Camp Fire – Fire Progression Timeline

NIST WUI FIRE DAYS 2022

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July 6, 2021

192 Contributors — THANK YOU!

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Office of the State Fire Marshal

Damage Inspectors (DINS)

Data Collectors

Fire Departments

Law Enforcement

Town of Paradise

Transportation

Water Districts

Emergency Medical Services

National Weather Service

Reviewers

Public Affairs Office

Presentation Themes

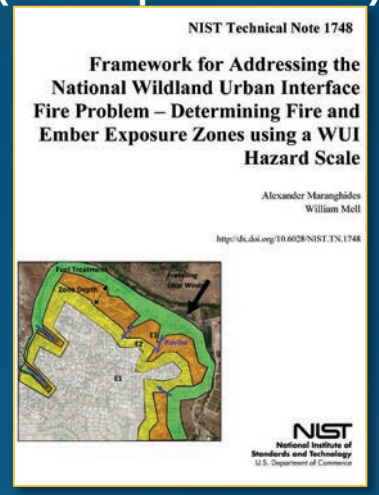
- ***Well prepared Intermix community***
- ***Rapid Fire Spread to and within Paradise***
  - impact on life safety, response and losses
- ***Burnovers***
  - large number (documented *versus* reported)
  - occurred in town and on major egress arteries
  - significant impact on life safety
- ***Not a unique event***
  - how many other communities are in a similar situation?

NIST *Interface* Case Studies and WUI Scale

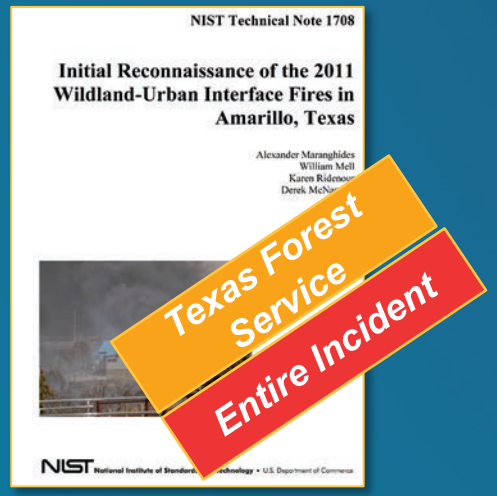
NIST TN 1635 (Witch #1)

NIST TN 1796 (Witch #2)

NIST TN 1748 (WUI Exposure Scale)

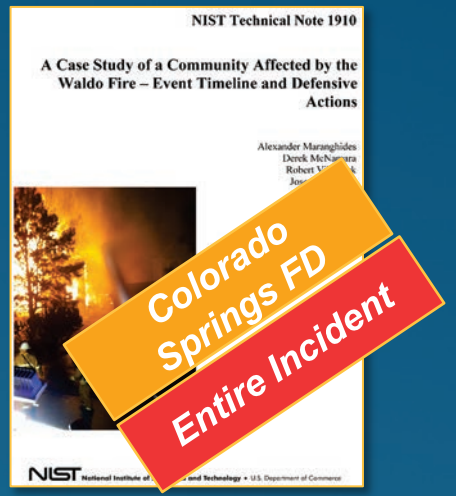


NIST TN 1708 (Amarillo #1)



NIST TN 1909 (Amarillo #2)

NIST TN 1910 (Waldo)



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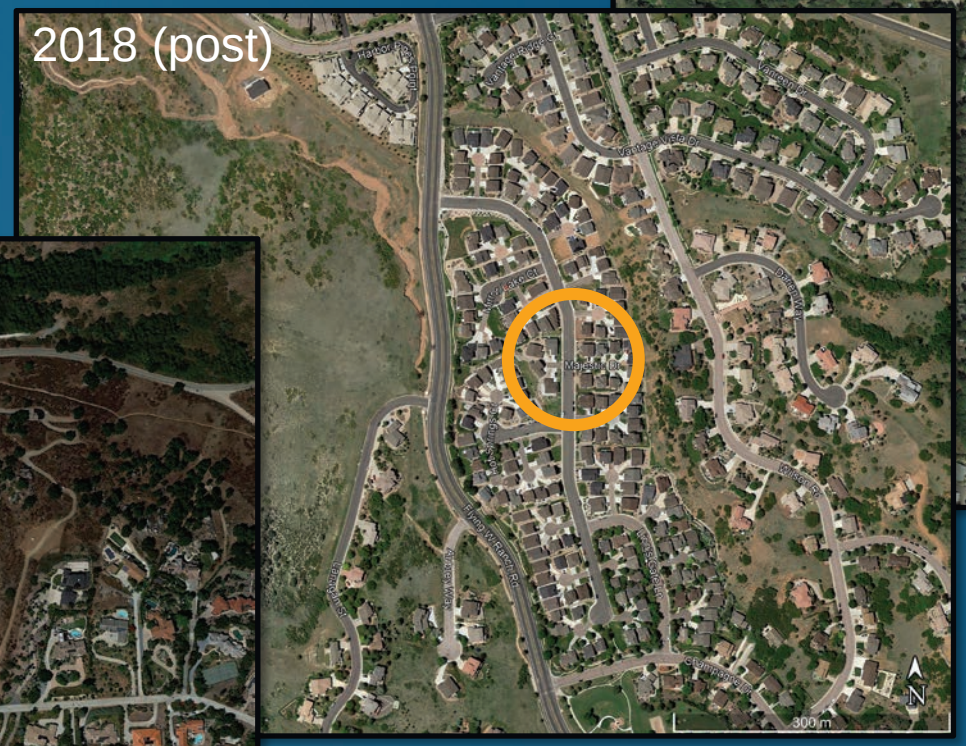
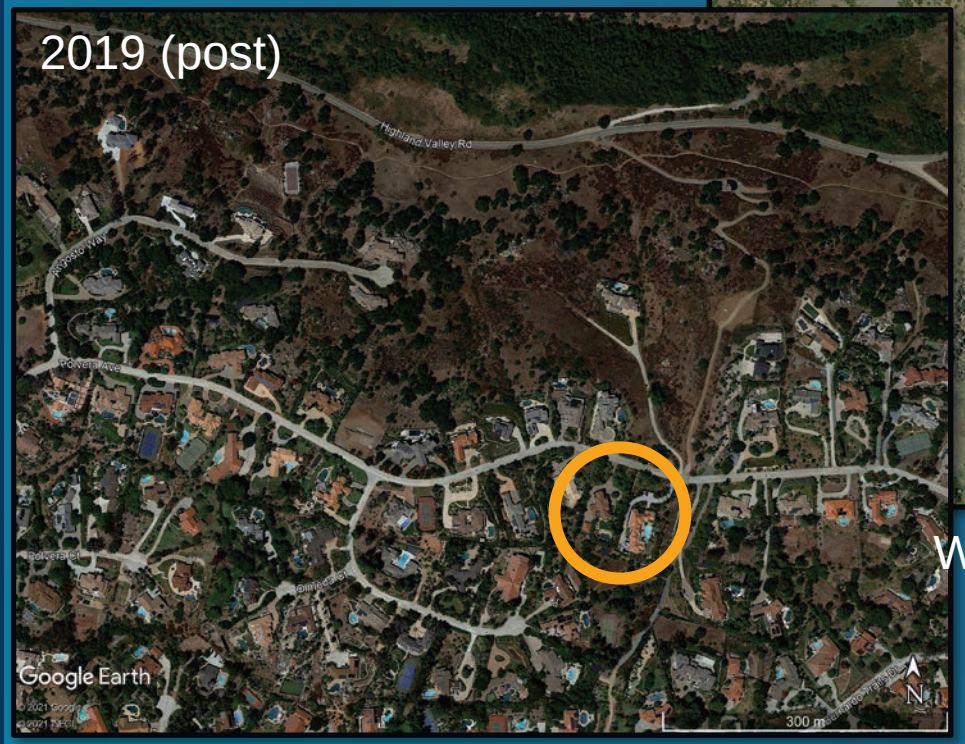
Community Differences

Interface/Intermix, housing density

Camp Fire, Intermix



Waldo Canyon Fire, Interface



Witch Fire, Interface

equal scale images

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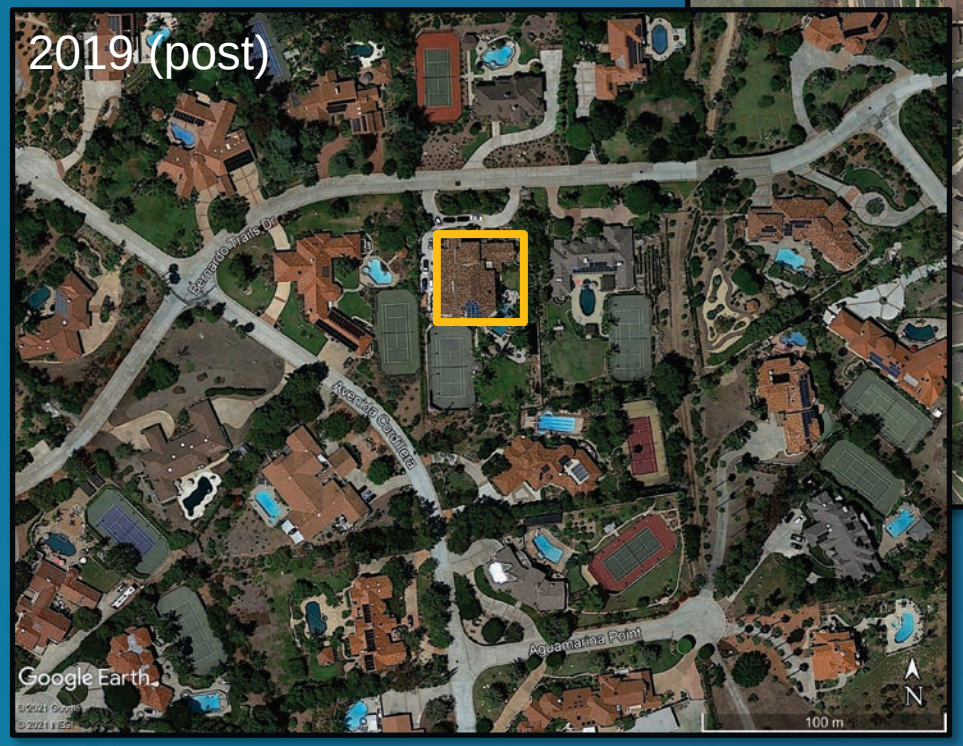
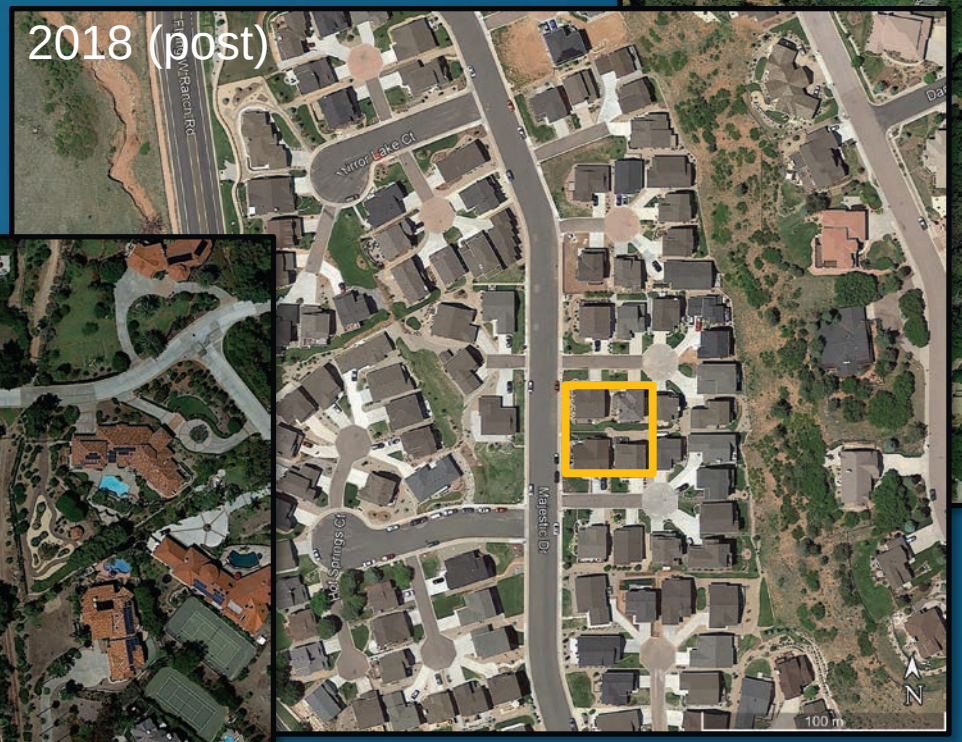
Community Differences

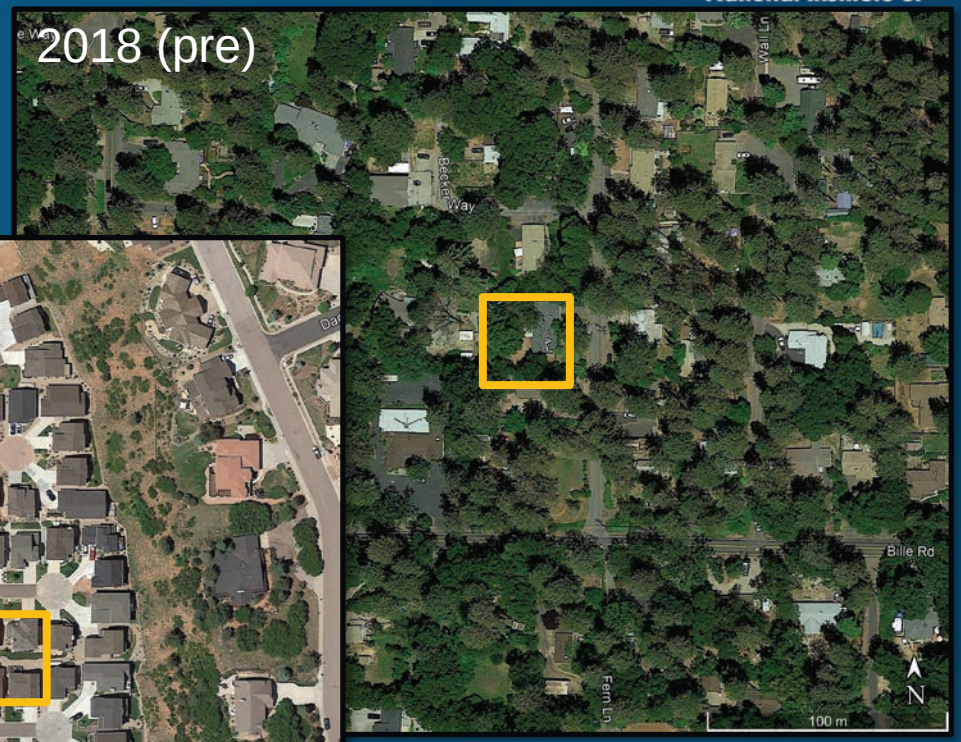
Interface/Intermix, housing density



Witch Fire, Interface



Waldo Canyon Fire, Interface



Camp Fire, Intermix

equal scale images

Intro and Previous Case Studies

Summary of Findings:

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

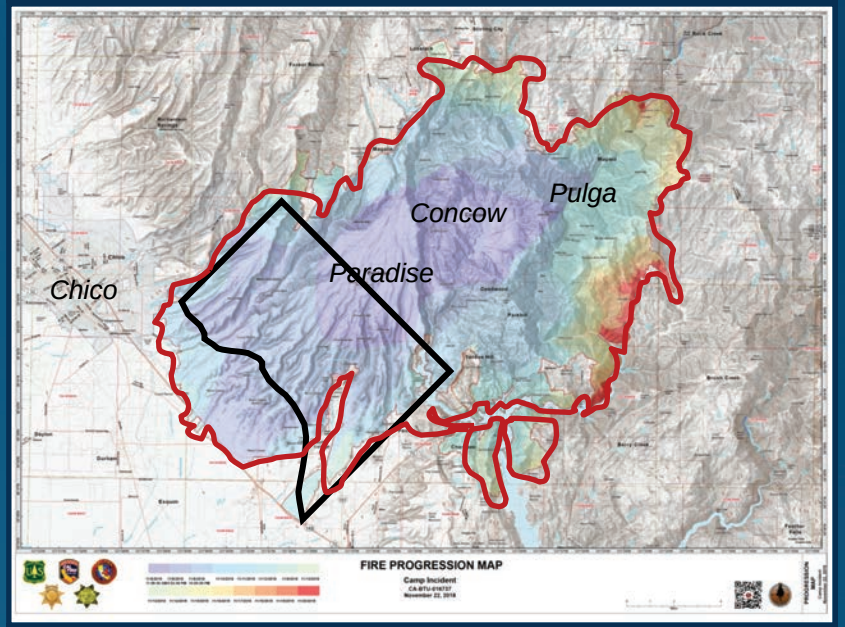
Key Takeaways:

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

Why The Camp Fire?

- 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

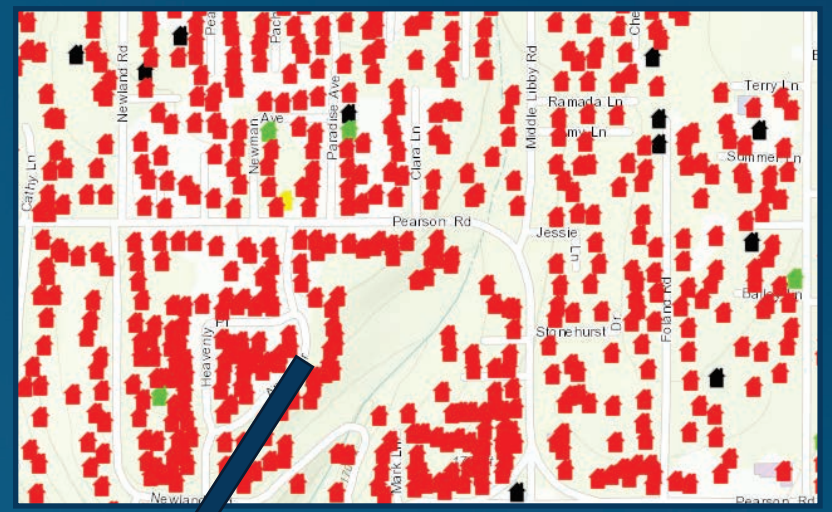
Camp Fire ~ 14 % Butte County area

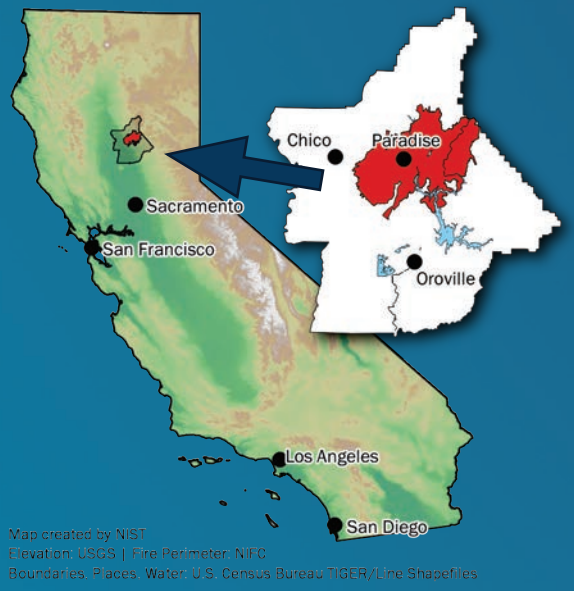


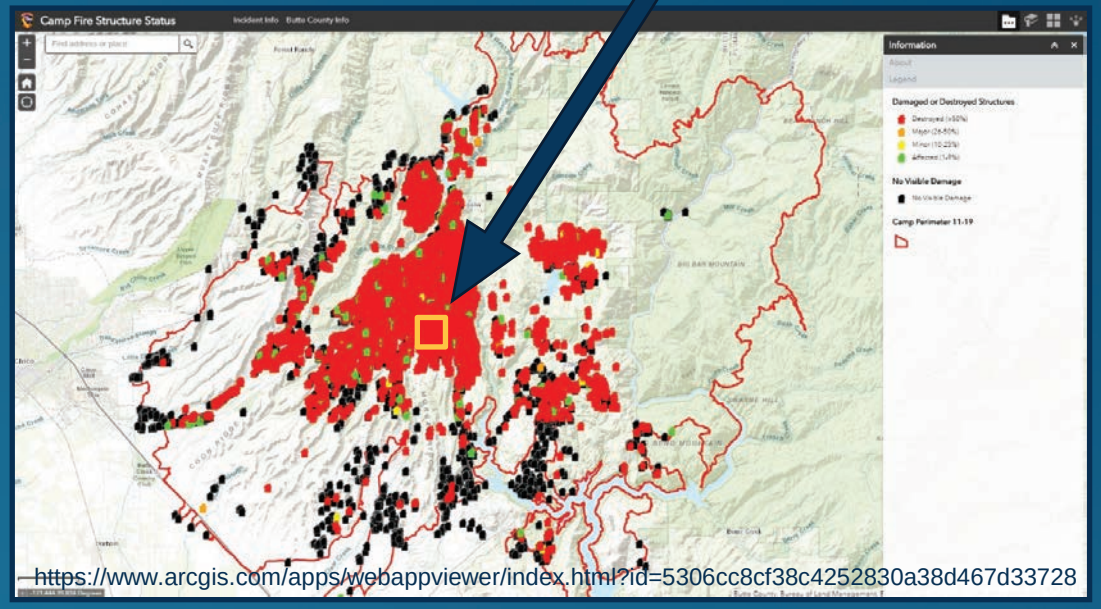
Camp Fire ~ 4× Washington, D.C. area

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

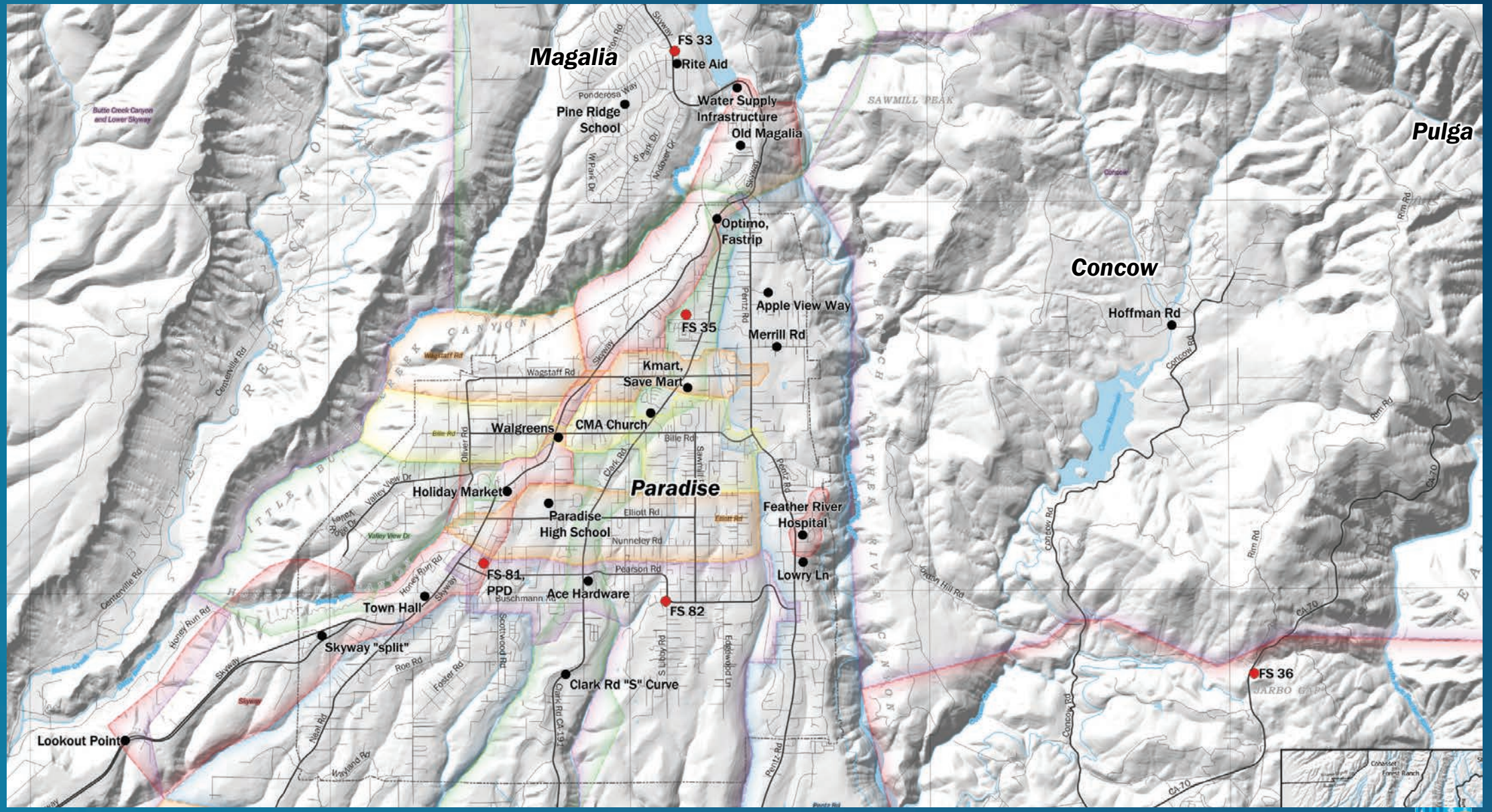






https://www.arcgis.com/apps/webappviewer/index.html?id=5306cc8cf38c4252830a38d467d33728

Paradise Points of Interest



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.

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

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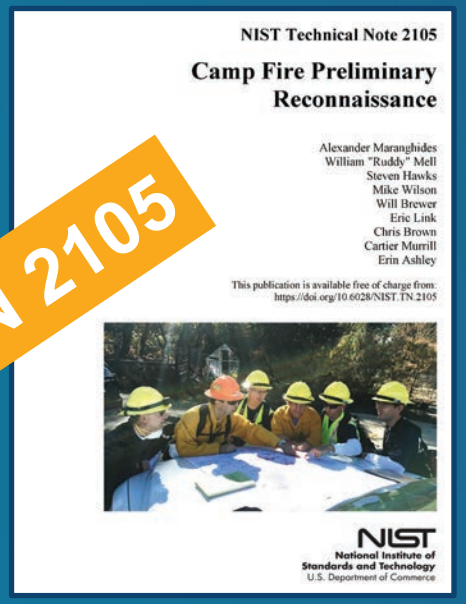
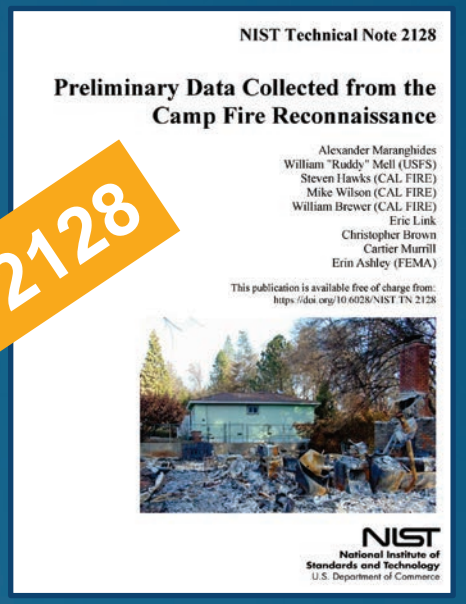
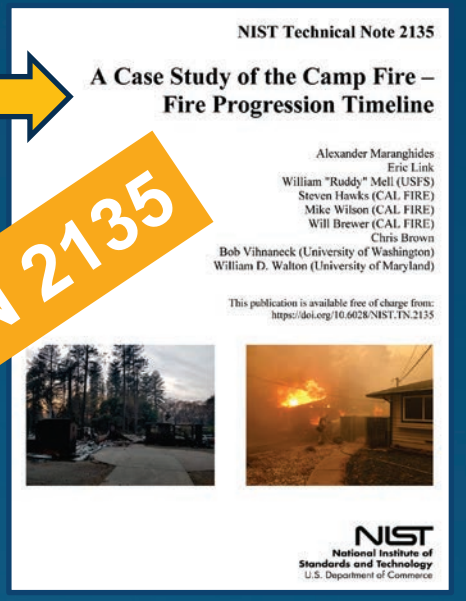
Camp Fire Technical Research



TN 2105



TN 2128



TN 2135

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

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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?*

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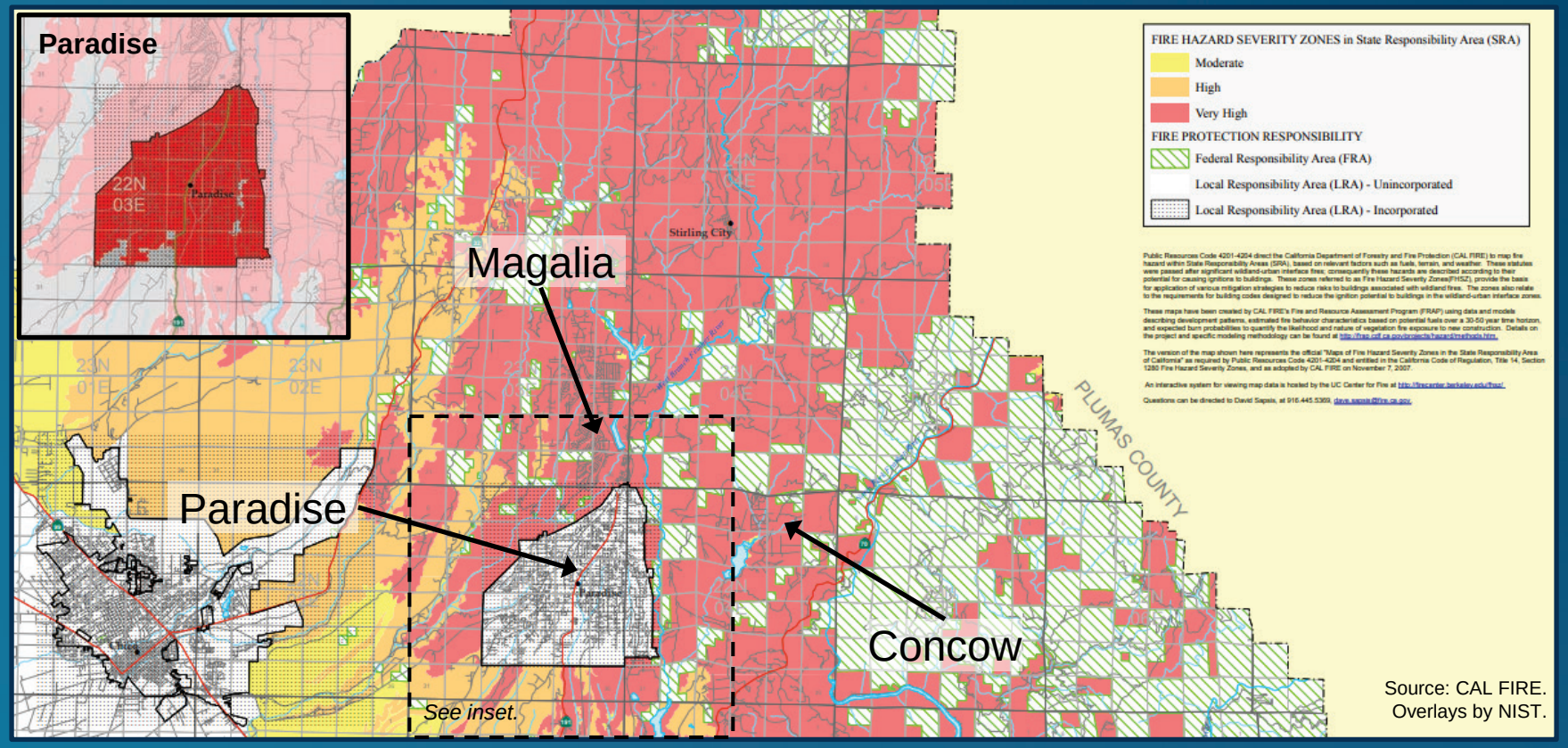
Pre-Fire Conditions

wind + drought + topography + fire history

Butte County Fire Hazard Severity



Majority of area Very High Fire Hazard Severity Zone

NIST Camp Fire Report #3, Figure 3.

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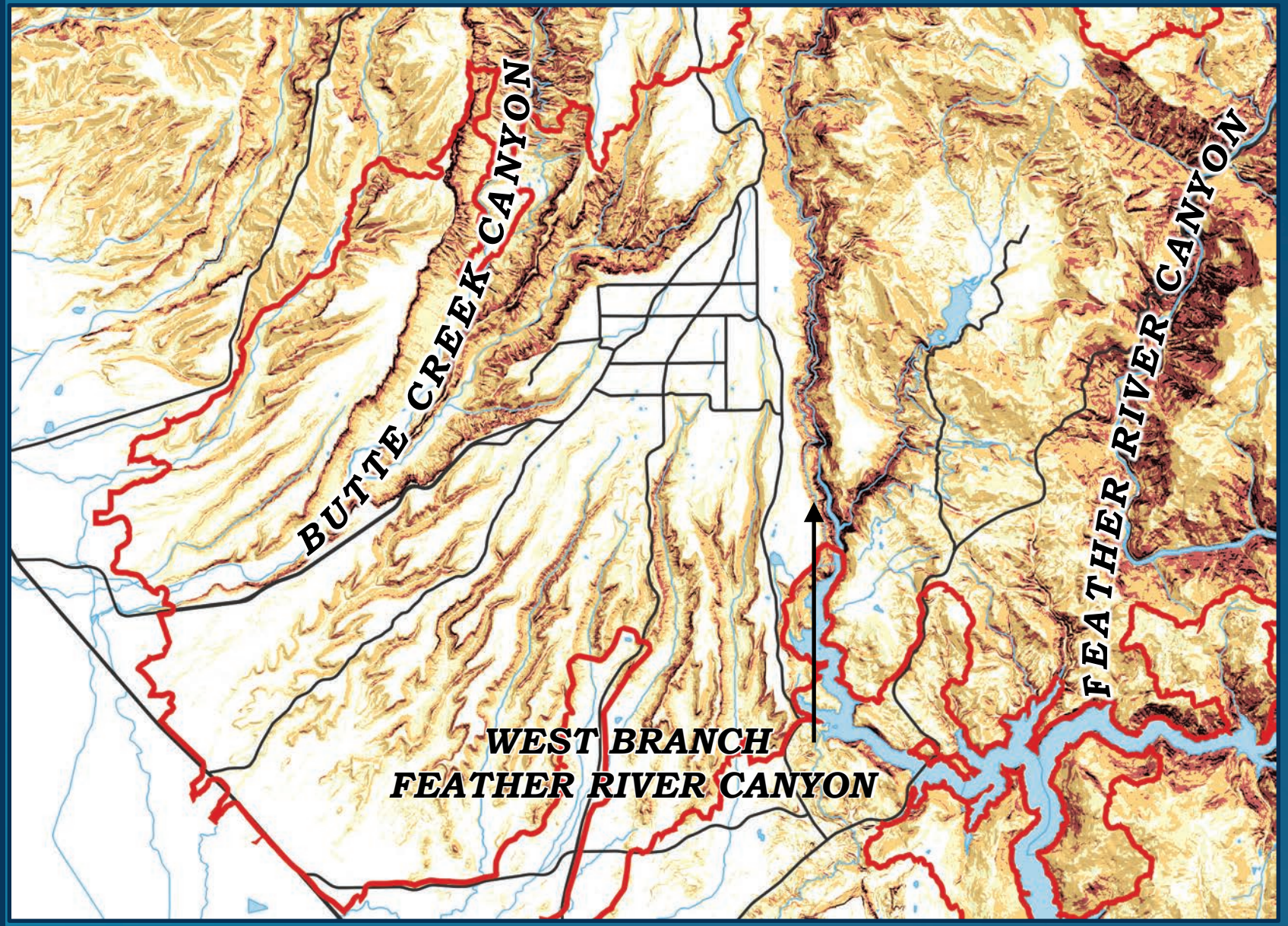
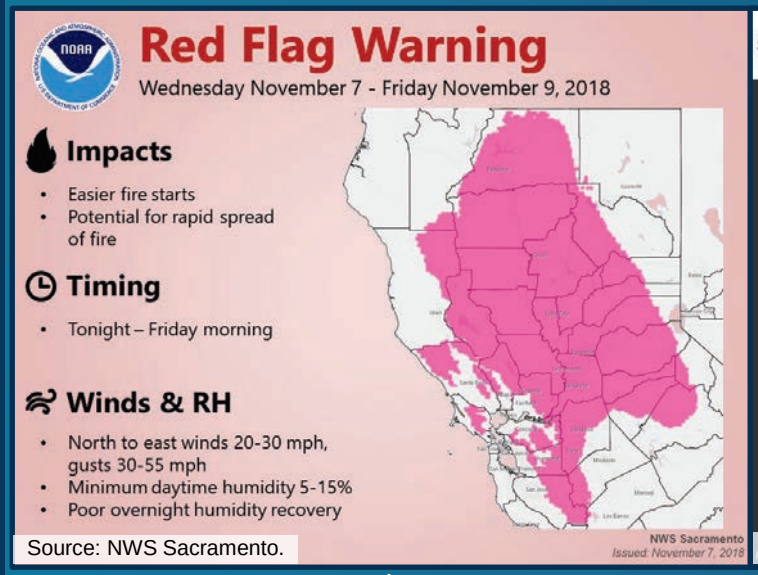
Topography



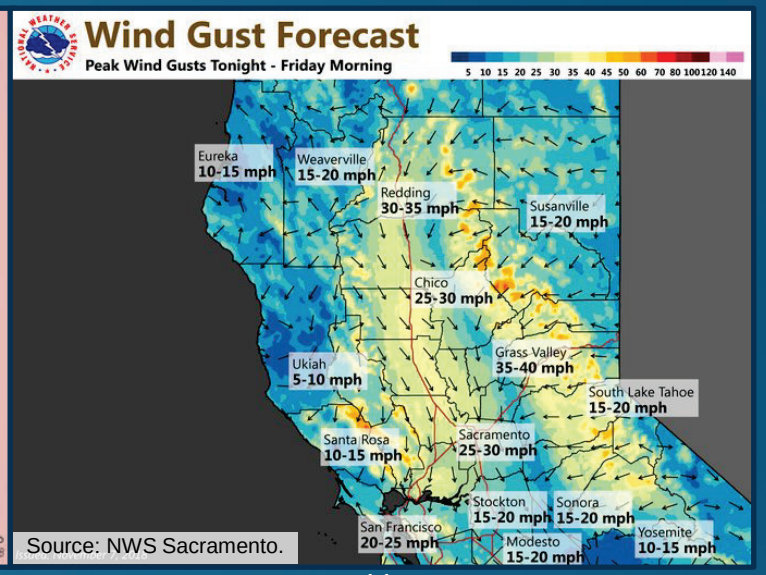
- Significant steep canyons
- Localized wind alignment
- Difficult access
- Restricted egress

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

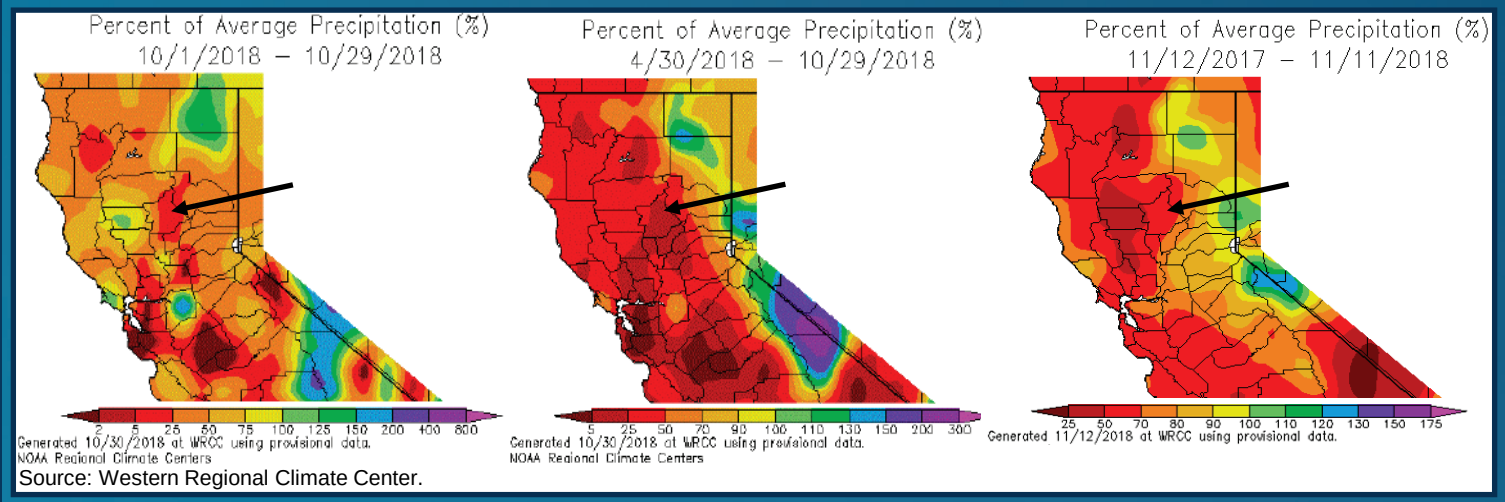
Red Flag Warning and Drought



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.

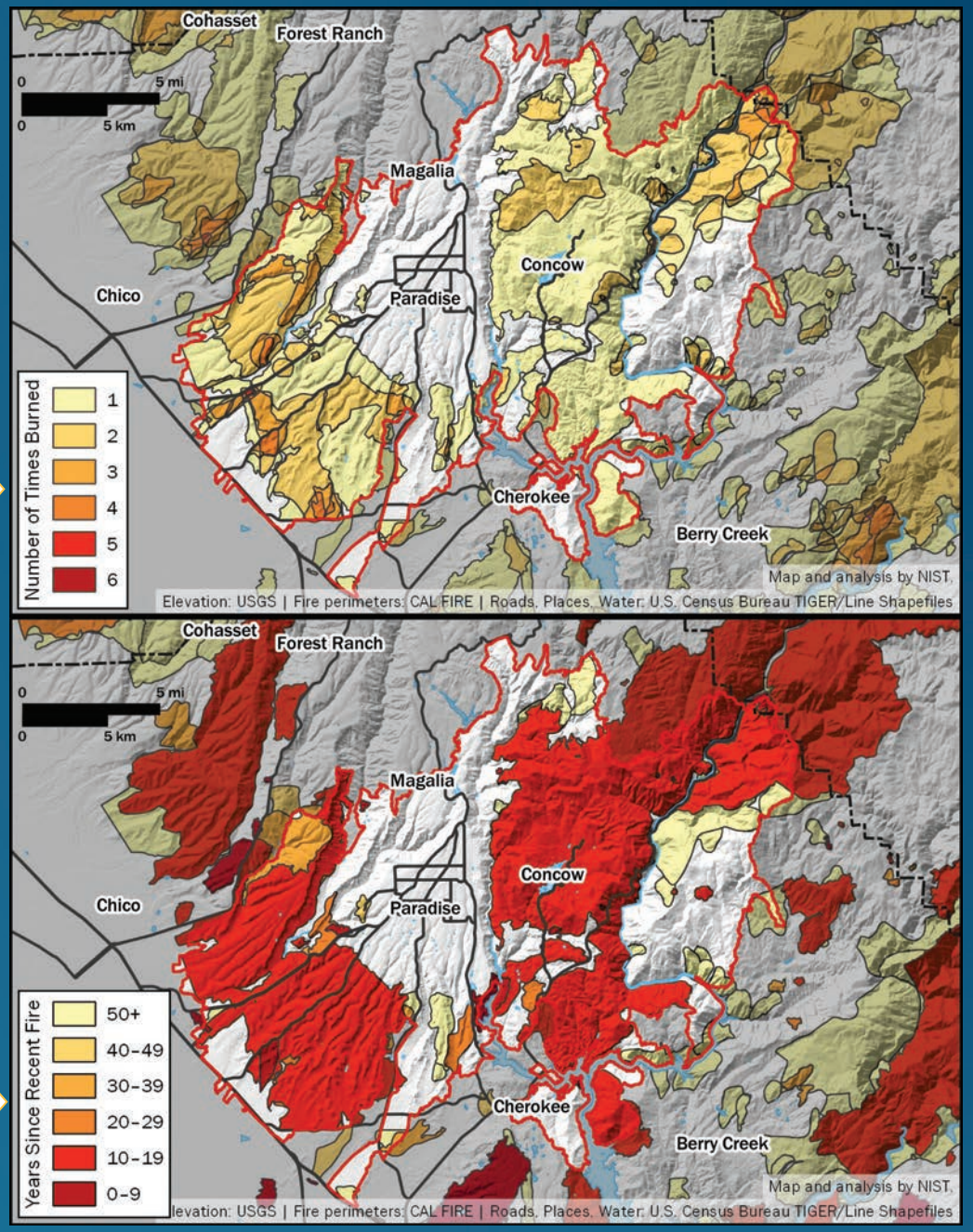
Fire History

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.

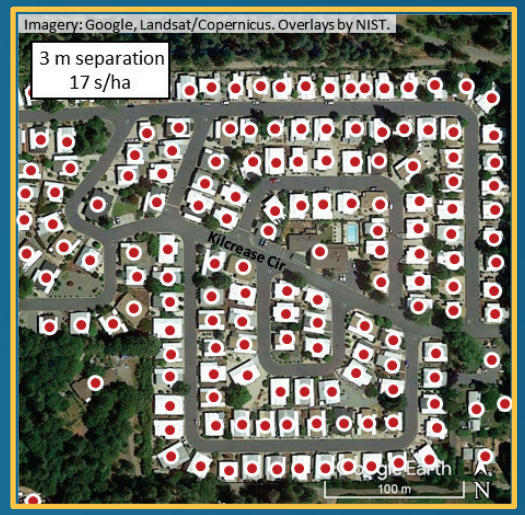


NIST Camp Fire Report #3, Figure 10.

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.

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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.

Pre-fire Conditions

Summary:

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

Implementation:

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

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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

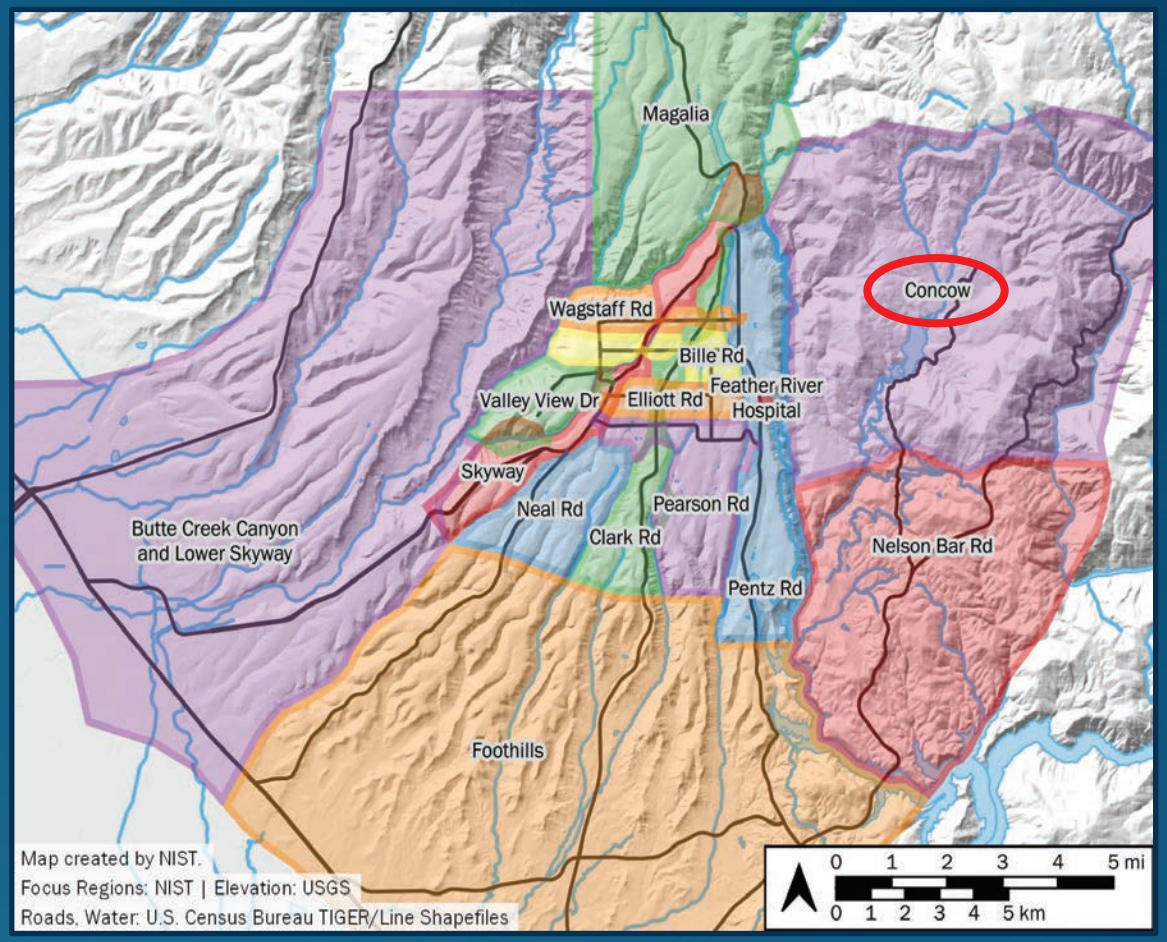
1. ***Overview*** in Executive Summary and report findings/conclusions *(3 pages)*

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

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

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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.

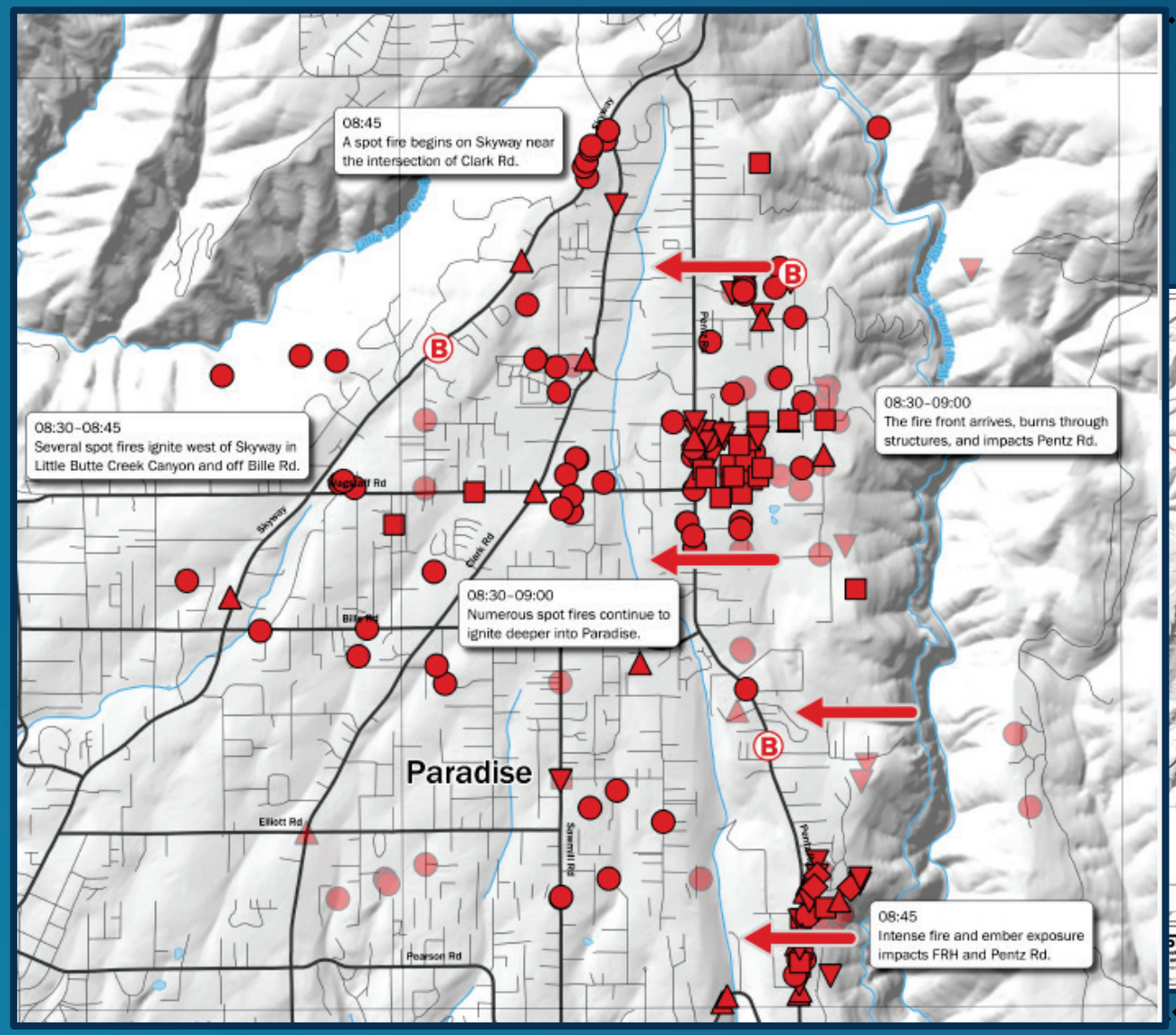
Strong Wind at Rim Road

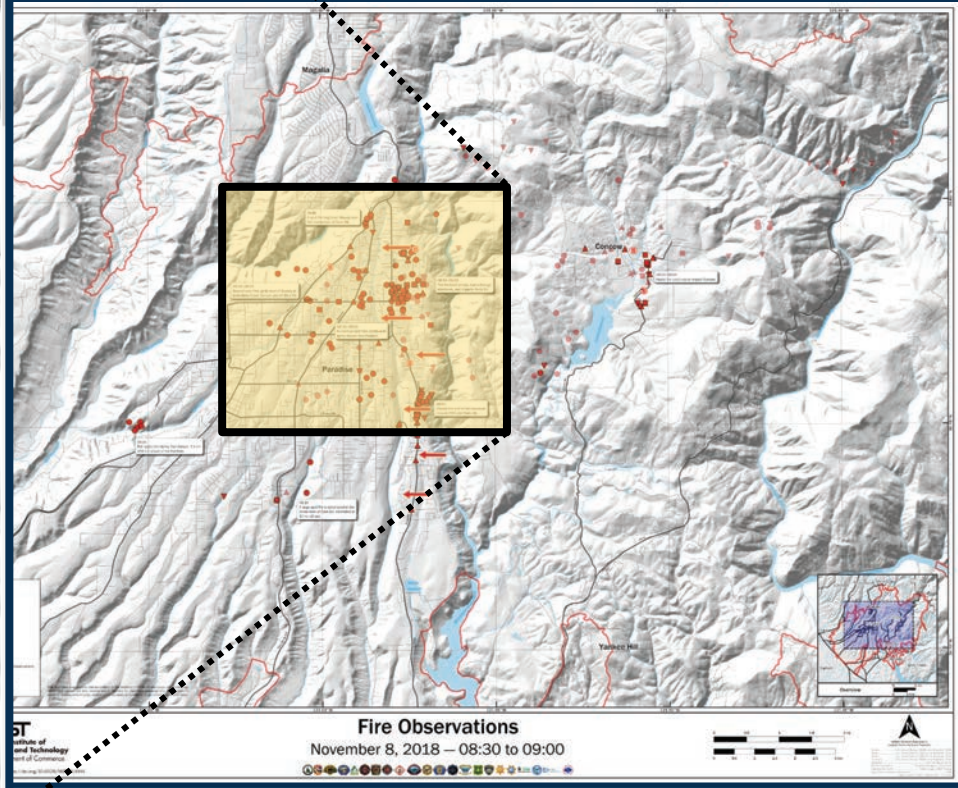
Video courtesy of TD-005, 07:32.
Used with permission.

- 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)





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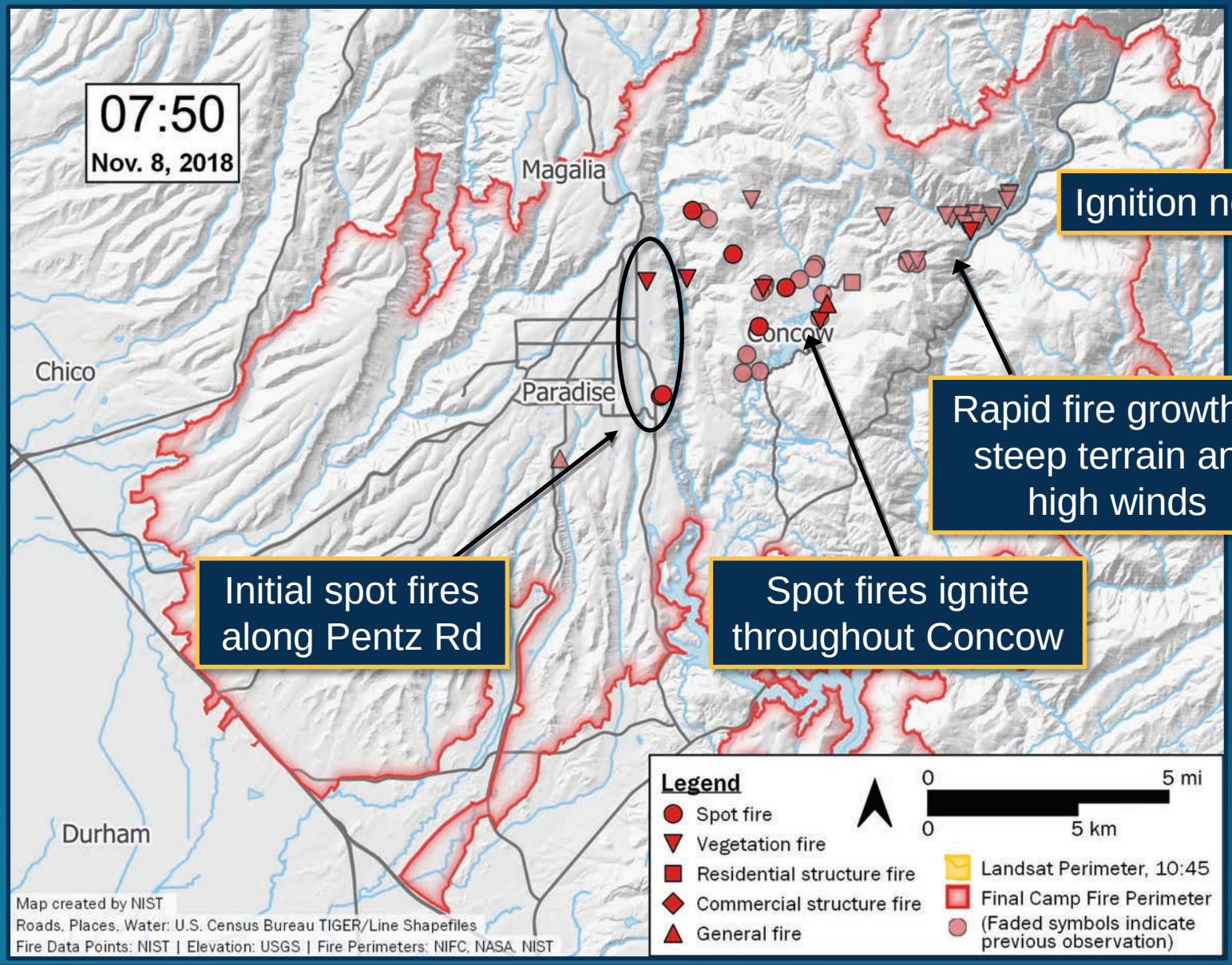
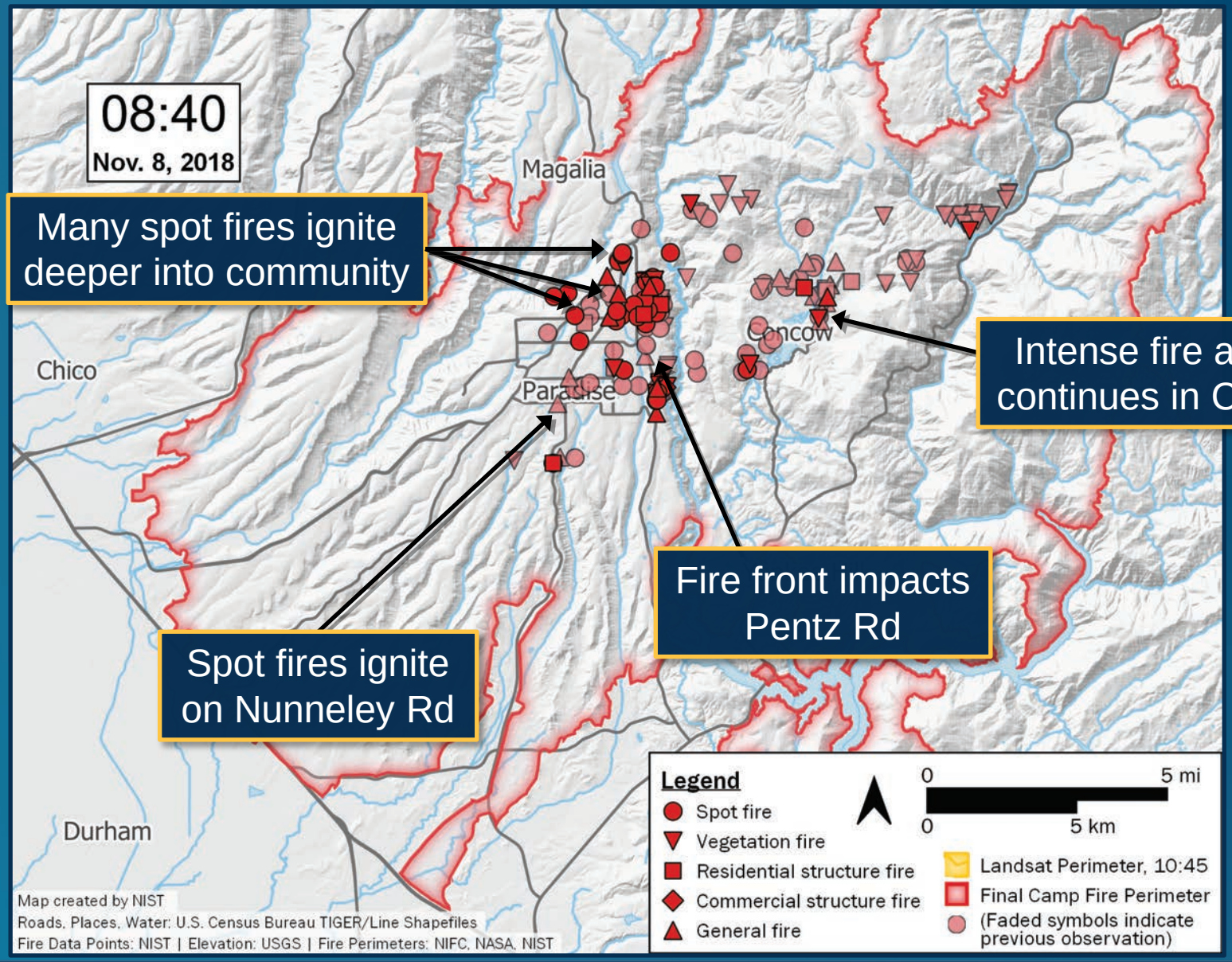
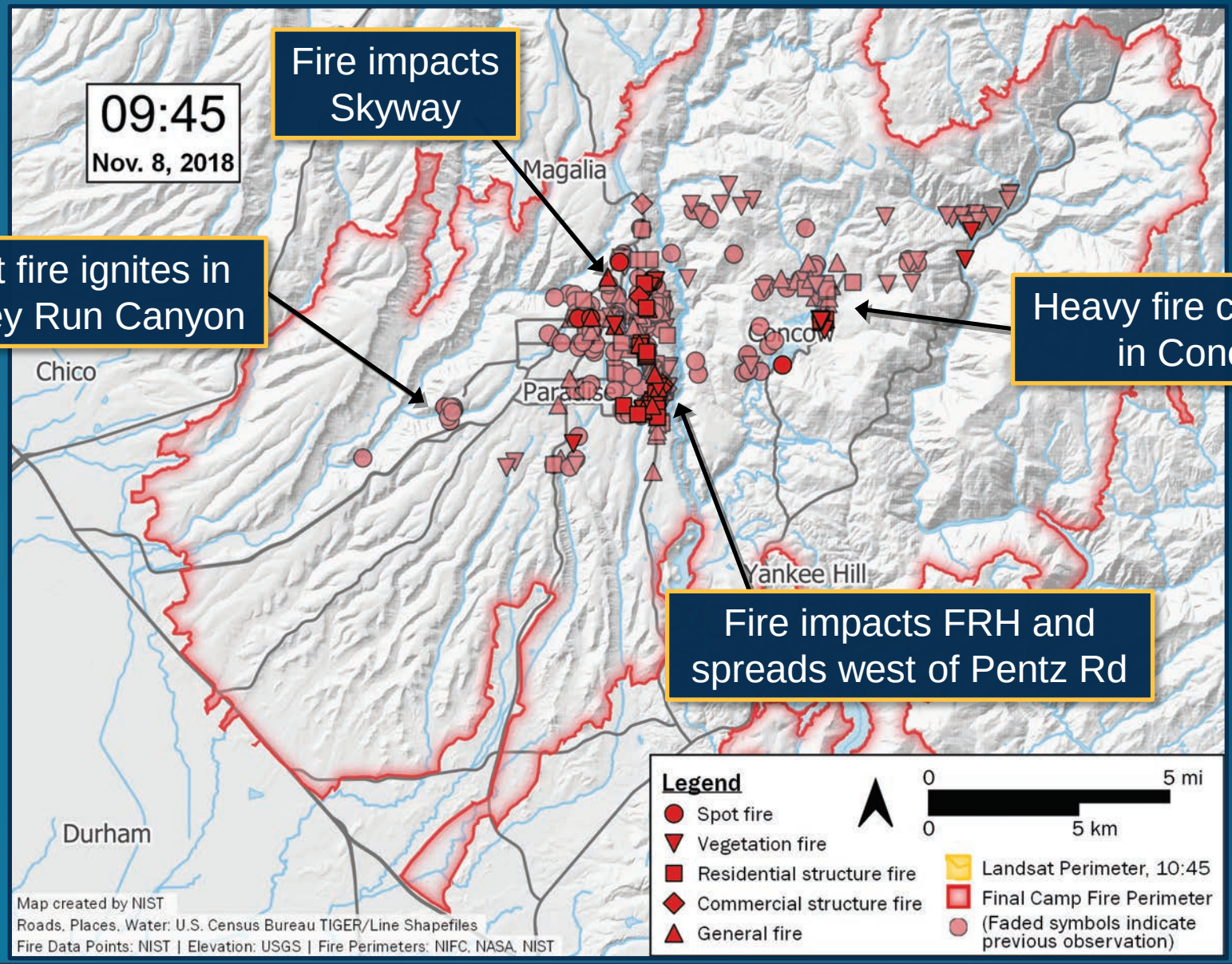
Fire Progression Summary 06:15 to 07:50



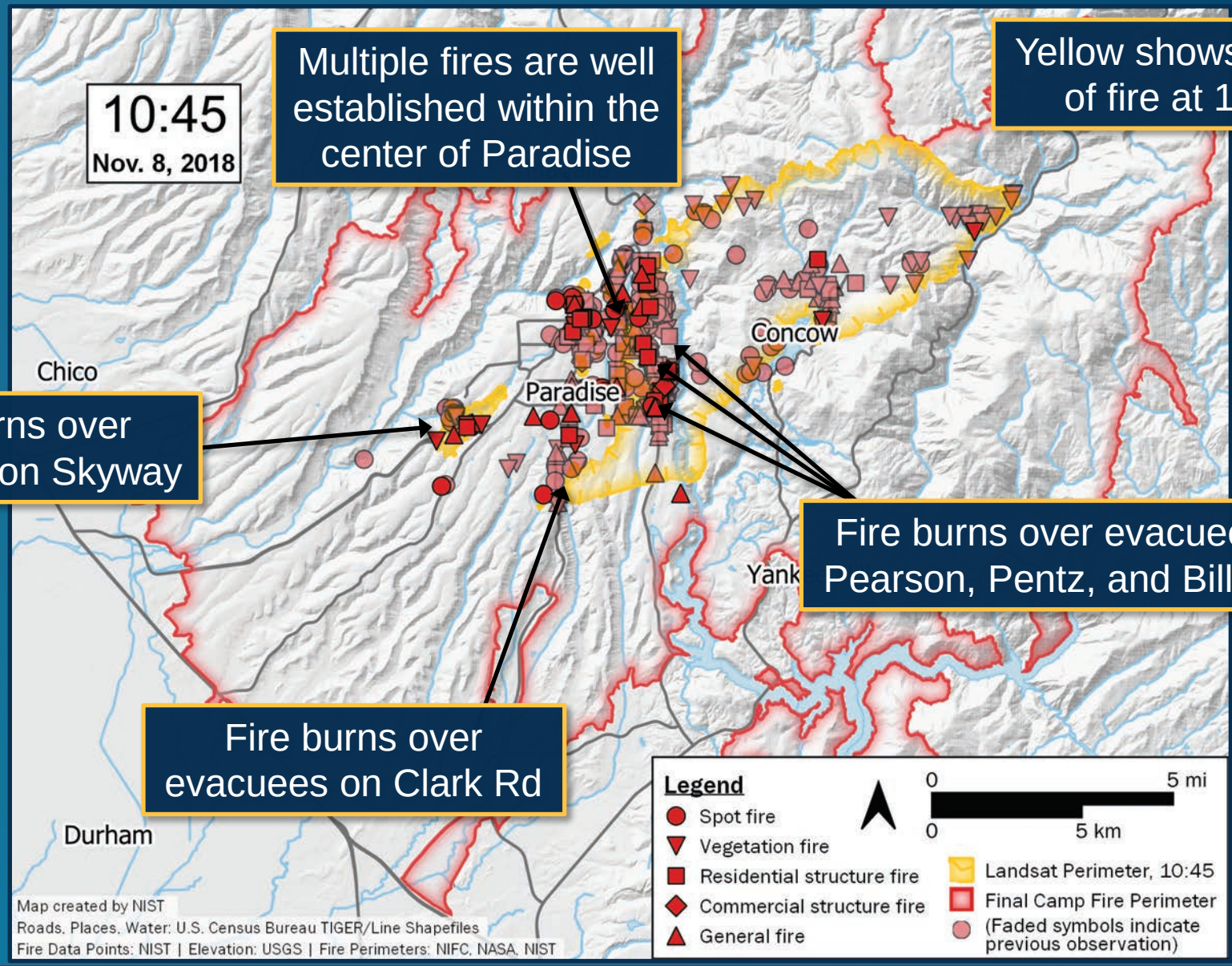
Fire Progression Summary 07:50 to 08:40



Fire Progression Summary 08:40 to 09:45



Fire Progression Summary 09:45 to 10:45



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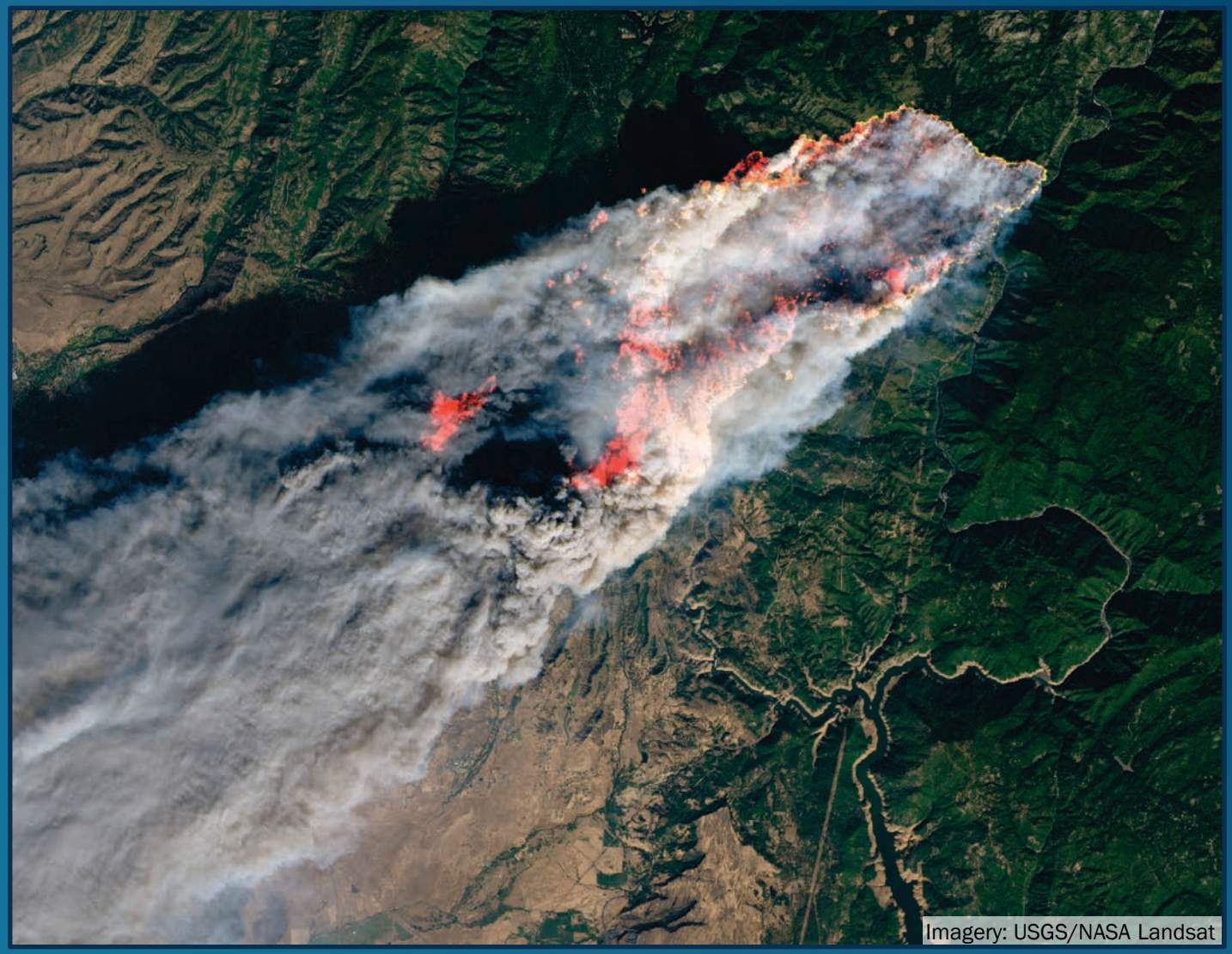
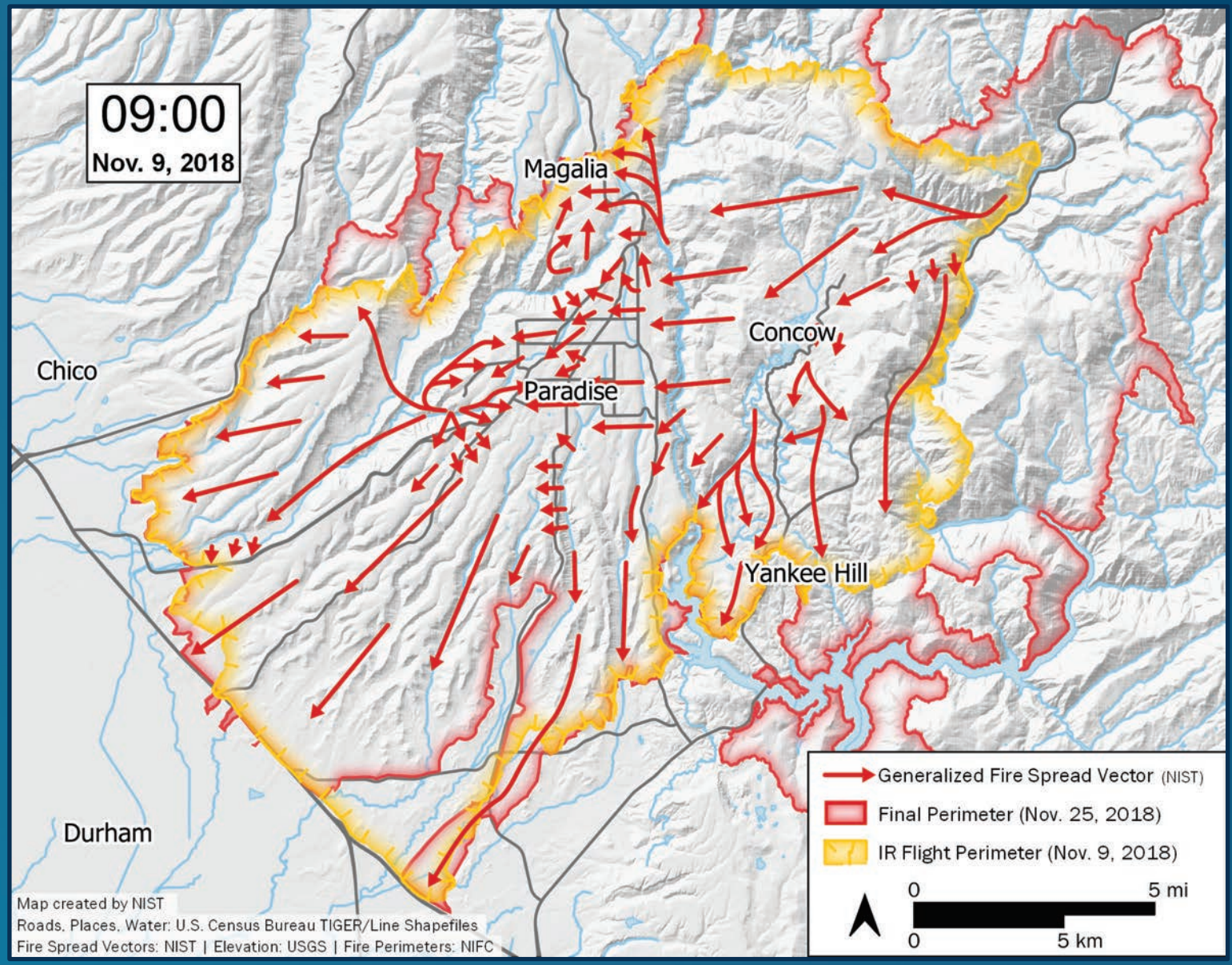
Fire Progression Summary by 10:45



Fire Progression Summary (Day 1)



NIST Camp Fire Report #3, Figure 22.

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Fire Progression

Summary:

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

Implementation:

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

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Burnovers

19 documented

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

19 Identified Burnovers

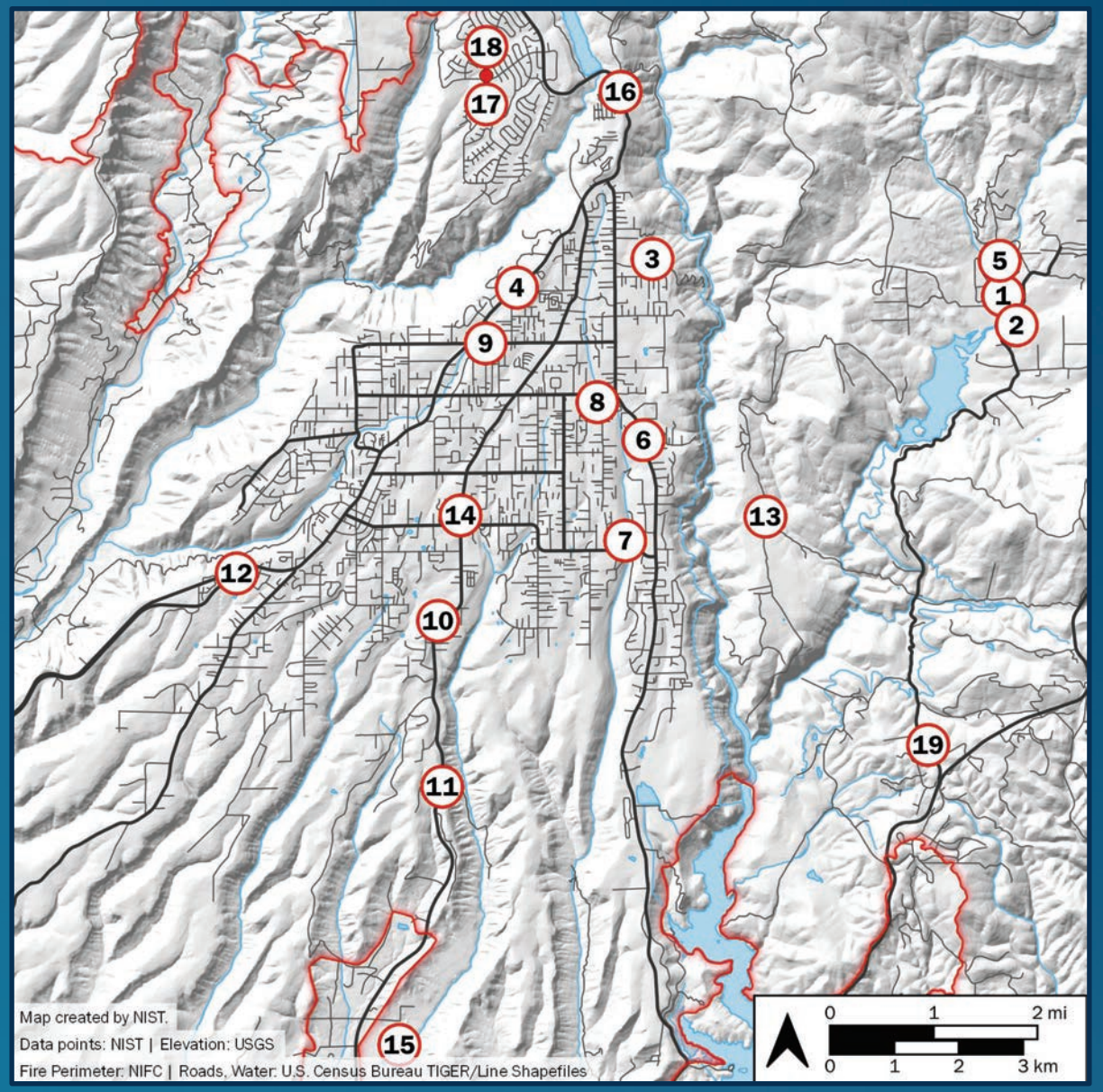
Report describes identified:

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.

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 Appendix B

1. Hoffman Road

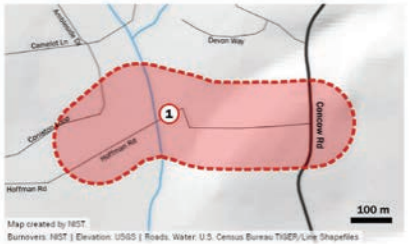
Date/Time:	November 8, 07:50–08:30
Location:	Hoffman Road, Concow
Coordinates:	[39.783963, -121.509288]
Related TRA/ Safety Zone:	after the Hoffman Rd burnover, civilians went to the Camelot Wildfire Safety Zone
Summary:	Fire activity in the form of a large spot was first reported in the Hoffman Rd area 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

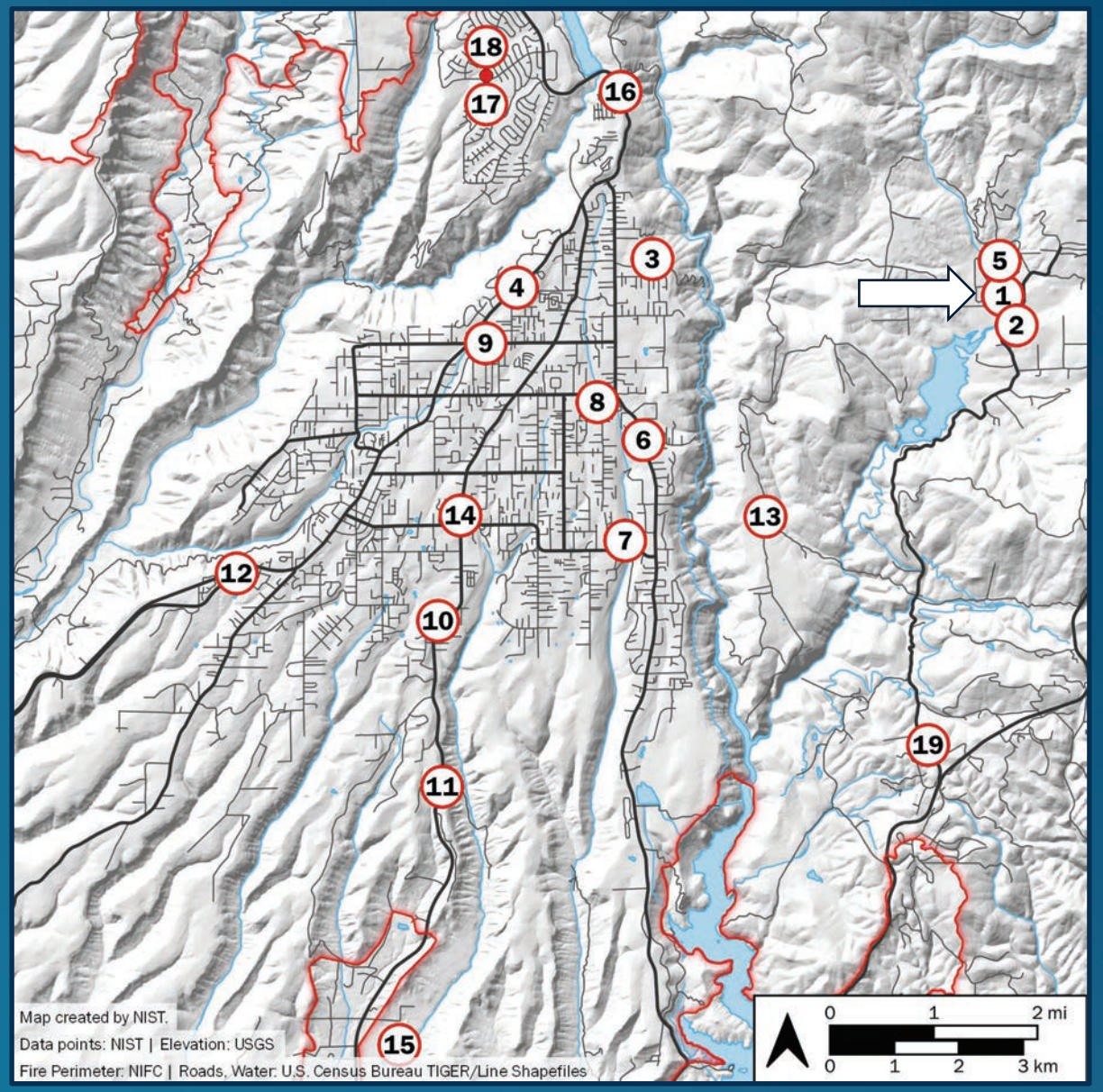
Street map:



Satellite view:

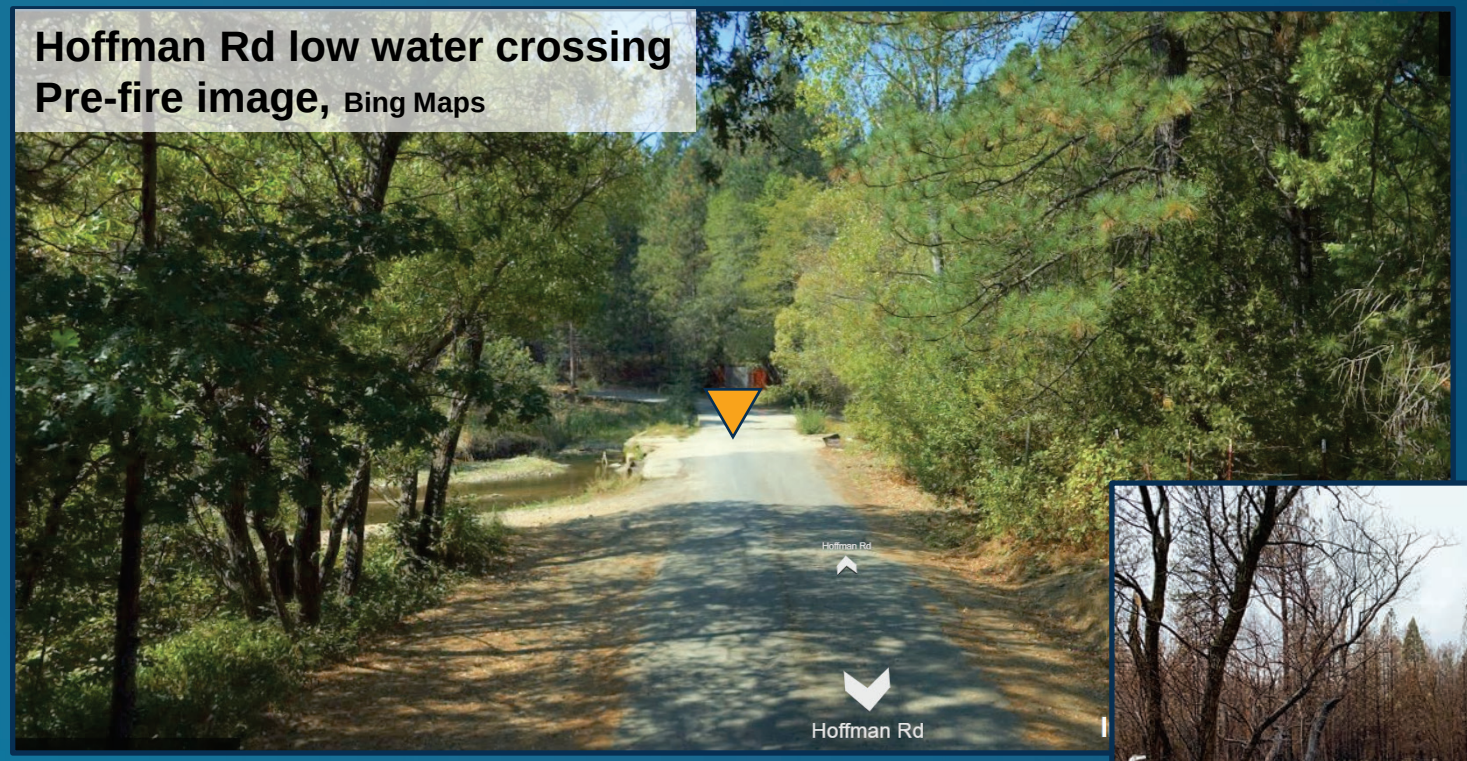
Hoffman Road Burnover Details

Burnover #1: Hoffman Rd



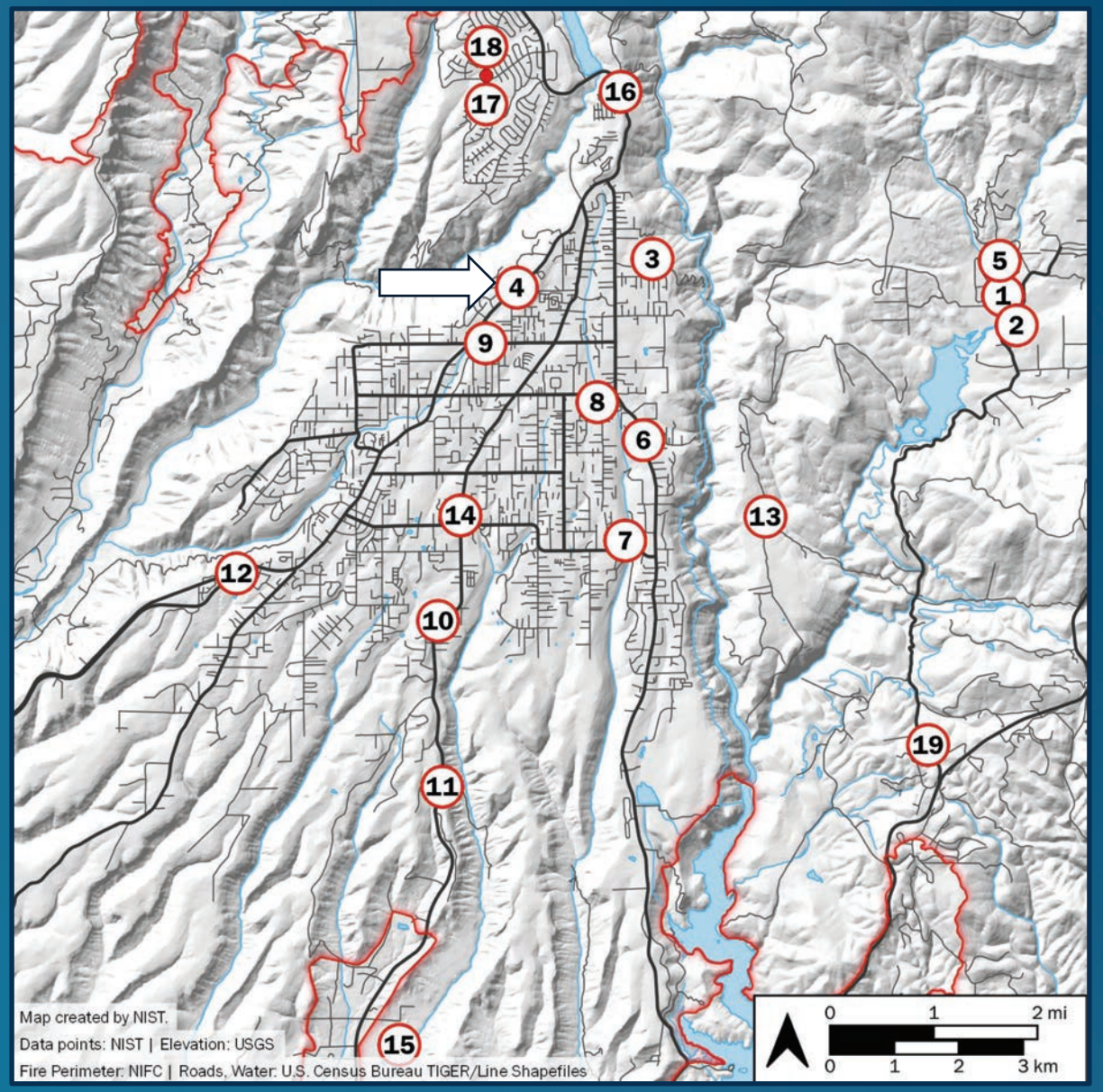
NIST Camp Fire Report #3, Figure 47.

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.

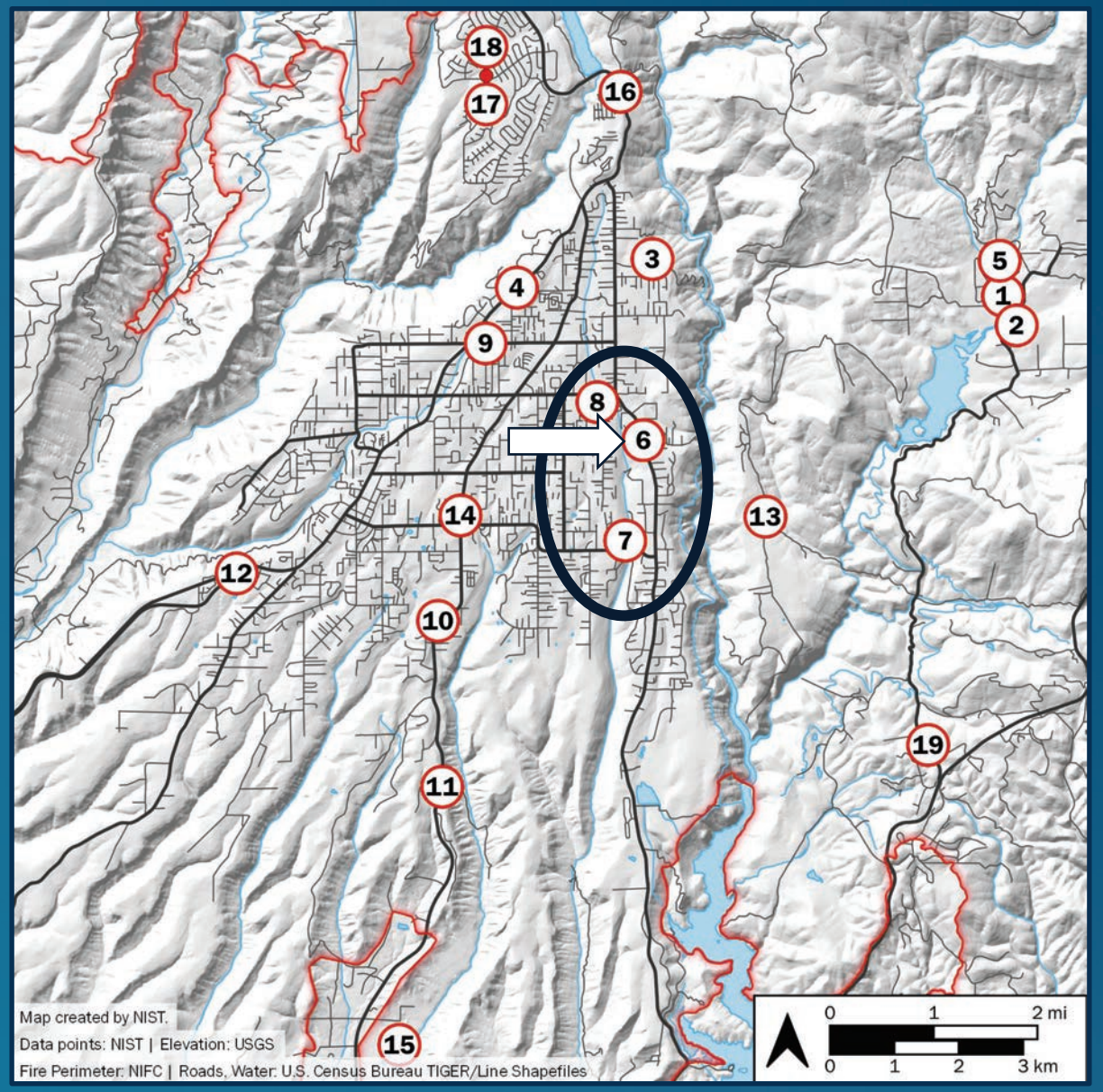
Burnover #4: Upper Skyway

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

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

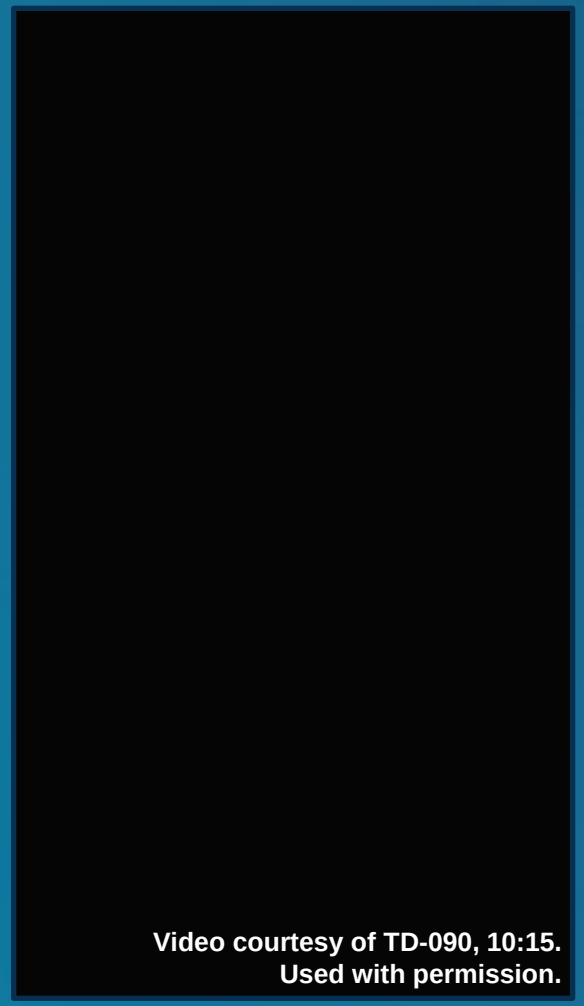
- Prolonged period of hazardous conditions
- Rapid spread of initial spot fires
- Standstill traffic
- Abandoned vehicles burning in roadway
- Prevented evacuation from points north

Burnover #6: Pentz Road



NIST Camp Fire Report #3, Figure 47.

Burnover #6: Pentz Road



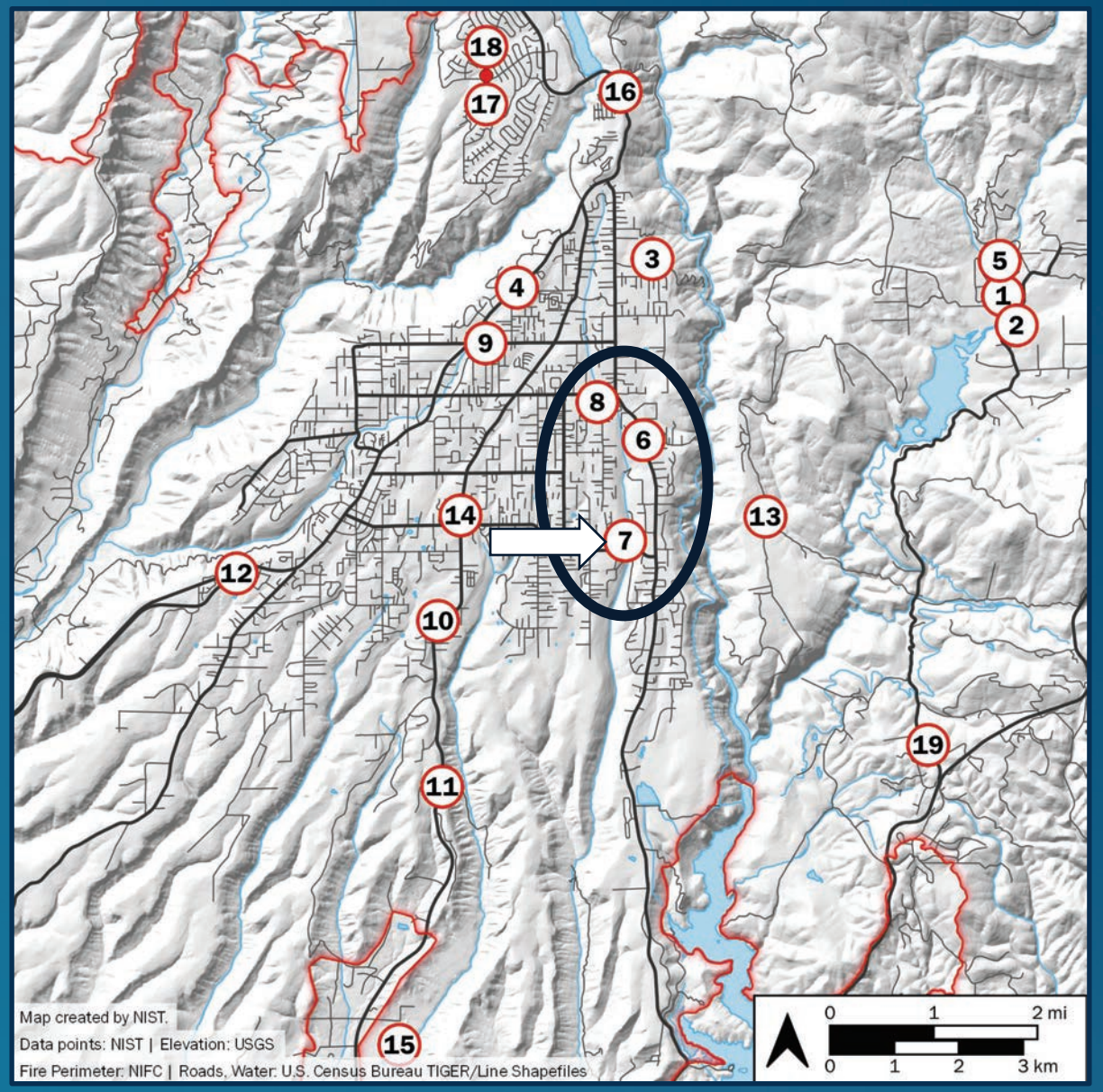
Zero visibility, on foot, re-directing traffic

- 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



NIST Camp Fire Report #3, Figure 47.

Burnover #7: Pearson Road

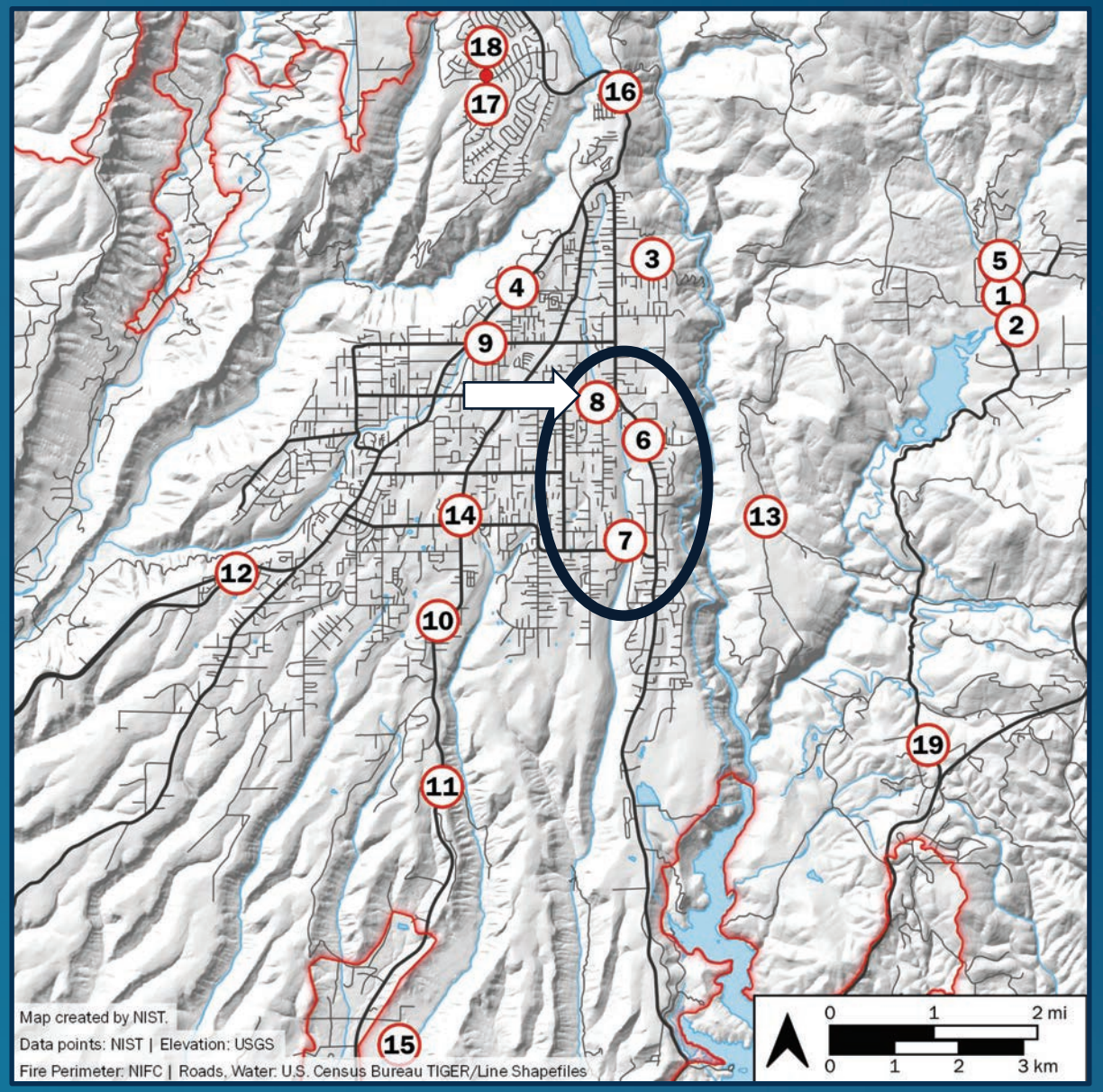

Photo courtesy of TD-122, 09:40. Used with permission.


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.

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Burnover #8: Bille Road

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

NIST Camp Fire Report #3, Figure 34.

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Life Safety

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

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

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

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

Severity of Local Conditions

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


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


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


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


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


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

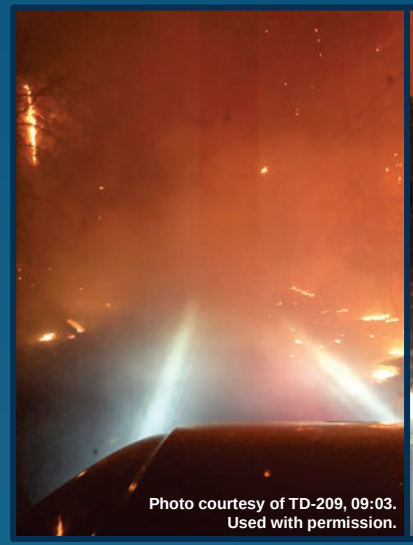
Photo courtesy of TD-209, 09:03.
Used with permission.

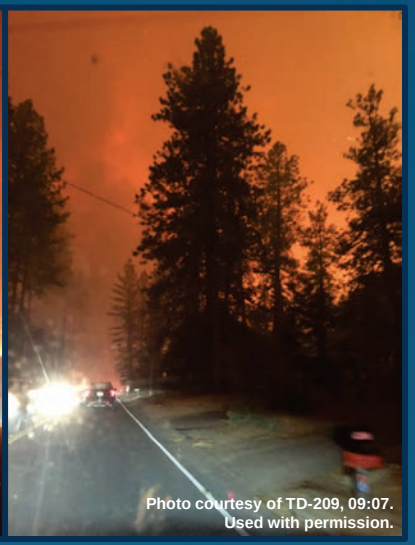
Photo courtesy of TD-209, 09:07.
Used with permission.

Difference 0.25 mi and 4 min.

Burnovers Summary

Summary:

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

Implementation:

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

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General Fire Behavior

effects of wind and terrain | spot fires

structure ignition pathways

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

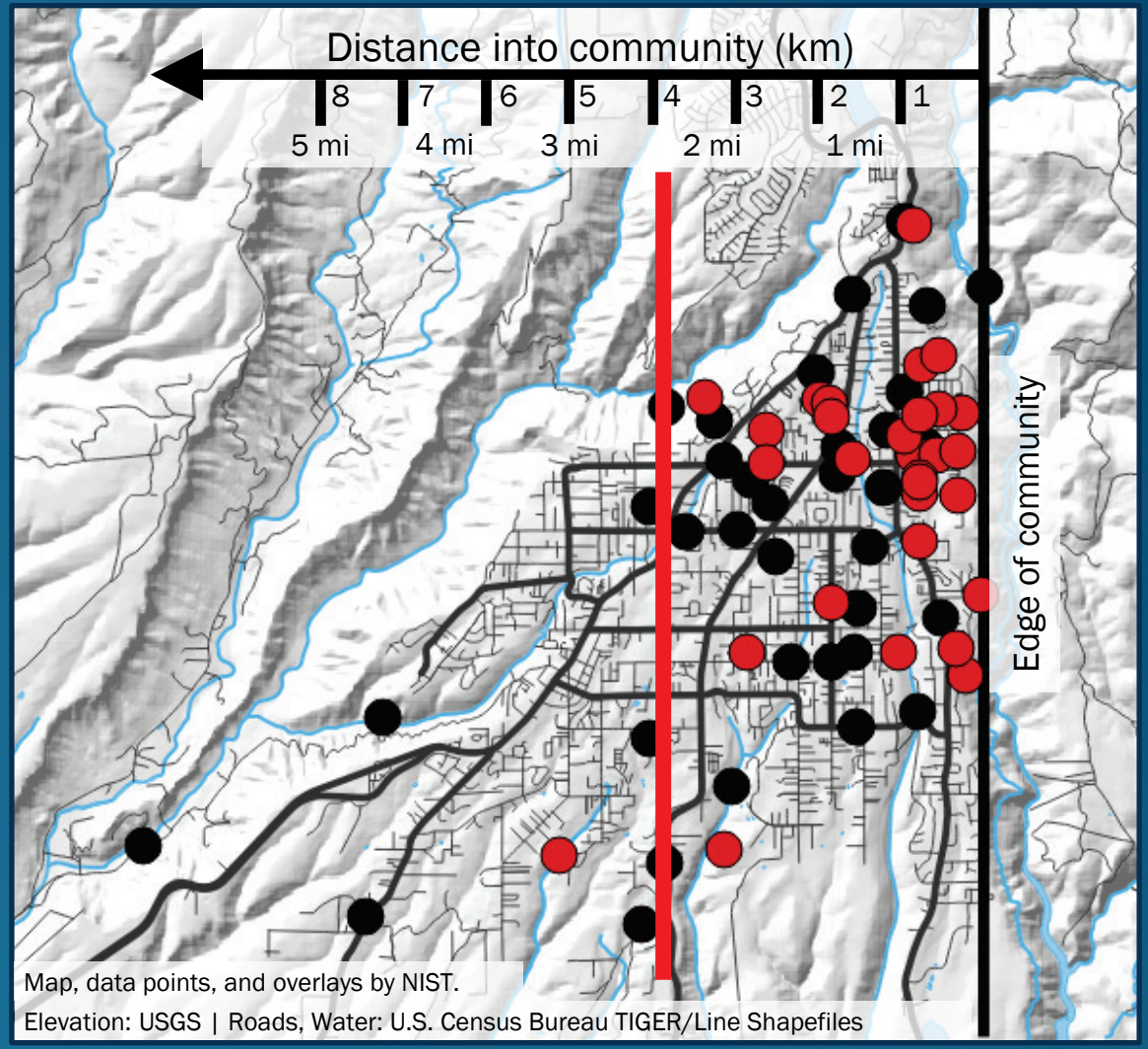
Impact of Winds, Wildland Fuels and Terrain on Fire Behavior

- 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]*

Early Spot Fires in Paradise

Spot Fire Ignitions

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

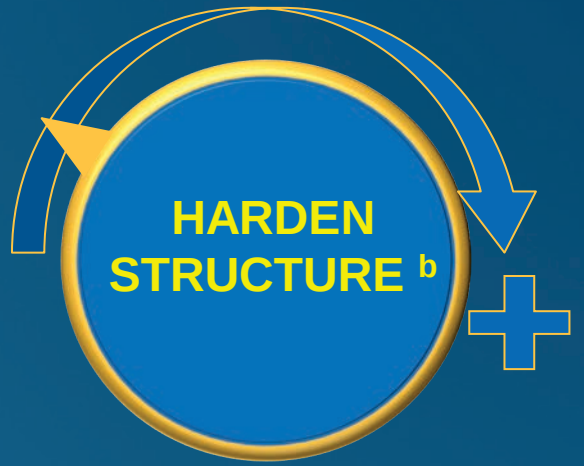


30 identified spot fires within first 40 minutes (red)

NIST Camp Fire Report #3, Figure 51.

Structure Ignitions – Exposure and Structure Hardening Relationship

Chapter 49,
Defensible Space
Chapter 7A Subcommittee 6

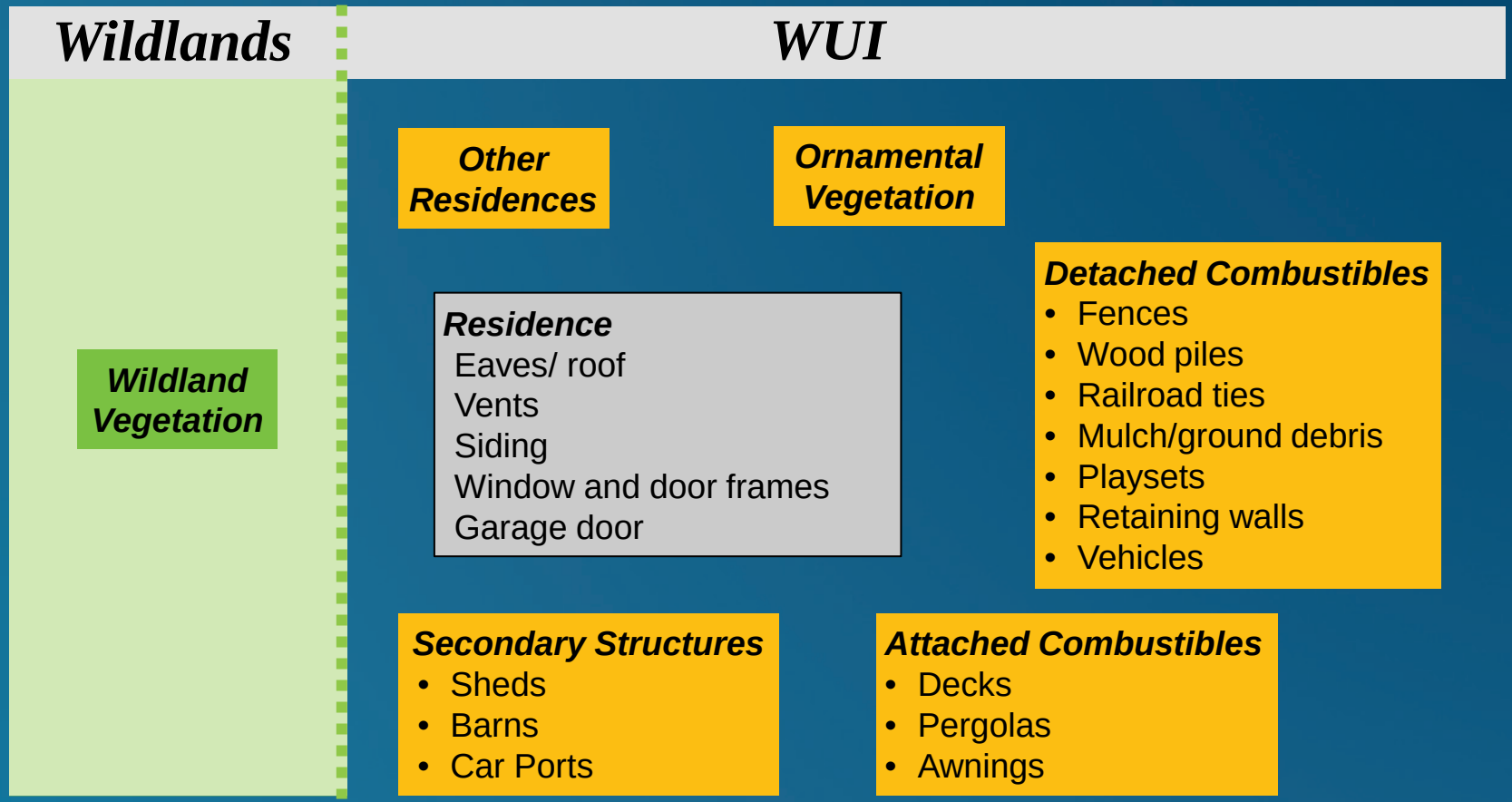


Chapter 7A

a Reduce fire and/or ember exposures

b Hardening for embers and/or fire

Structure Ignition Pathways



NIST Camp Fire Report #3, Figure 54.

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Vulnerabilities – Failure Points

windows

NIST Photo. Camp Fire 2018.

NIST Photo. Camp Fire 2018.

roof / eaves

NIST Photo. Camp Fire 2018.

NIST Photo. Camp Fire 2018.

Vulnerabilities – Failure Points

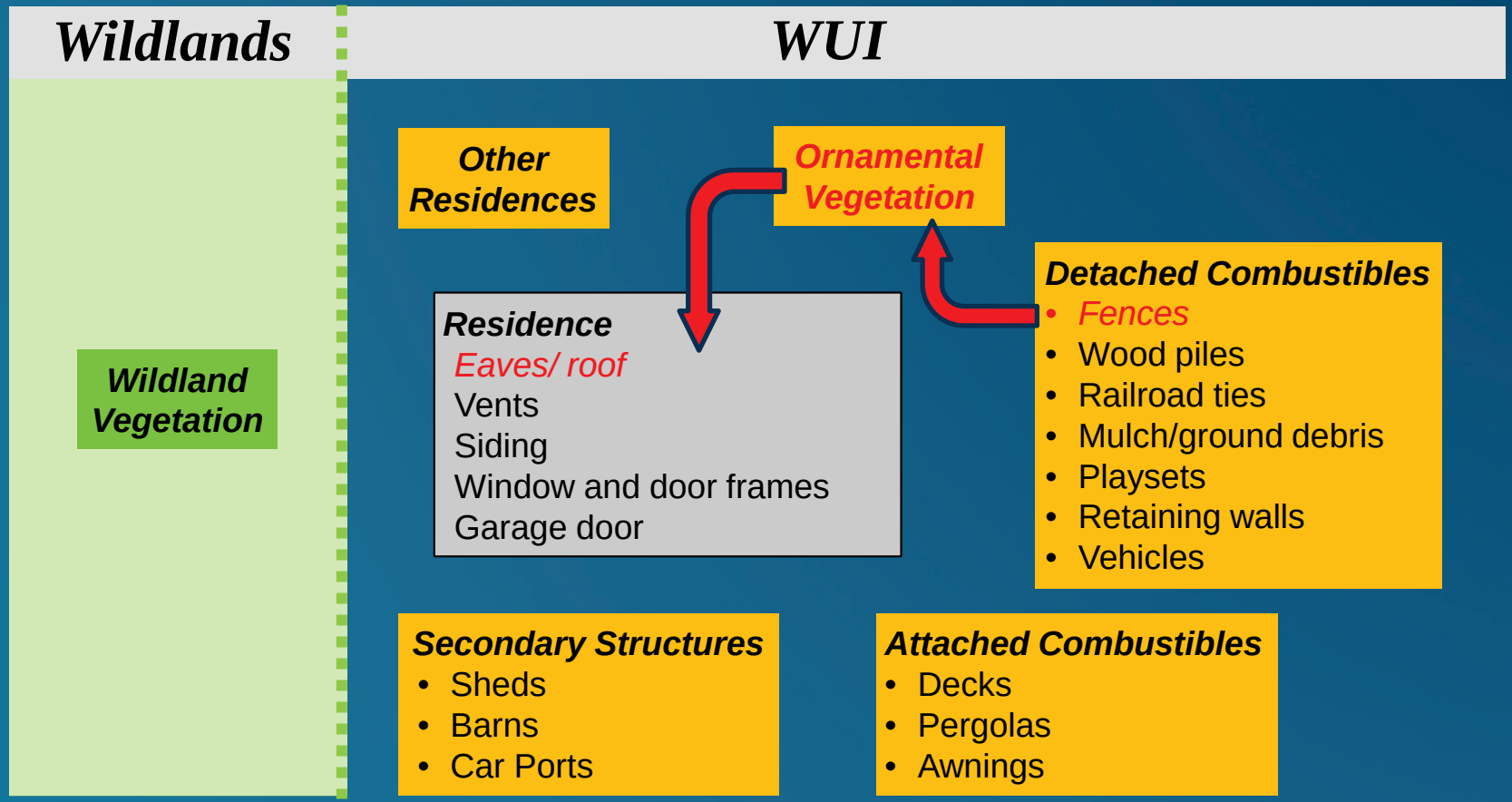
eaves / vents

Failure: multiple locations along eaves

Failure: eave at facia board

Failure: eaves/roof truss near eave vent

Structure Ignition, Example 1



NIST Camp Fire Report #3, Figure 54.

Structure Ignition, Example 1

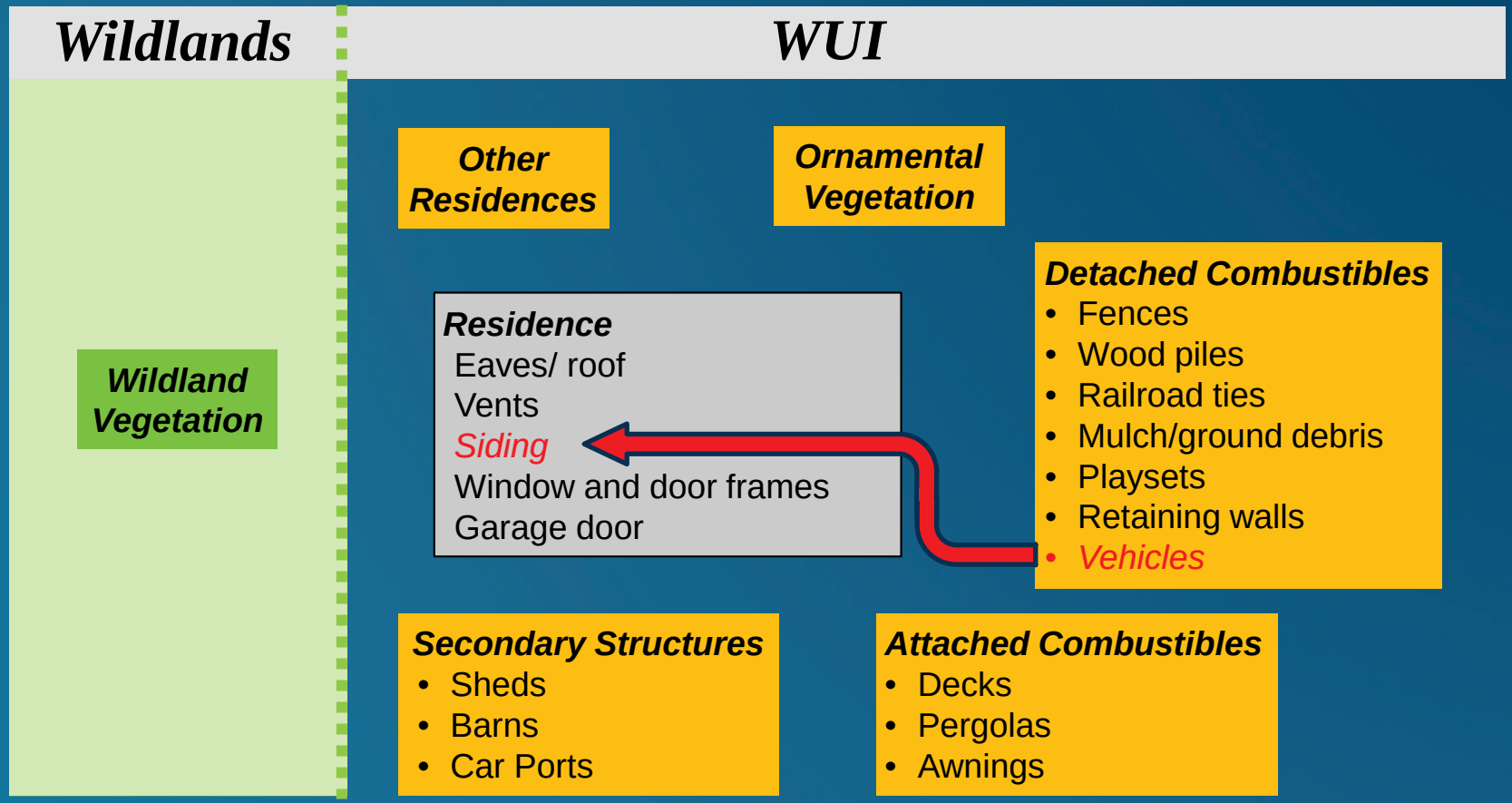
a) t = 0 s

b) t = 139 s

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

NIST Camp Fire Report #3, Figure 53.

Structure Ignition, Example 2



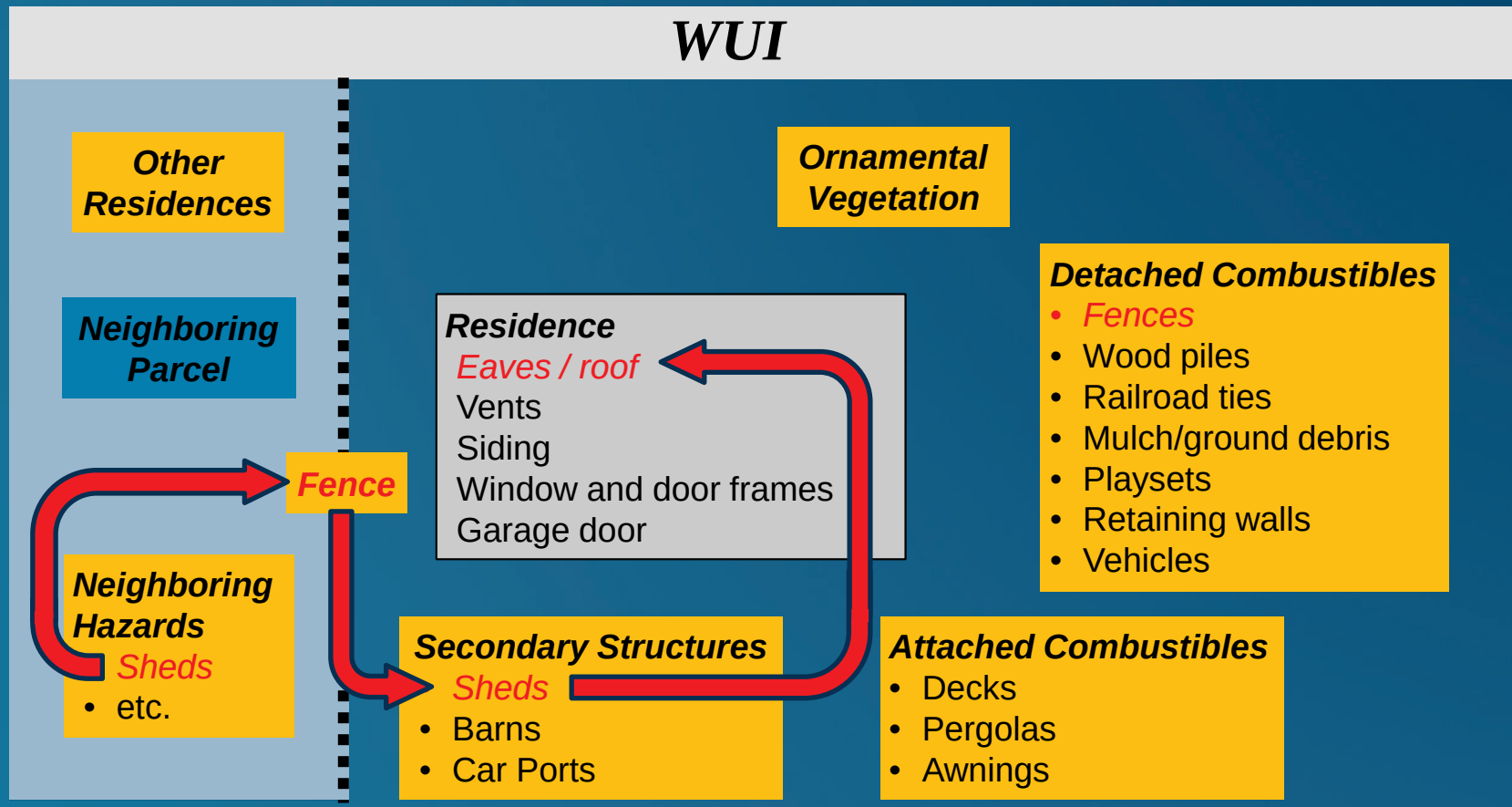
Structure Ignition, Example 2

a) A dozer displaced the vehicle to stop fire spread

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

NIST Camp Fire Report #3, Figure 52.

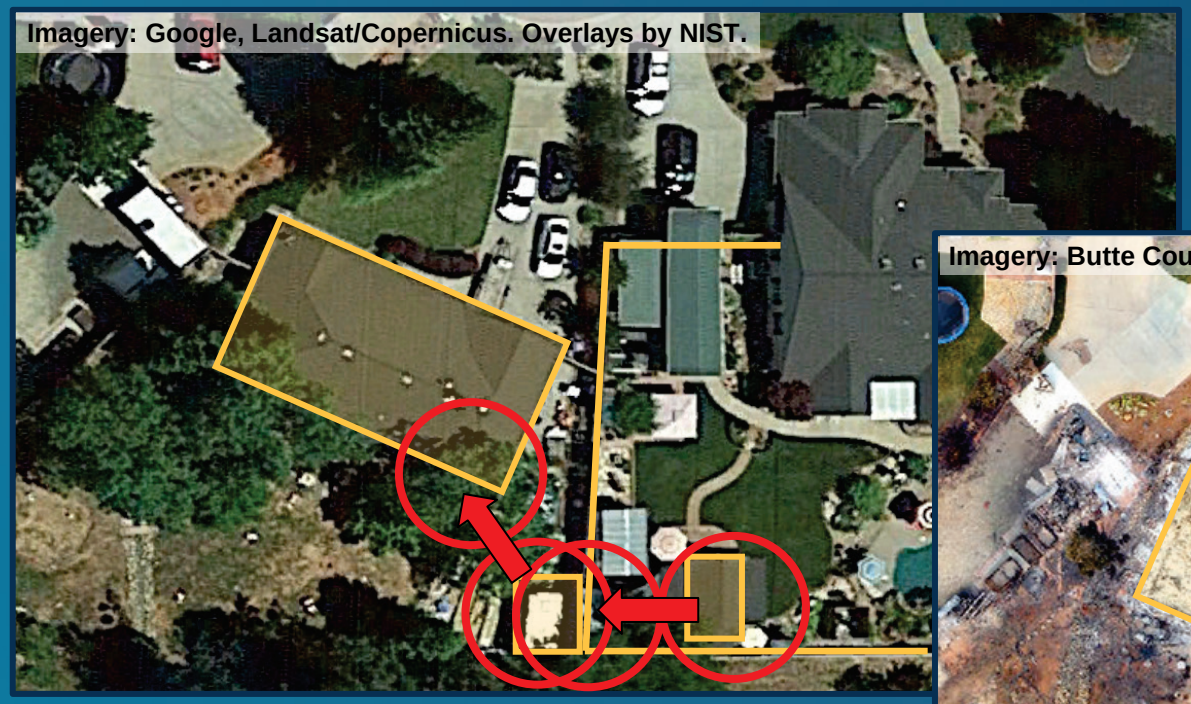
Structure Ignition, Example 3

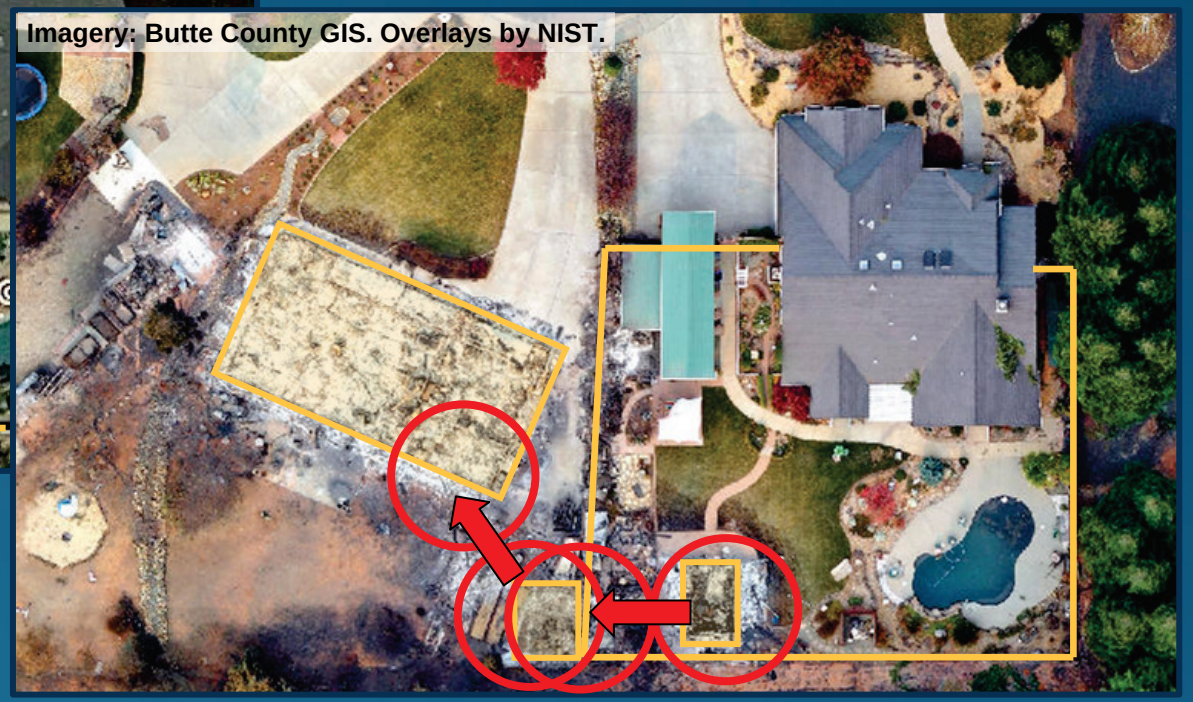


Structure Ignition, Example 3

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

Shed ignition leading to residence destruction





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

Residential Structure Ignition Pathways Identified by Direct Observation

	Data Source	Time of Obs.	Location[a]	Building Ignition Pathway	Source to Target Distance m	Source to Target Distance ft
Mulch / vegetation	TD-005	10:20	Canyon View Dr	Bark mulch to **wall** of house (OSB and vinyl)	unknown	
	TD-091	14:06	Neal Rd	Mulch to **garage**	unknown	
	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	
Detached combustibles	TD-015 TD-017 TD-064 PPD	14:37	Skyway	Fence to **wall** of building	2.4	8
	TD-044	22:30	Valley Ridge Dr	Woodpile to **house**	0.3–0.7	1–2
Structures	TD-060	11:06	Sweetbriar Ln	Structure ignition via radiation from neighboring structure on fire	11	35
	TD-100 TD-101	14:53	Pearson Rd	Commercial structure to commercial structure roof to **eave**	0.7	2
	TD-091	17:23	Sutter Rd	8 m × 4 m (26 ft × 13 ft) shed to house **eaves**	2.4	8

[a] **Location in Paradise unless noted.**

NIST Camp Fire Report #3, Table 35.

Residential Structure Ignition Pathways Identified by Direct Observation

	Data Source	Time of Obs.	Location[a]	Building Ignition Pathway	Source to Target Distance m	Source to Target Distance ft
Vehicles	TD-091	14:06	Lewis Ranch Rd	Burning car to side of **house**	1.5–2.4	5–8
	TD-205	20:12	Clark Rd	Boat on fire to **eaves** of house	2.5	8
Multiple hazards	TD-045	09:10	Chris Ct	Shed to fence to shed to **house**[b]	2.7	9
	TD-092	13:52	Neal Rd	Burning car to shed to **house**	unknown	
	TD-044	19:00	Valley Ridge Dr	Fence to boat to **house**	2.7–3.6	9–12
	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.

General Fire Behavior

Summary:

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

Implementation:

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

Introduction and Previous Case Studies
Camp Fire Overview
NIST Camp Fire Case Study
Pre-Fire Conditions
Fire Progression
Burnovers
General Fire Behavior
Primary Driving Factors
Technical Findings
Recommendations

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.

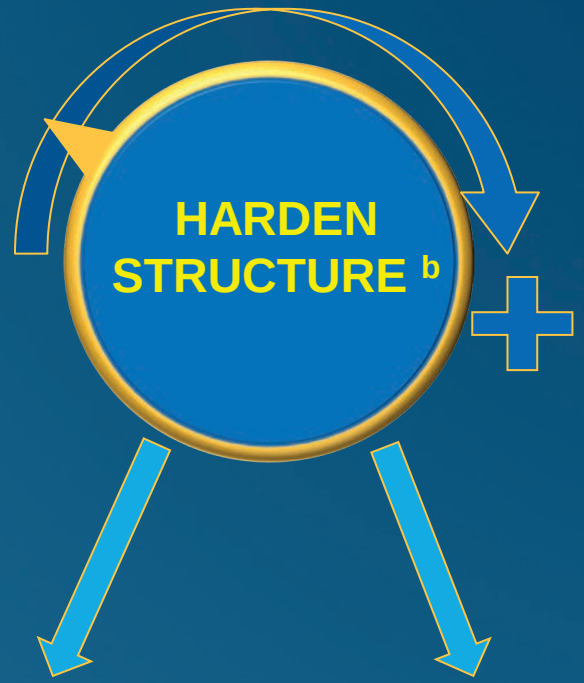
Density of Vegetative and Structural Fuels

- 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

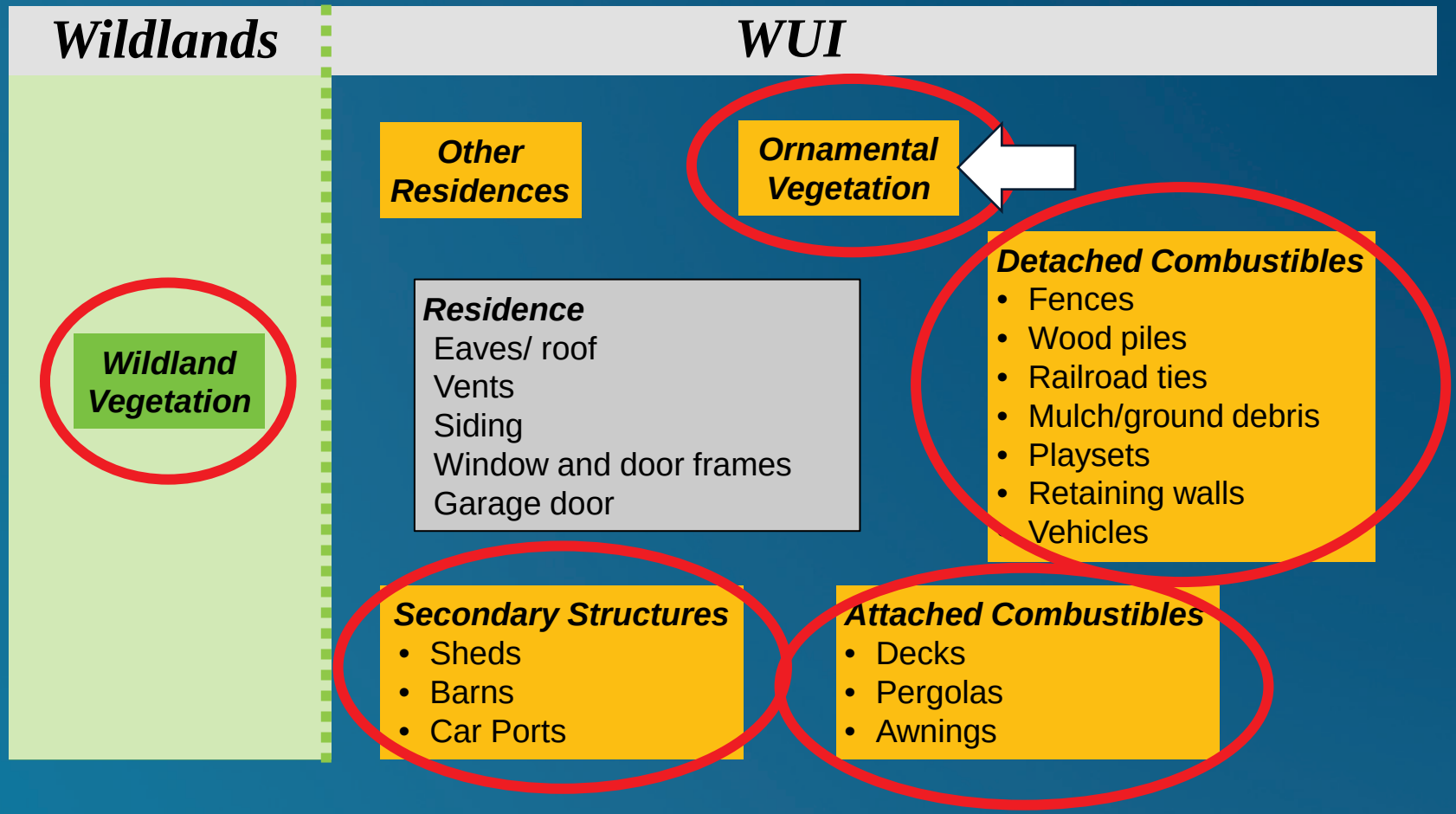
Community Design

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.

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.

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

Photo by NIST (June 24, 2019).

Thinning and mastication fuel treatment and reduction conducted pre-fire

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

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.

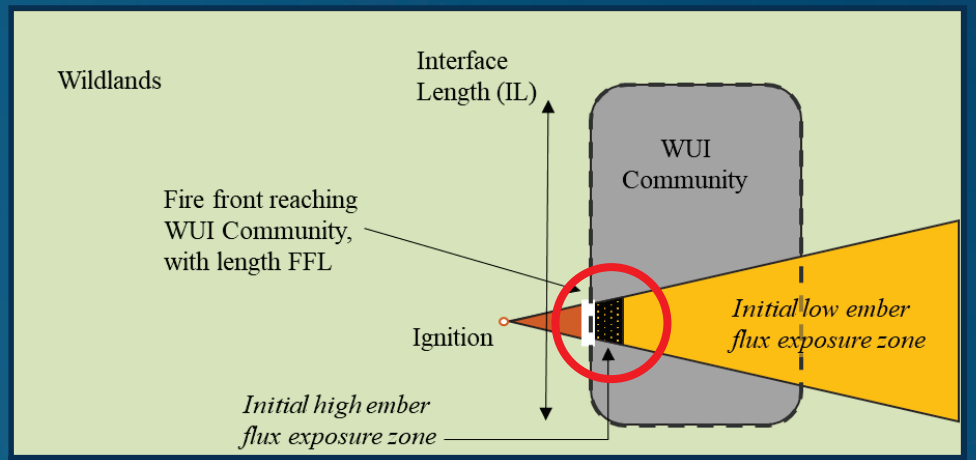
** Wind was not extreme throughout the event (temporally and spatially)*

Extent/Size of Fire Front Reaching the Communities

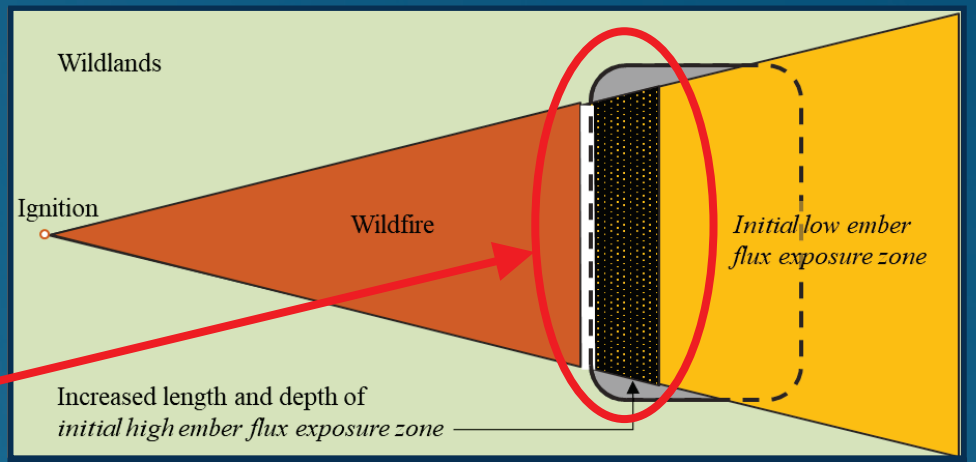
Idealized relationship between ignition location, near or far from WUI Community, and fire front and ember exposures reaching the community.

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.

Primary Driving Factors Summary

Summary:

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

Implementation:

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

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

BURNOVERS

PARCEL LEVEL EXPOSURES

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)*

Contributors – Technical Discussions

THANK YOU!

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

151 Technical Discussions

100 Fire Department

19 Law Enforcement

15 Town of Paradise

13 Transportation

2 Water Districts

1 Emergency Medical Services

1 National Weather Service

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