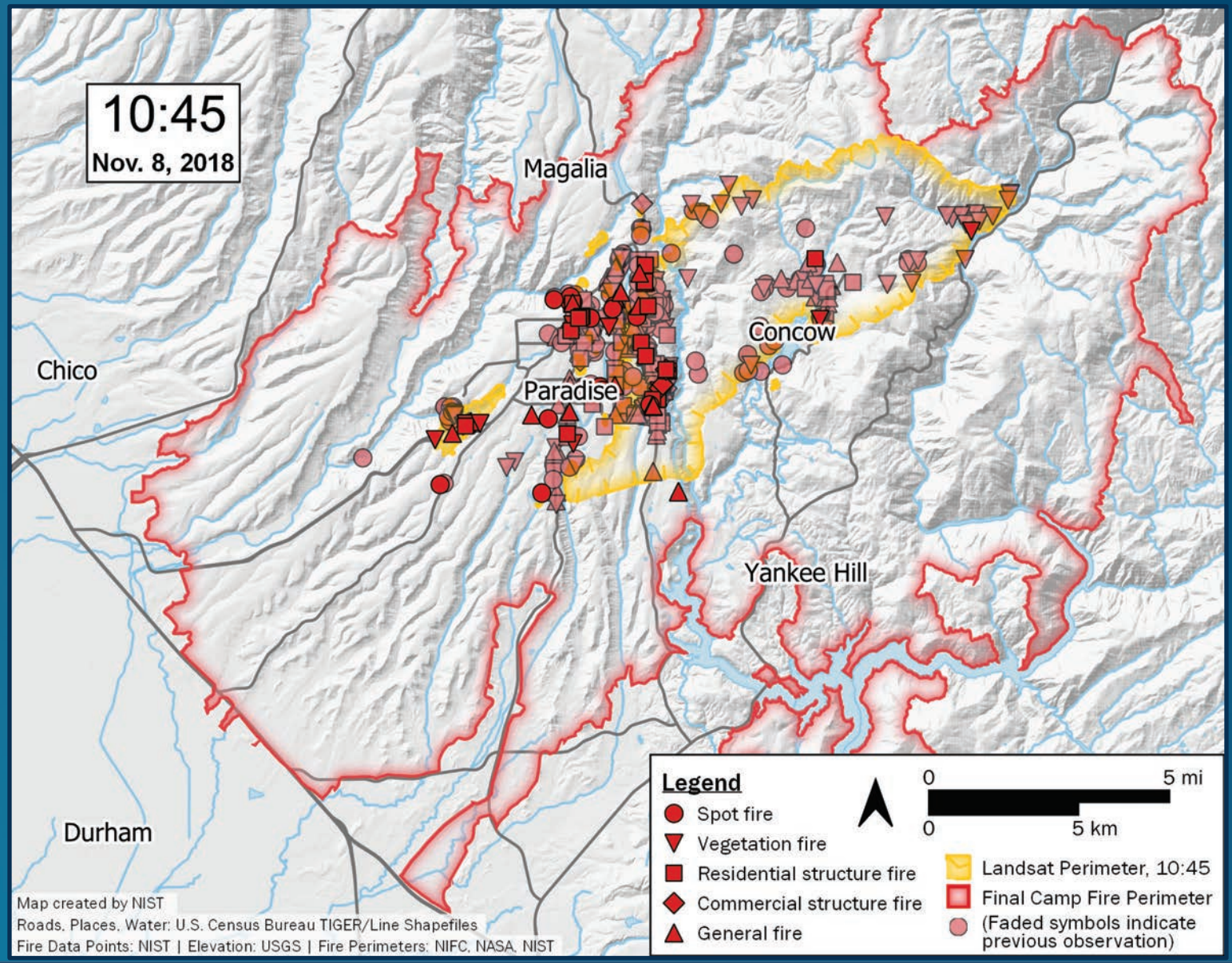
NIST Camp Fire Report #3, Figure 26.

14 E-size Maps (3 ft × 4 ft)

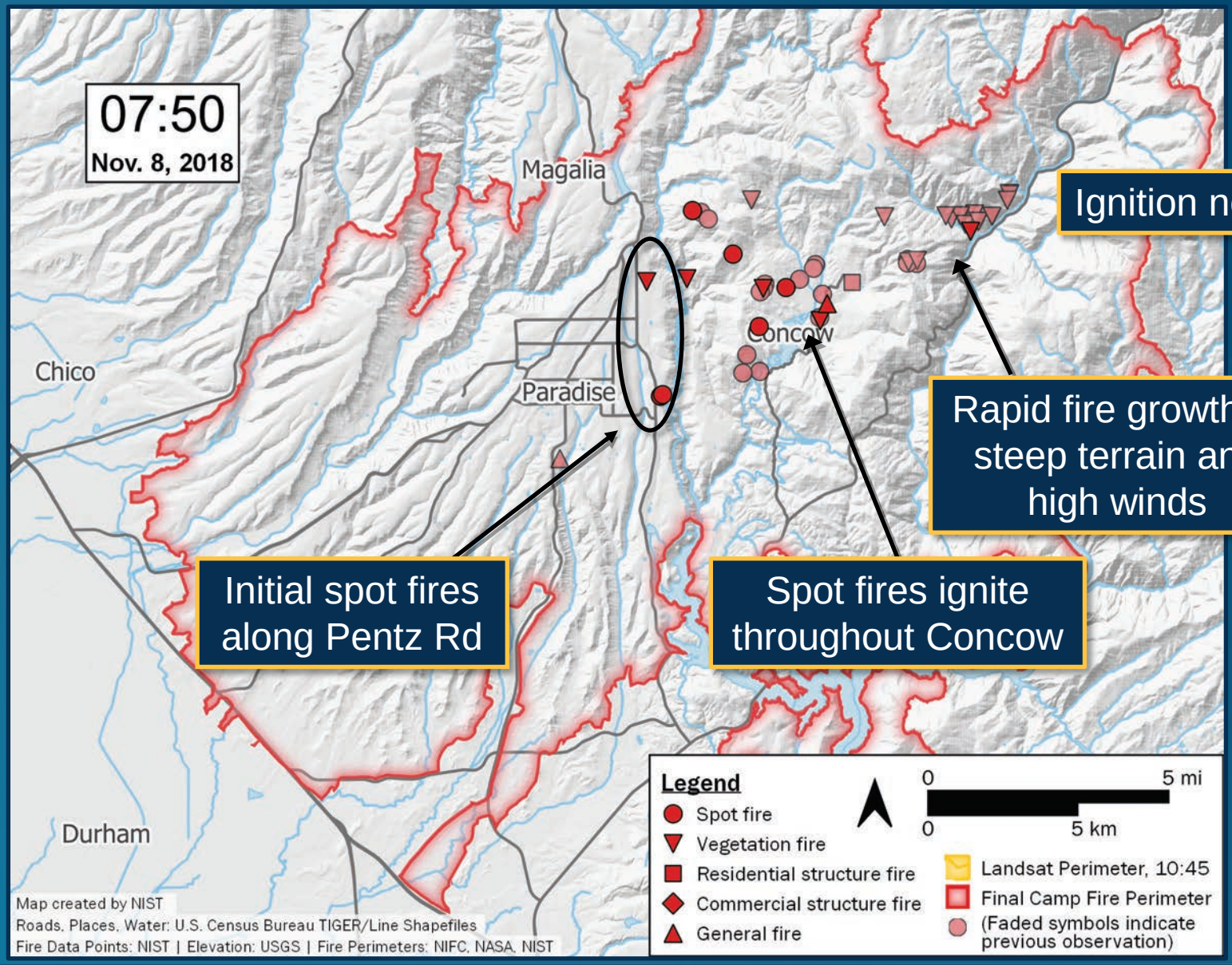




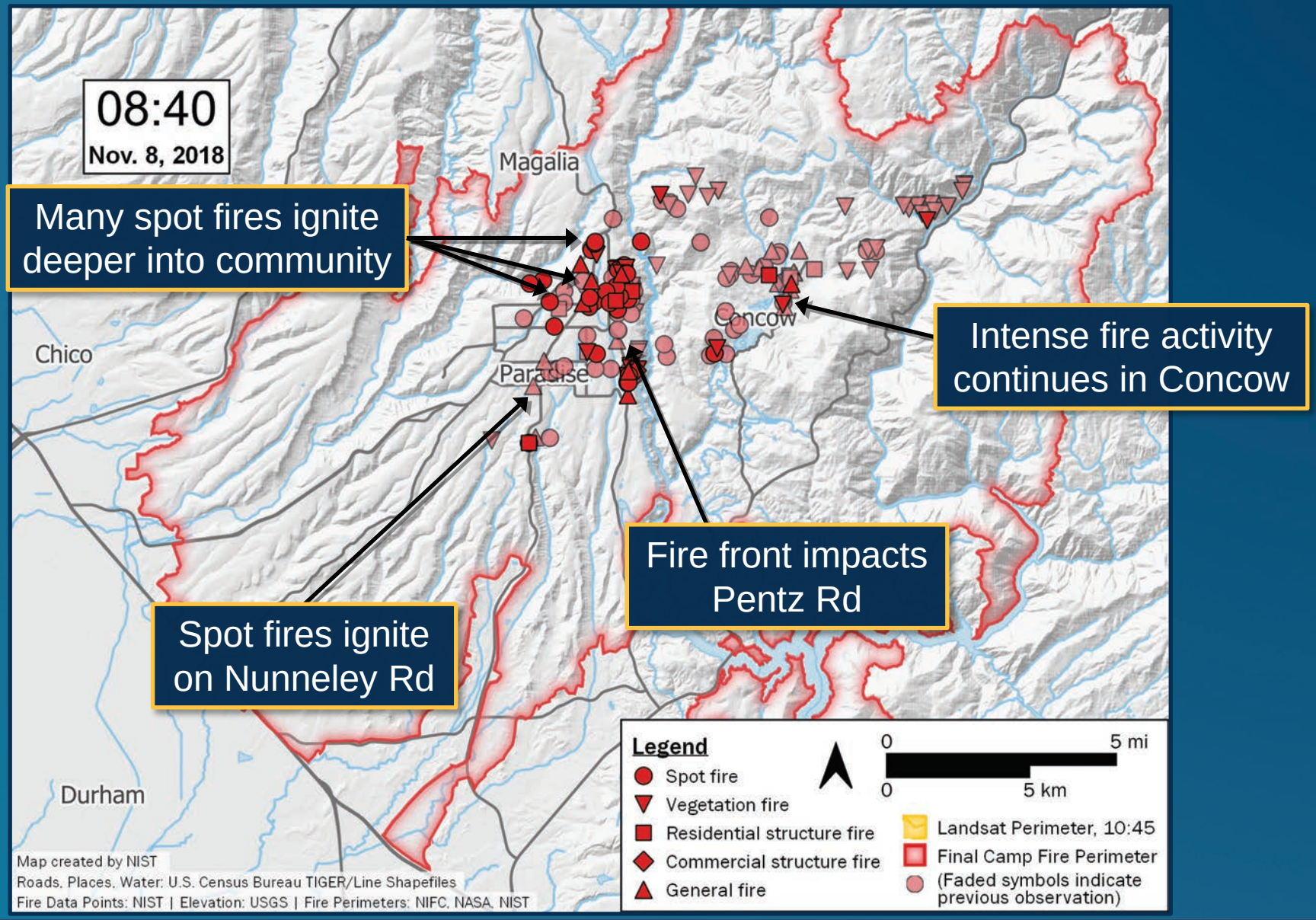
Fire Progression Summary 06:15 to 10:45



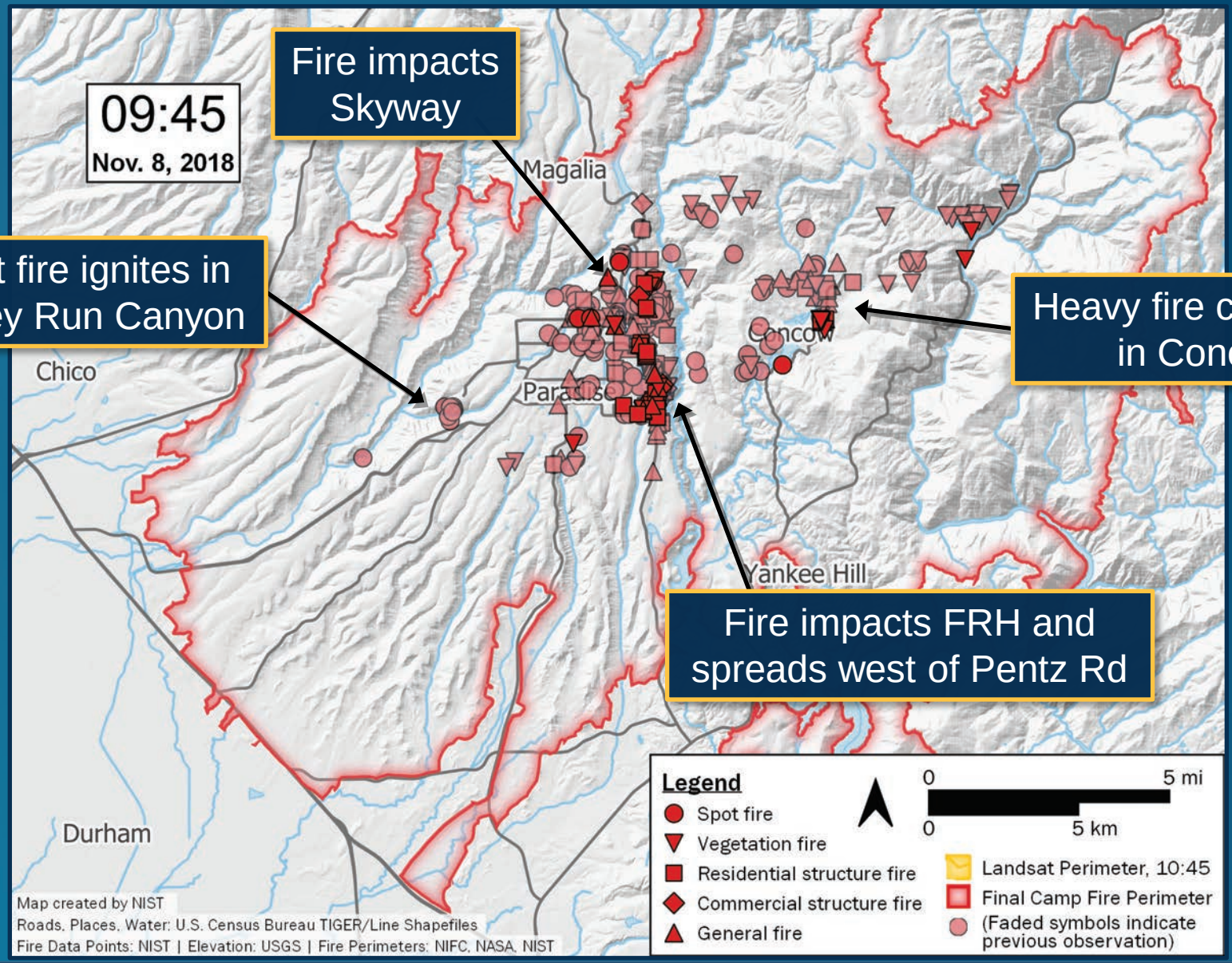
Fire Progression Summary 06:15 to 07:50



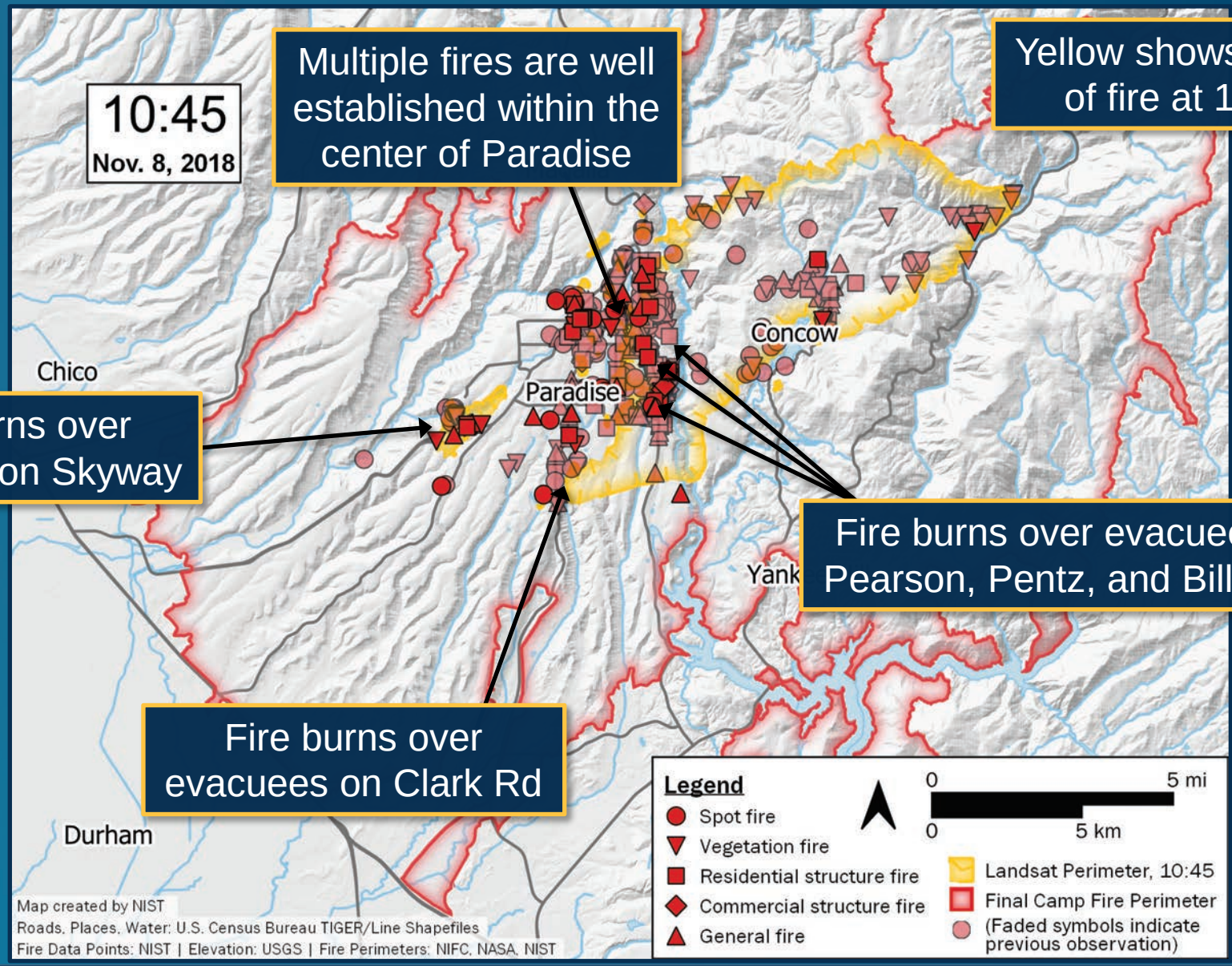
Fire Progression Summary 07:50 to 08:40



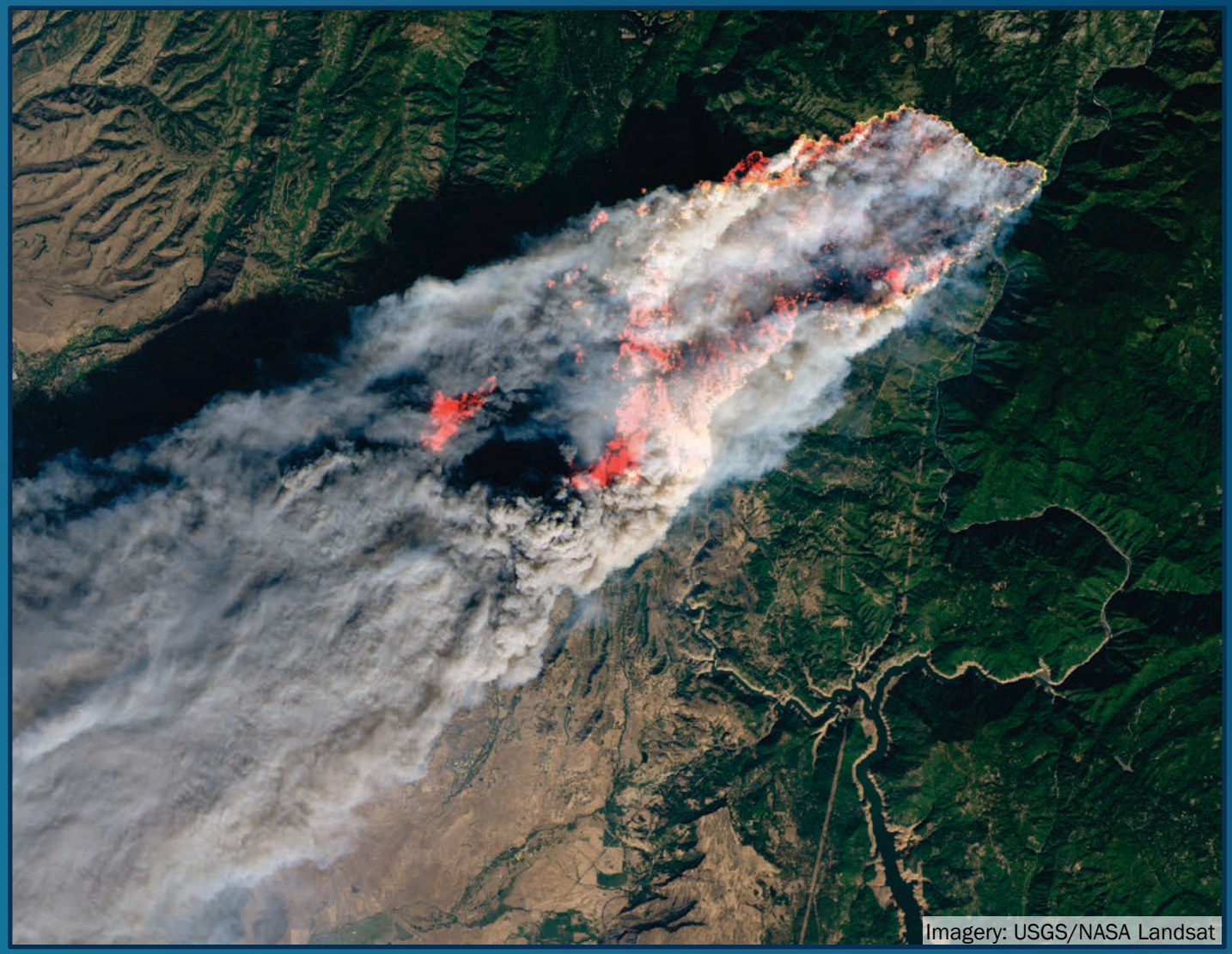
Fire Progression Summary 08:40 to 09:45



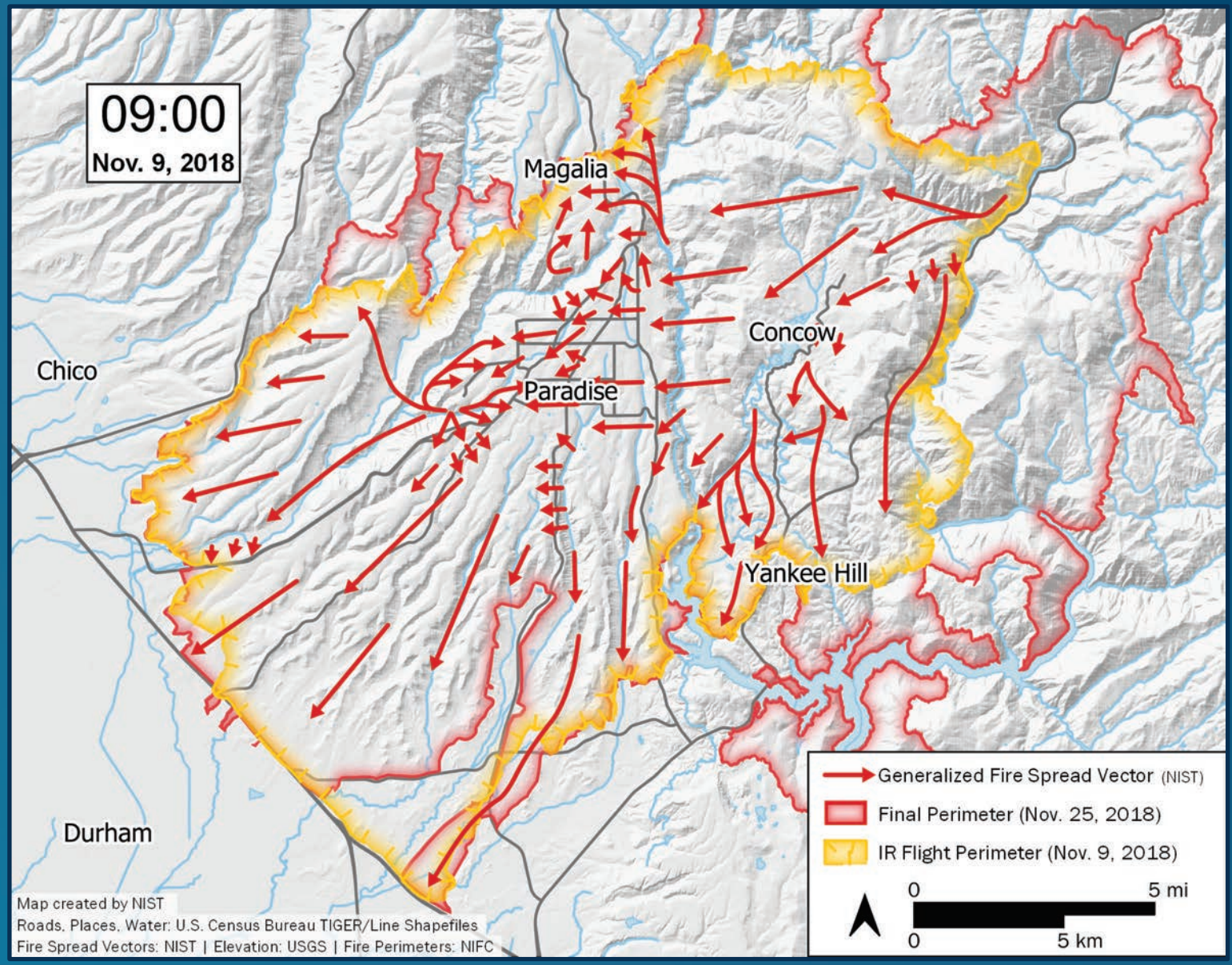
Fire Progression Summary 09:45 to 10:45



Fire Progression Summary by 10:45



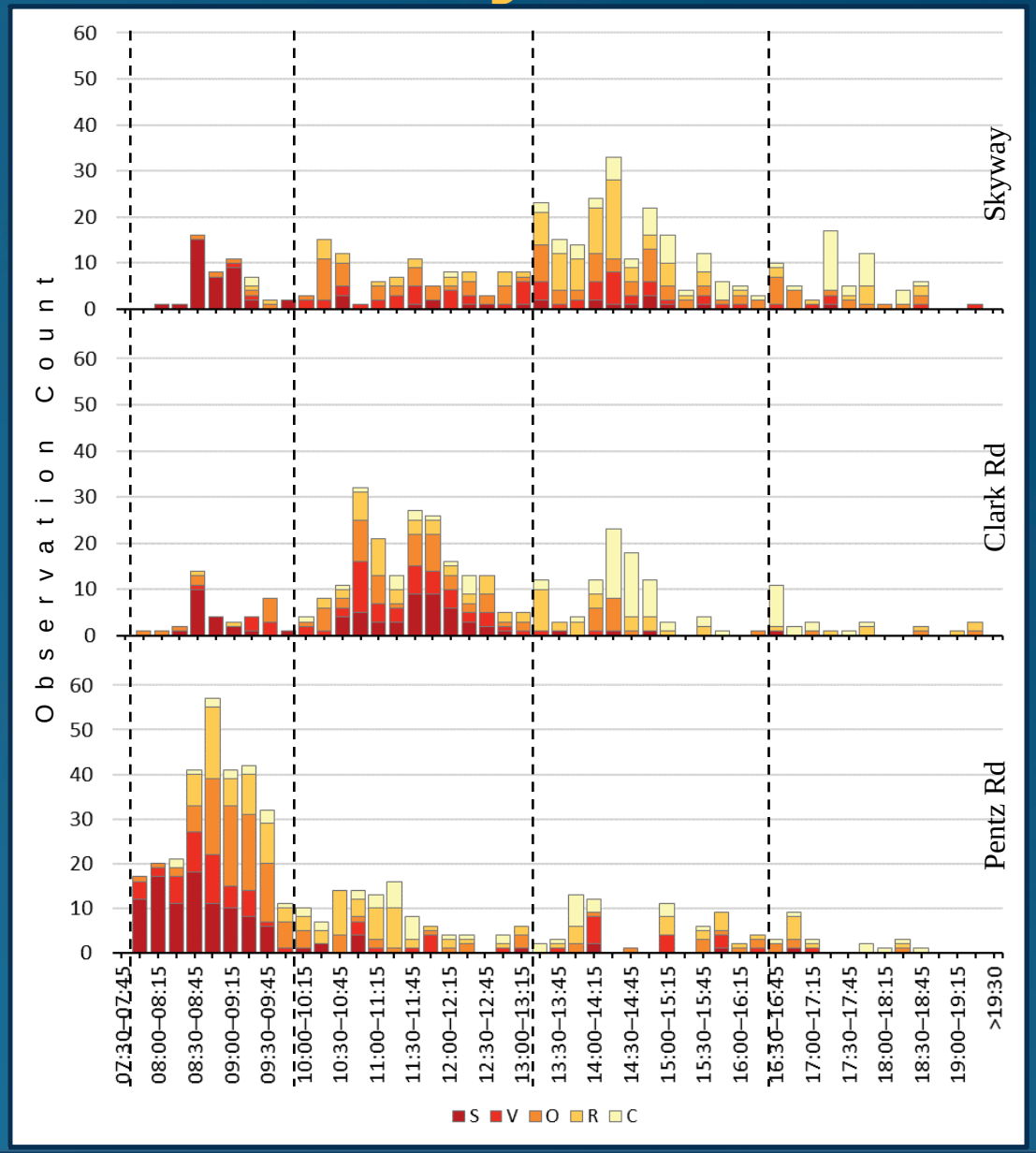
Fire Progression Summary (Day 1)



NIST Camp Fire Report #3, Figure 22.

Fire Observations Summary

- Spot Fire
- Vegetation Fire
- Other/General Fire
- Residential Structure Fire
- Commercial Structure Fire



NIST Camp Fire Report #3, Figure 45.

Fire Observations Summary

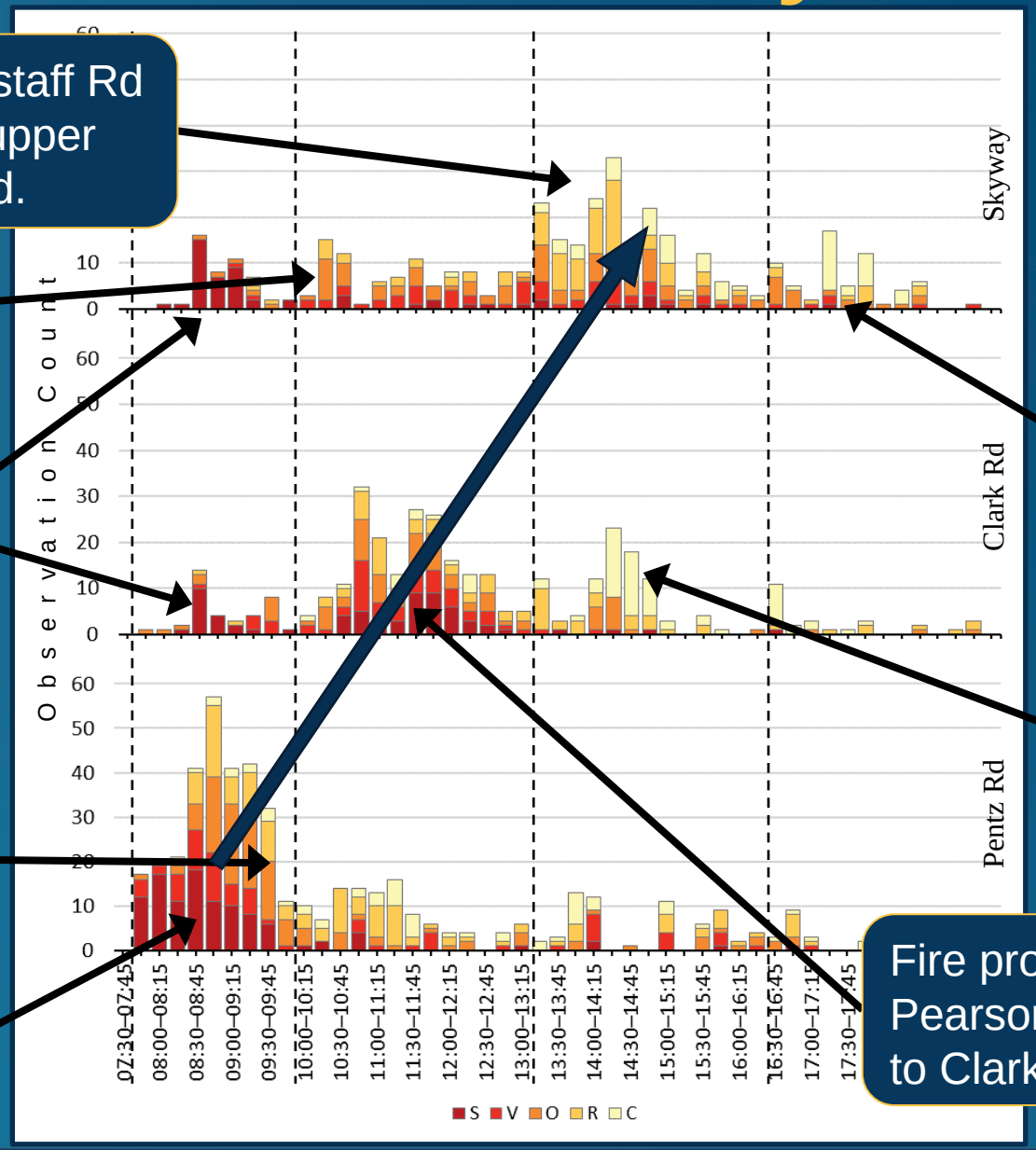
Heavy fire north of Wagstaff Rd (continued burnover of upper Skyway) and at Clark Rd.

Skyway (upper and lower) is burned over

Initial spot fire ignitions at Skyway and Clark Rd.

Pentz Rd: Most fire observations before 10:00.

Spot fires are significant fraction early in event.



General progression of fire from east to west

Fire establishes in downtown Paradise early evening.

Commercial structures burning early afternoon.

Fire progresses west down Pearson, Nunneley, Bille Rd to Clark Rd.

NIST Camp Fire Report #3, Figure 45.

Burnovers

19 documented

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

Burnovers

Report describes identified:

burnovers, entrapments, and "near misses"

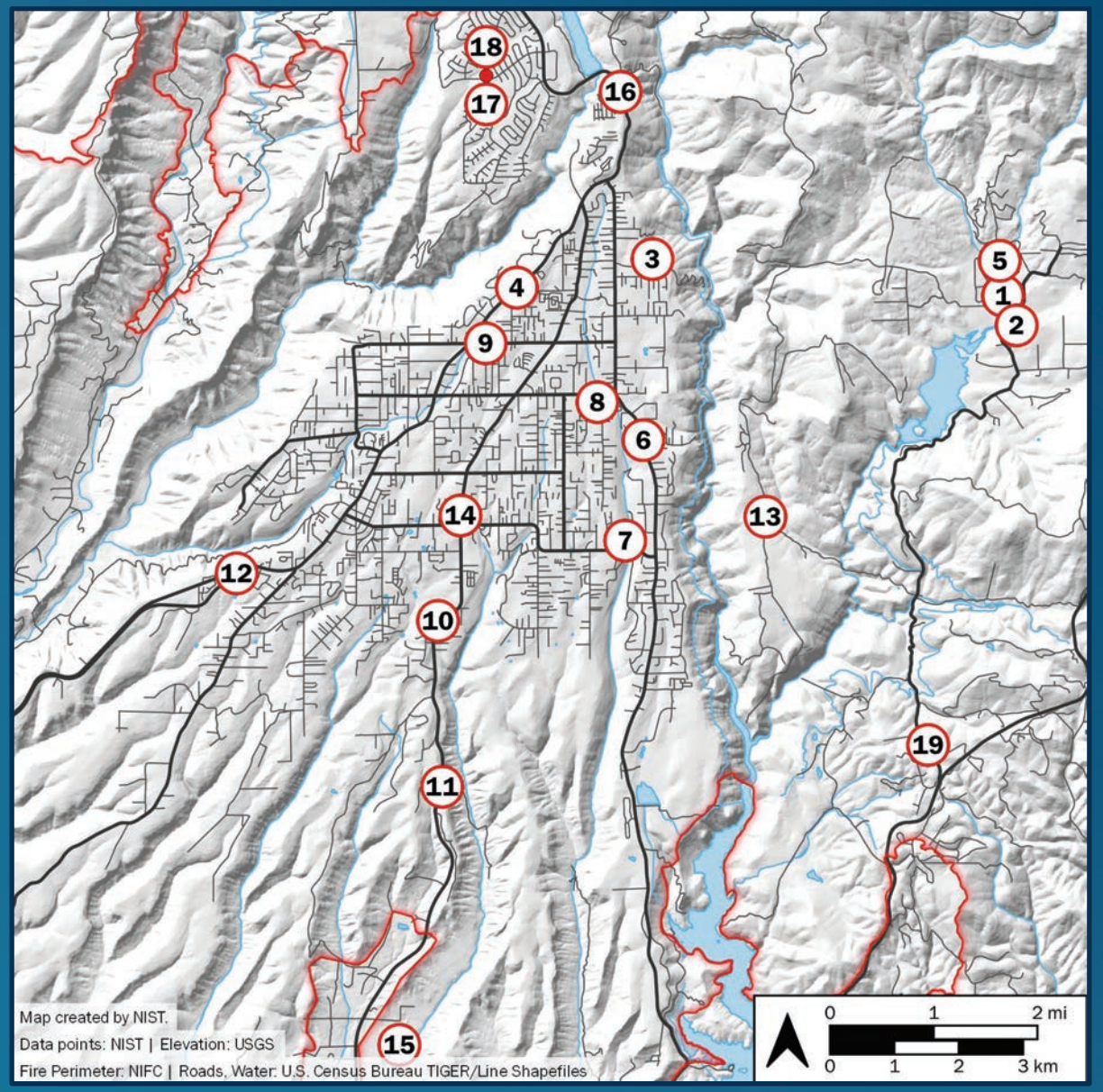
- Unexpectedly caught
- Life-threatening position
- Fire overtakes personnel or equipment
- Escape routes or safety zones are absent, inadequate, or compromised
- May or may not result in injury
- Possible damage to equipment

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

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

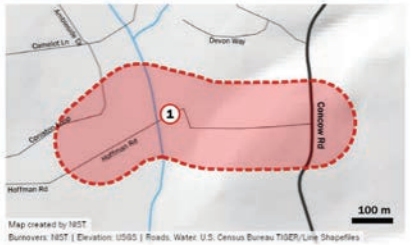
Fuels: brush / trees

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

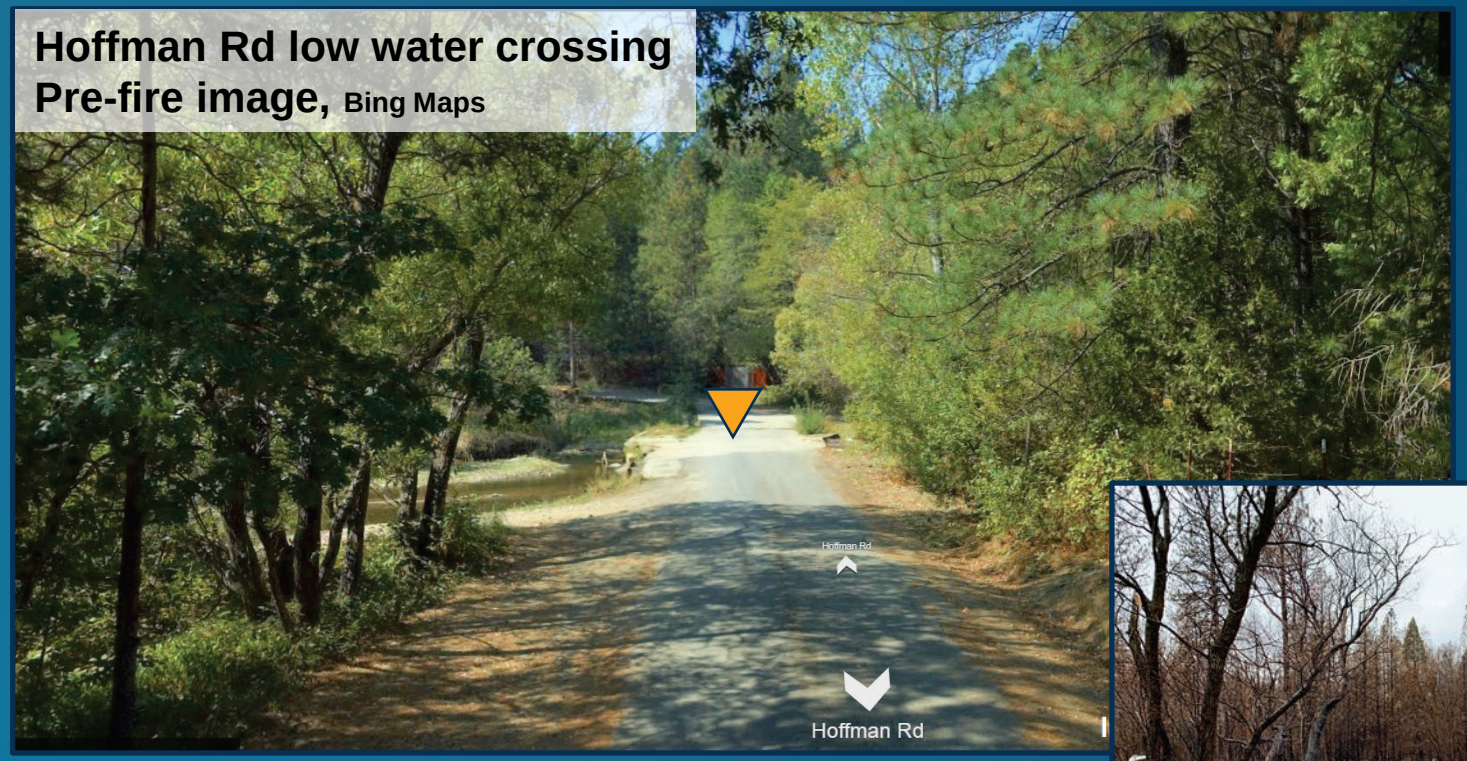
Street map:



Satellite view:

Hoffman Road Burnover Details

Burnover #1: Hoffman Rd



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

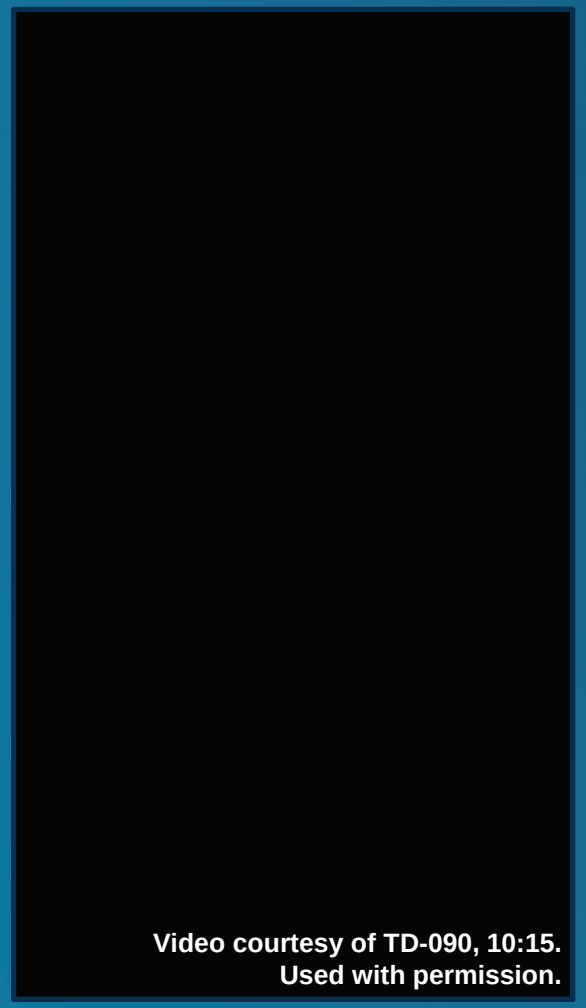
Burnover #4: Upper Skyway

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



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

Conditions south of hospital after burnover

NIST Camp Fire Report #3, Figure 48.

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

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

effects of wind and terrain* | *spot fires

structure ignition pathways* | *analysis

Impact of Winds, Wildland Fuels and Terrain on Fire Behavior

- Firsthand observations on Rim Road at 07:20 on November 8 talked of “softball size rocks hitting the engine” *[TD-005]*
  - Local winds in the range of 22 m/s to 27 m/s (50 mi/h to 60 mi/h)
  - Values agree with the forecasted ridgetop winds

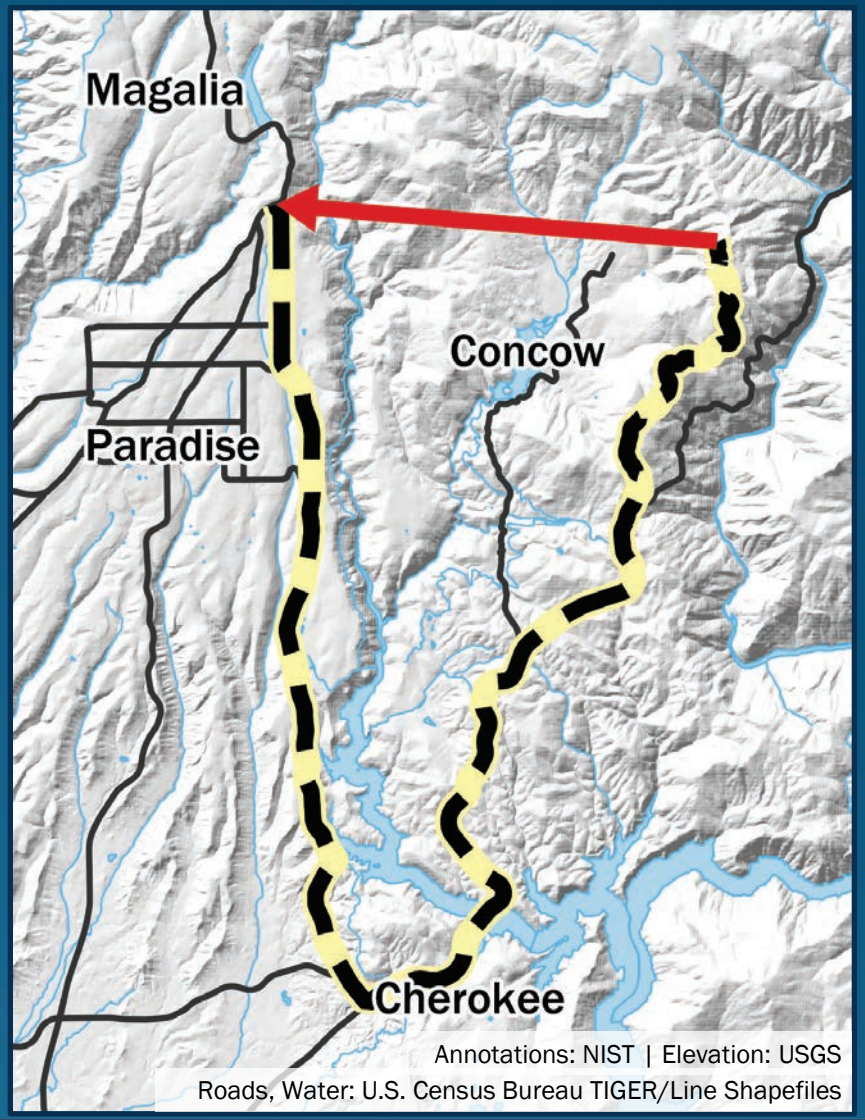
Impact of Winds, Wildland Fuels and Terrain on Fire Behavior

- During the Coutolenc Road burnover at 00:30 on November 9
  - very strong, gusty winds coming up from the West Branch canyon
  - estimates of 22 m/s (50 mi/h) *[TD-041, TD-061, TD-209]*

- Terrain also directly impacted fire behavior
  - dramatic fire behavior around 18:00 on November 8
  - flame lengths of 30 m to 60 m (100 ft to 200 ft) breaking out of the Butte Creek Canyon into Wilder Drive *[TD-117]*

Impact of Winds, Wildland Fuels and Terrain on Fire Behavior

- Terrain restricted or slowed down access by first responders
- Rim Road to Skyway
  - 9.3 km (5.75 mi) straight line
  - 40 km (25 mi) and 43 minutes of drive time

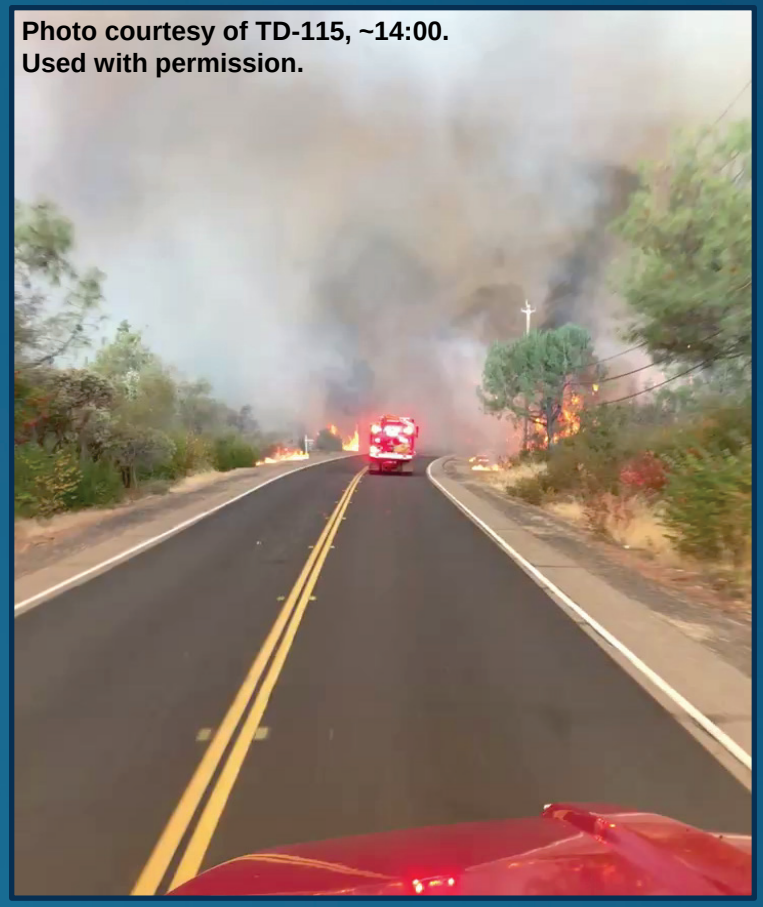


Variability in Local Conditions - Smoke

a) t = 0 s, x = 0 ft
b) t = 20 s, x = 400 ft
c) t = 46 s, x = 725 ft
d) t = 93 s, x = 1200 ft

- Visibility is intermittent and wind directions shift 180°over short distances and time periods.

A Wall of Smoke on Pentz Rd



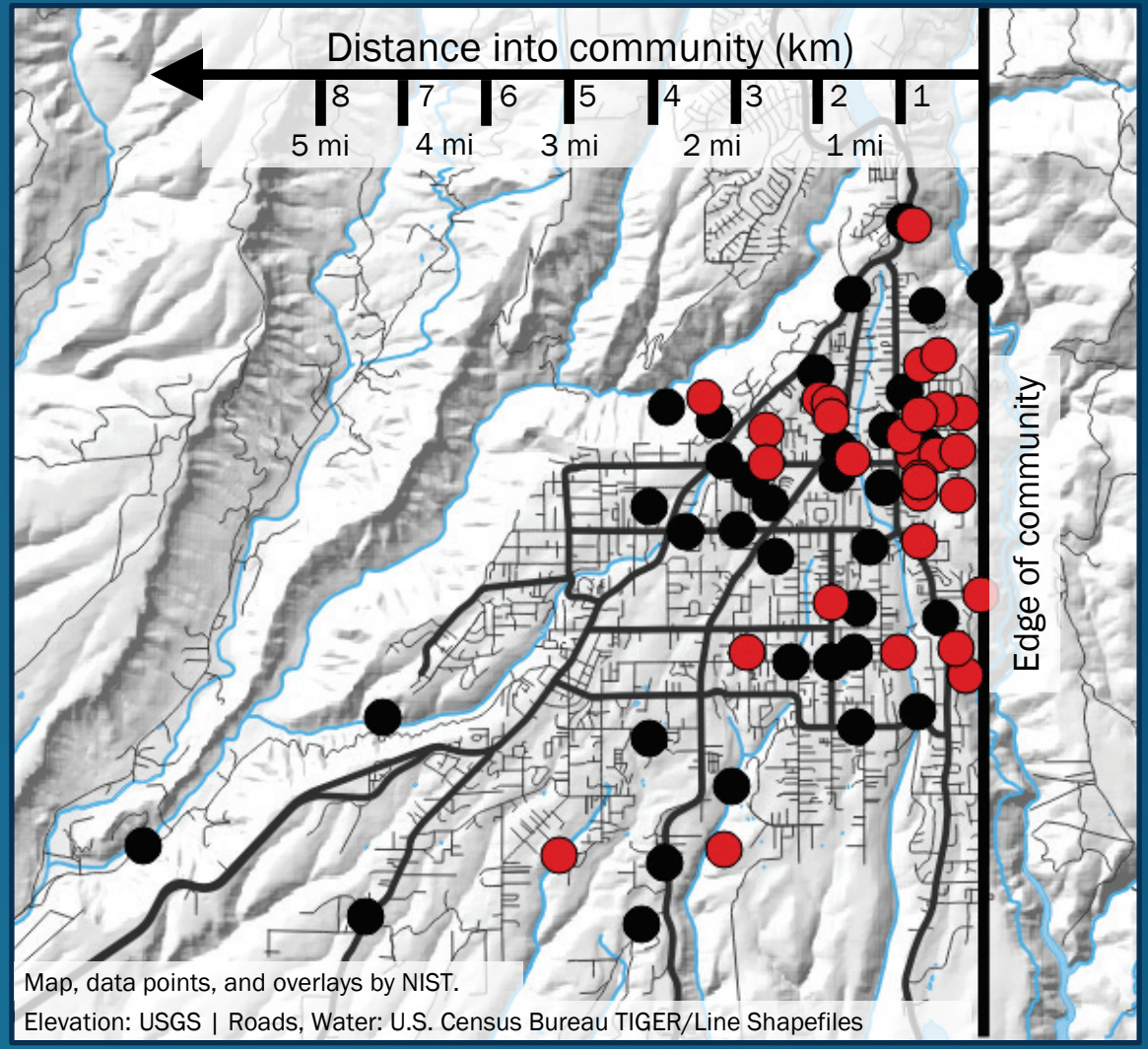
- Wall of smoke observed on Pentz Rd, going north, at Dry Creek Rd.

NIST Camp Fire Report #3, Figure 49.

Early Spot Fires in Paradise

Spot Fire Ignitions

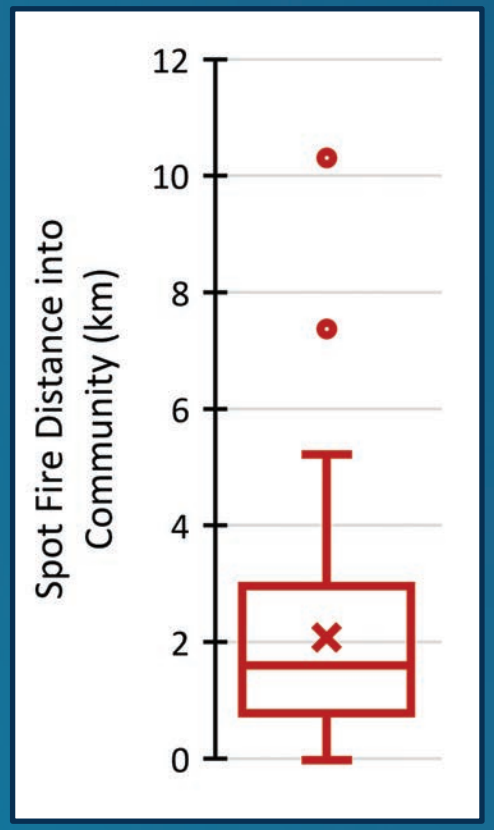
- 07:49 – 08:30 (N=30)
- 08:30 – 10:30 (N=35)



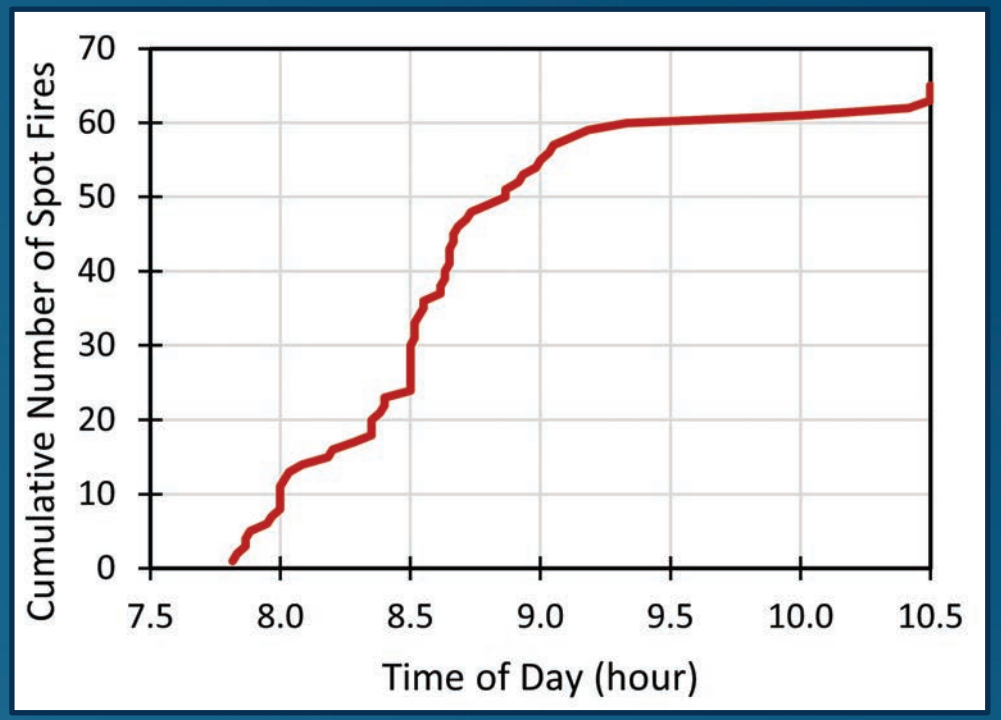
30 identified spot fires within first 40 minutes (red)

NIST Camp Fire Report #3, Figure 51.

Spot Fire Quantity and Timeline



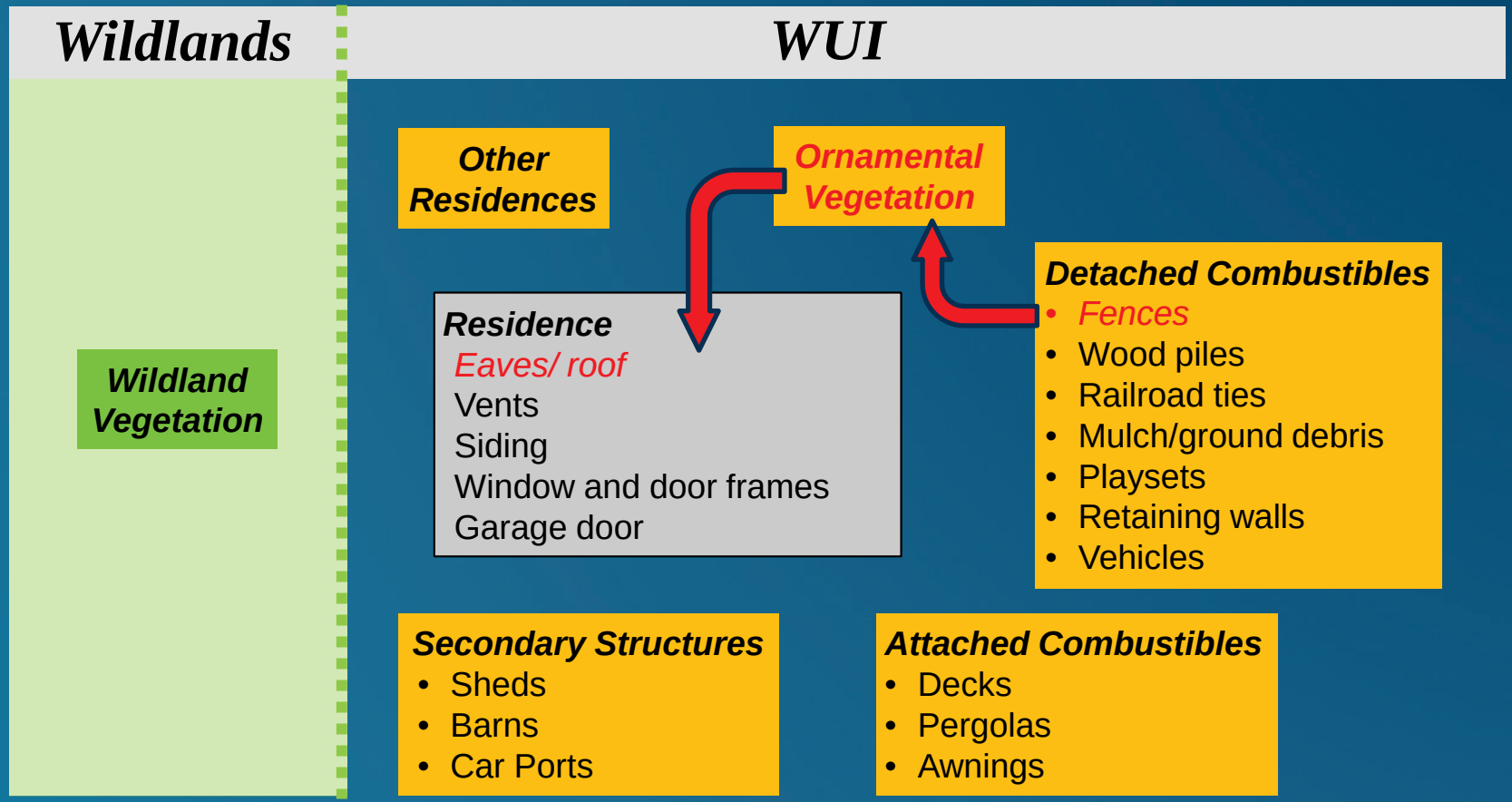
a) Distribution of distance into the community of the 65 documented spot fires



b) Cumulative number of spot fires before 10:30

NIST Camp Fire Report #3, Figure 50.

Structure Ignition, Fatalities 1



NIST Camp Fire Report #3, Figure 54.

Structure Ignition, Example 1

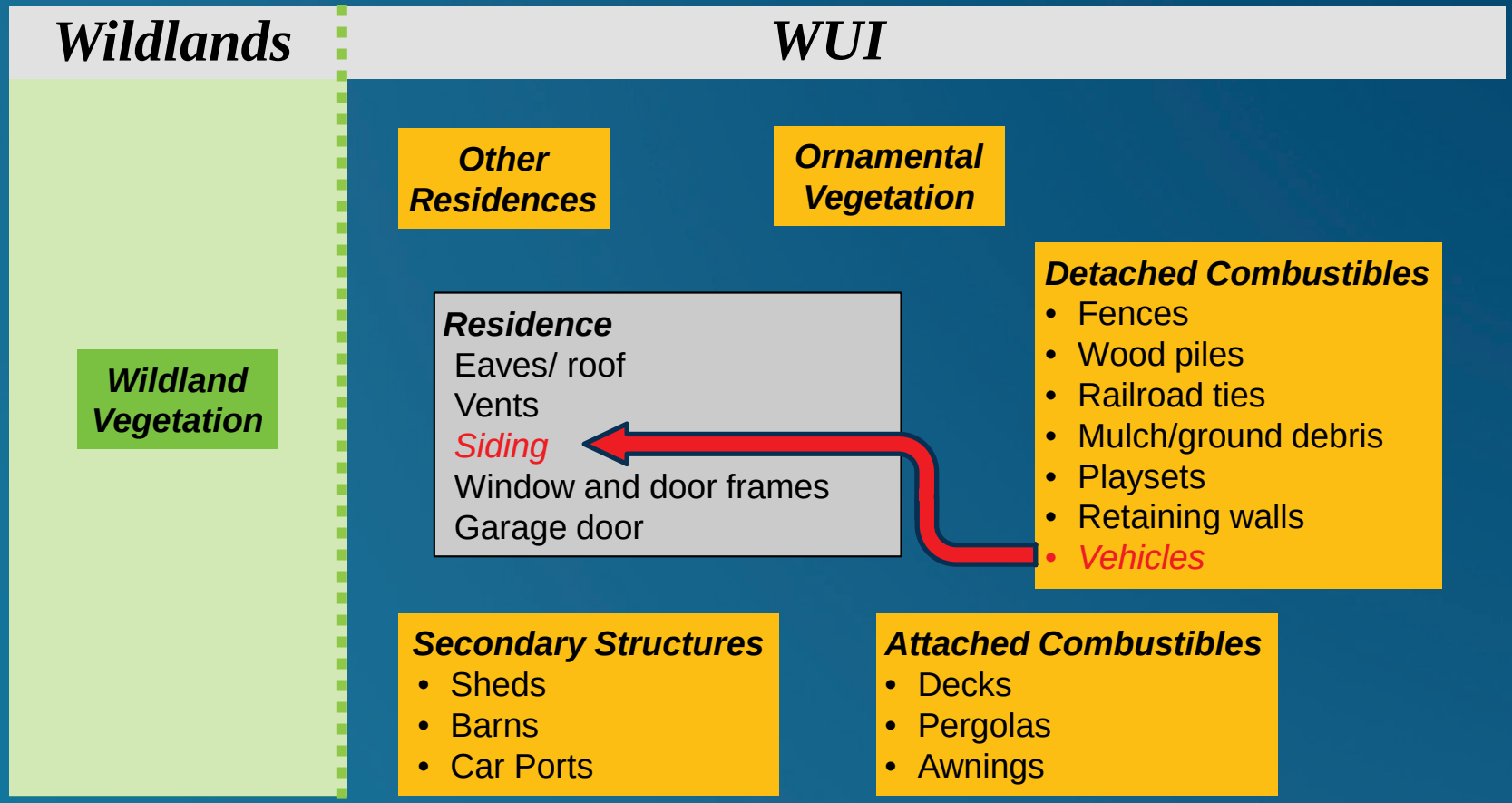
a) t = 0 s

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.

First Responder Comments

Pre-Fire Planning/ Mitigation	Count
Vegetation	24
Water	5
TRA	4
Utilities	3
WUI	2
Research	1
Resources	1
Total	40

Pre-Fire Hazard	Count
Vegetation	18
Pine needles	4
Infrastructure	3
Wind	2
Clearance	1
Conditions	1
Defensive space	1
Egress	1
Embers	1
Fences	1
Fuel model	1
Inspection	1
Regulation	1
Research	1
Structure	1
Visibility	1
Windows	1
Total	401

Fire Behavior	Count
Wind	24
Conditions	23
Embers	19
Hazards	11
Fire history	7
Flames	6
Structure	6
Topography	5
Vegetation	3
Pine needles	2
Total	106

NIST Camp Fire Report #3, Table 36.

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

Fuel Ignition Potential

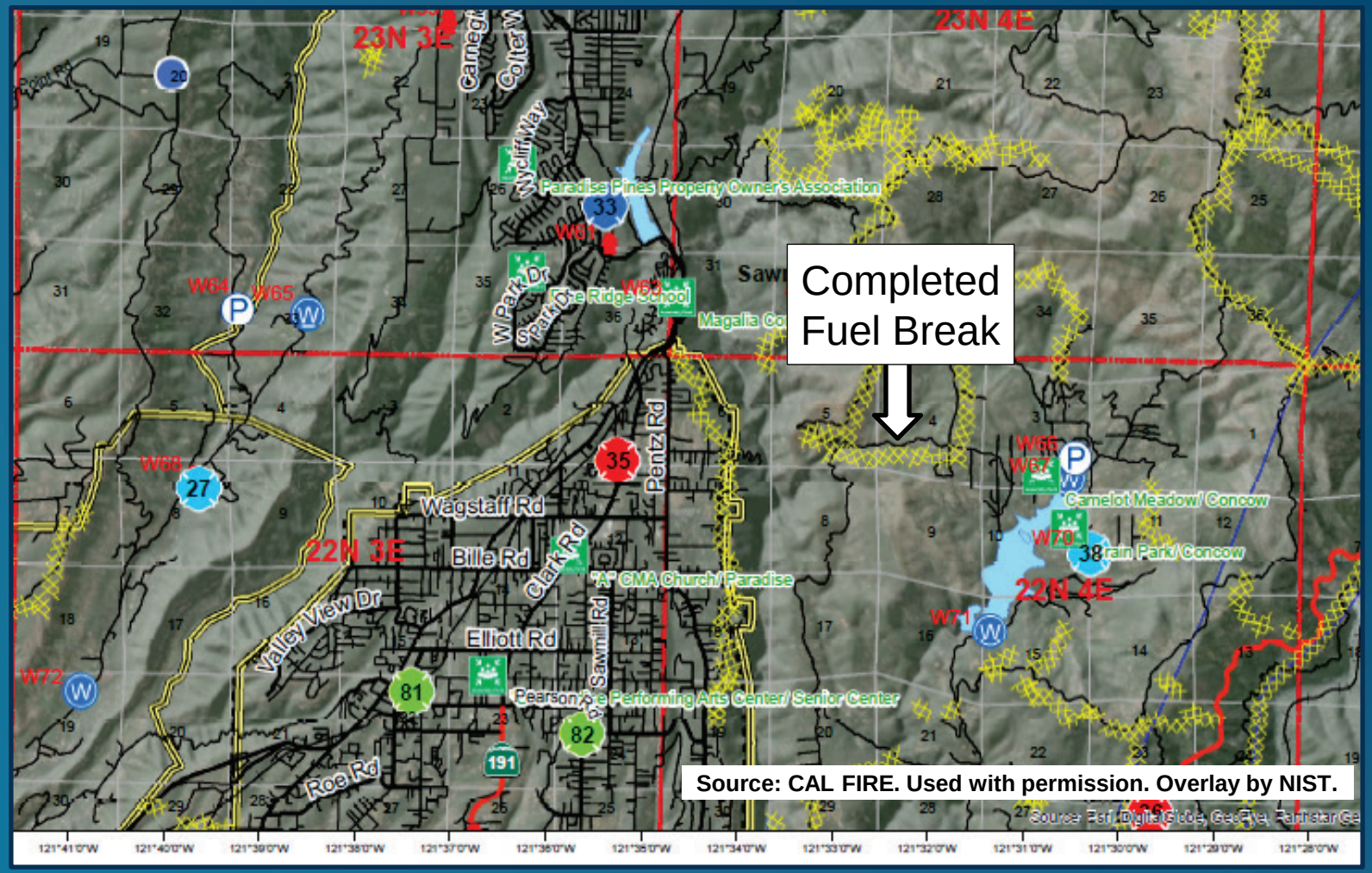
- Dry fuels receptive to ignitions from embers
- "100 % ember ignitions" *[TD-041, TD-079]*
- Numerous spot fires ignited in fine fuels (pine needles, ornamental vegetation) well ahead of the fire front
- In Paradise, ignitions started approximately 30 min to 40 min before the arrival of the fire front

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]*

Wildland Fire Pre-Plan — Butte County Fire Department



NIST Camp Fire Report #3, Figure 55.

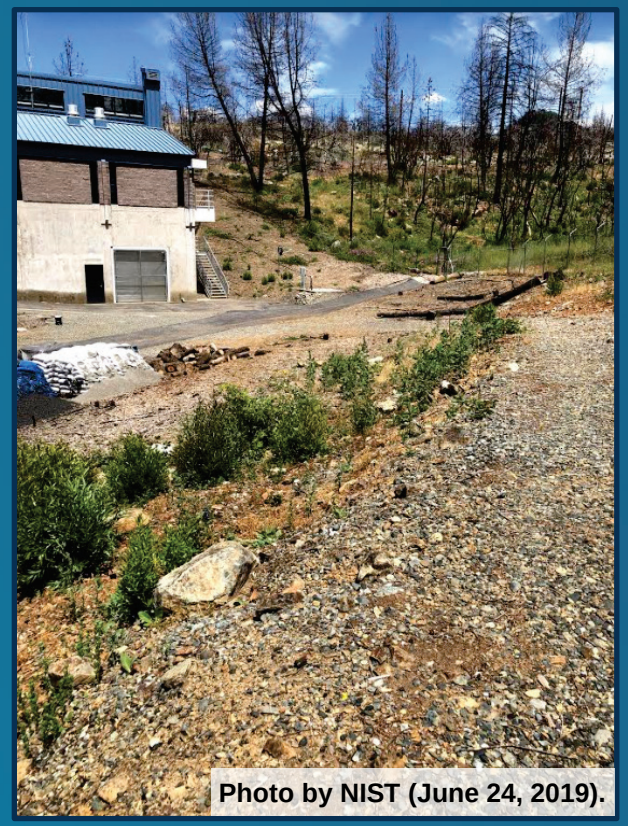
Fuel Treatment Around Critical Infrastructure (Paradise Irrigation District)

Fuel treatment and reduction conducted pre-fire 2018

Note: Imagery captured before completion of fuel treatment

NIST Camp Fire Report #3, Figure 56.

Fuel Treatment Around Critical Infrastructure (Paradise Irrigation District)



Area of reduced fuel loading

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

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

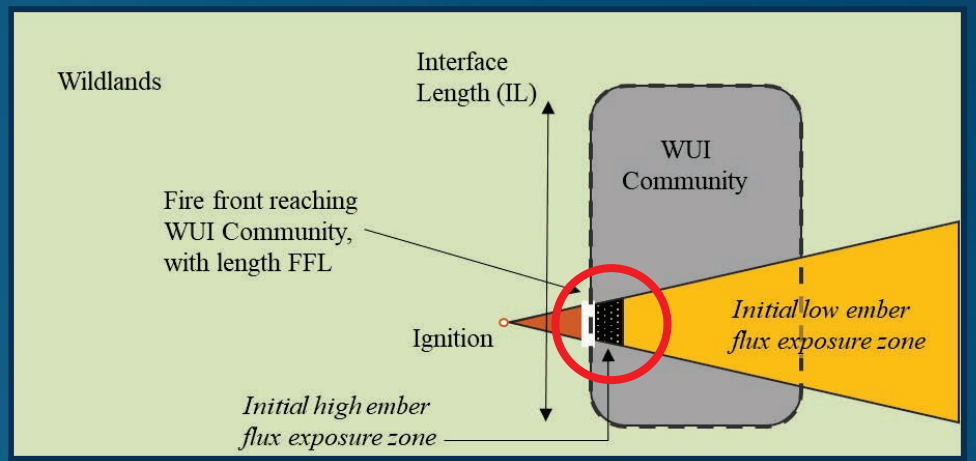
Video courtesy of TD-005, 07:32. Used with permission.

Extent/Size of Fire Front Reaching the Communities

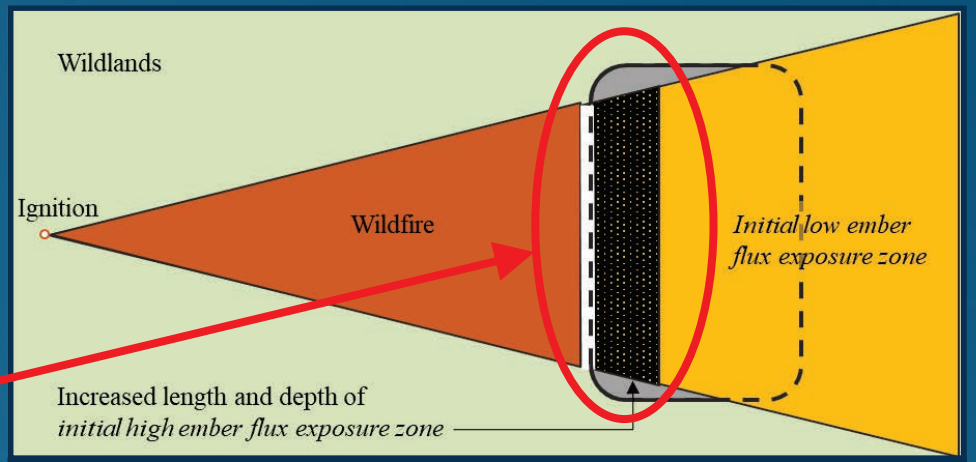
Idealized relationship between ignition location, near or far from WUI Community, and fire front and ember exposures reaching the community.

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

Technical Findings

community preparedness | pre-fire conditions

fire spread and progression | burnovers | community characteristics

Technical Findings

Community Preparedness

F1. Communities did have multiple programs in place to increase awareness of and reduce fire hazards associated with WUI fires.

F2. The Town of Paradise did have an emergency notification and evacuation plan.

F3. Paradise Public Works staff had received training in how to response to a WUI fire.

F4. Infrastructure was specifically addressed in pre-fire preparations.

Technical Findings

Pre-Fire Conditions

F5. Dry winds, with recorded gusts at Jarbo Gap exceeding 22 m/s (50 mi/h) from the northeast, increased fire spread in vegetative and structural fuels.

F6. Steep topographical features including river canyons and creek drainages channeled north winds and accelerated fire spread through vegetative fuels.

F7. Extremely dry vegetative fuels, associated with over 200 days without any significant precipitation, increased the fuel ignition potential around and within Concow, Paradise, and Magalia.

F8. Fire spread toward Paradise from Concow was fueled by heavy conifer forests with brush understory. At lower elevations oak woodlands and savannah grass were the primary fuels.

Technical Findings

Fire Progression

F9. Fire ignited near Pulga and Concow, was pushed by gusty wind across steep terrain toward Paradise, swept through Paradise, and then spread into Magalia.

F10. Extensive intermediate- and long-range firebrand spotting caused multiple ignitions ahead of the main fire line and resulted in different exposures to fire conditions.

F11. The fire travelled and/or spotted more than 11 km (7 mi) downwind of the origin to reach Paradise in less than 1.5 hours after ignition.

Technical Findings

Fire Progression

F12. Fire consumed a significant fraction of the Town of Paradise over a period of 6 hours, between 08:30 and 14:30.

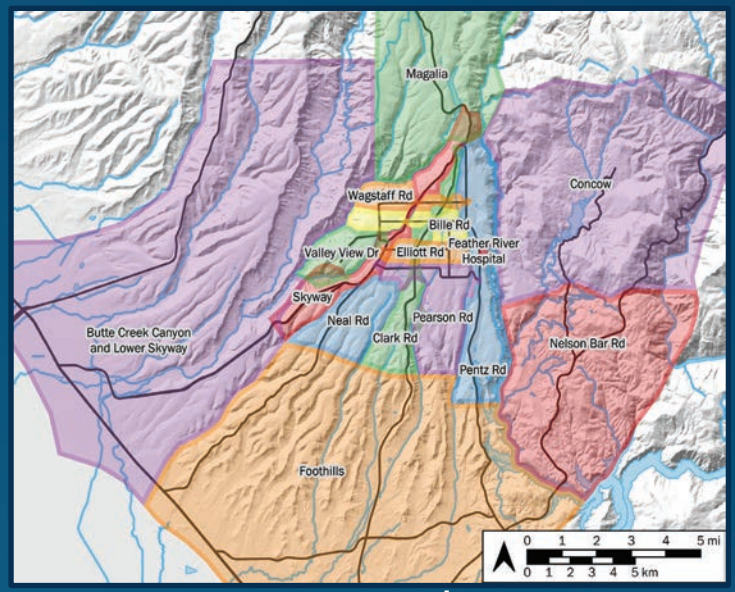
F13. Fire spread down slope through the foothills at an average 1 m/s (2.2 mi/h, 180 ch/h) through grassy wildland fuels south and west of Paradise.

F14. Fire spread rates for Paradise and Magalia could not be readily computed due to extensive spotting fire behavior.

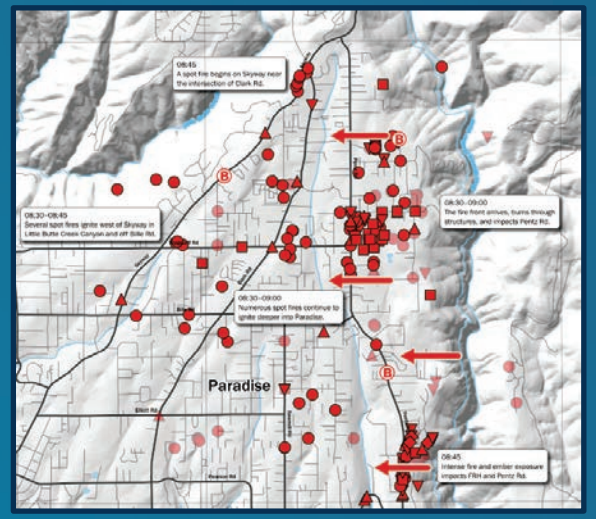
Technical Findings

Fire Spread Summary

- Overview in Executive Summary and report findings/conclusions *(3 pages)*
- Detailed fire behavior, by focus regions in body of report *(71 pages)*
- All the data in Appendix *(113 pages, 8 font)*



Focus Regions



E-size Maps – by time

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

Tables – by region

Technical Findings

Burnovers

F15. Multiple burnovers occurred during the Camp Fire.

F16. Burnovers adversely affected pre-planned evacuation routes and led to use of Temporary Refuge Areas.

F17. Intense vegetation and structure fires occurred along roadways and resulted in multiple road closures which adversely impacted response and evacuation activities.

F18. Fire resulted in downed utility poles and associated electrical and utility lines along roadways blocked multiple streets and impaired access for response and evacuation.

Technical Findings

Wildland Fire Ignition Relative to the Community

F19. The ignition of the fire in wildland fuels over 11 km (7 mi) from Paradise allowed the fire to grow in intensity and size before reaching the affected communities.

Technical Findings

Structure Ignition Pathways

F20. Post-fire field data collection and first responder observations identified structure ignition vulnerabilities including structure-to-structure ignition pathways.

F21. Fire spread through Paradise, and subsequently Magalia, was fueled by vegetative fuels, including ornamental shrubs, bushes, and trees; structural fuels, including homes, garages, detached auxiliary buildings, commercial occupancies; and cars, trucks, and campers.

F22. Separation distances between fuel packages within a parcel as well as between parcels did not prevent rapid fire spread.

Technical Findings

Community WUI Fire Hazard Evaluation Framework

F23. A standardized community wildland-urban interface hazard evaluation framework would improve assessment of fire risk for communities

Community WUI Fire Hazard Evaluation Framework

Community
Population
Notification
Evacuation
Infrastructure
Fire Fighting Response

Data Types
GIS Layers
Histograms
Other

Data Use
Pre-fire
During Fire
Post Fire

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

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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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