A Case Study of the Camp Fire –

Notification, Evacuation, Traffic, and Temporary Refuge Areas (NETTRA)

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U.S. DEPARTMENT OF COMMERCE

Photo courtesy of Paradise Police Department

Module 1: Camp Fire Introduction and Pre-Fire Conditions and Planning for Notification and Evacuation


Photo courtesy of CAL FIRE

NIST WUI DAYS 2023 – Session 1.4

November 1, 2023

Alexander Maranghides
Eric Link
National Institute of Standards and Technology

192 Contributors — THANK YOU!

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U.S. DEPARTMENT OF COMMERCE

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

Why The Camp Fire?

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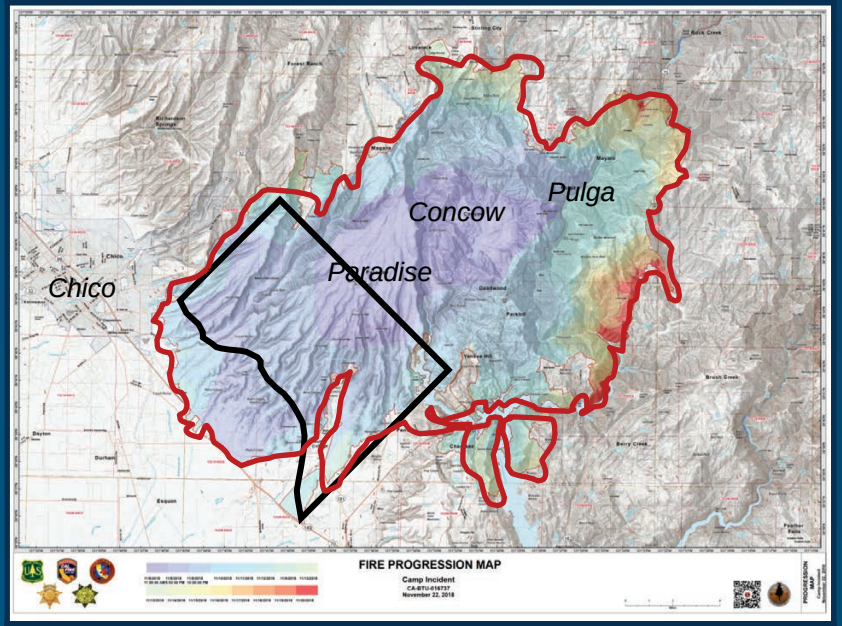
- Intermix Fire with:
  - extreme fire behavior
  - size and losses and
  - evacuation of entire town
- Data-rich scene
- NIST technical partnerships in place
- Fully integrated with local officials (CALFIRE)
- Representative of many other similar communities

Camp Fire ~ 14 % Butte County area



Camp Fire ~ 4× Washington, D.C. area

Camp Fire Overview Statistics

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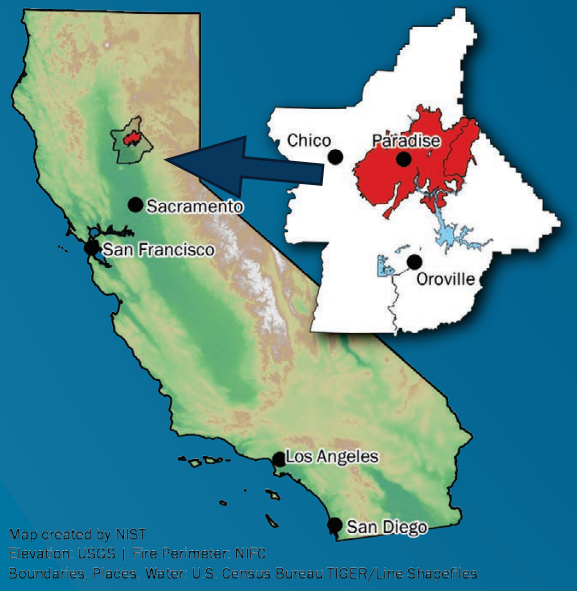
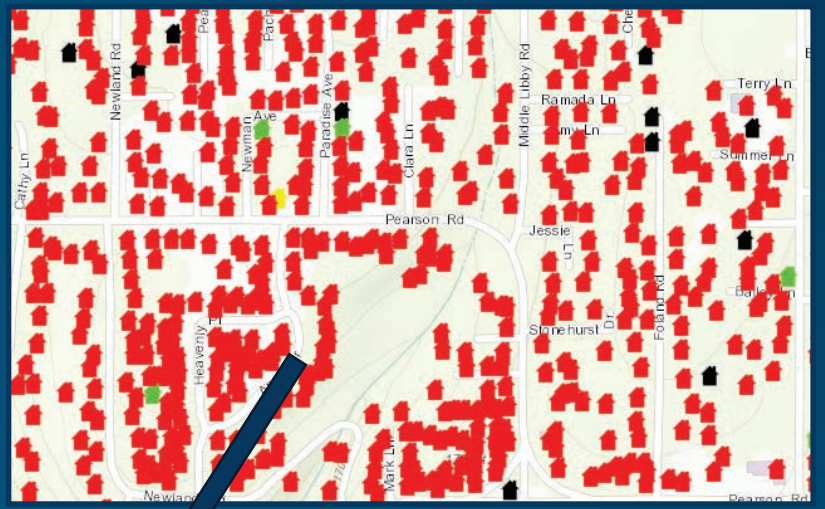
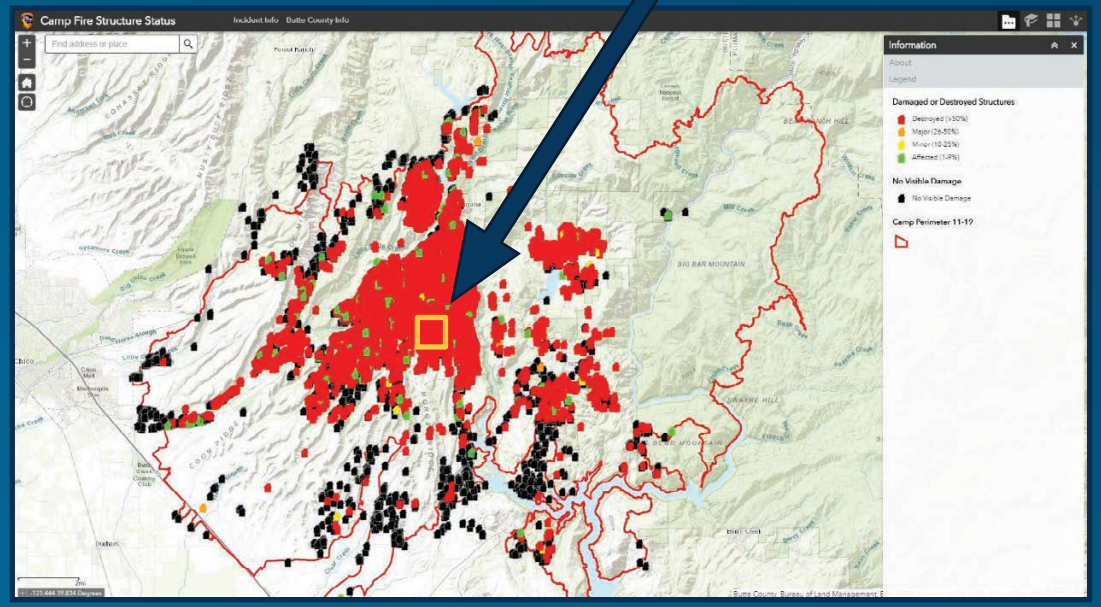
- *Size:* 153 336 acres
- *Start:* Nov 8, 2018, ~6:30 am
- *Dates:* Nov 8–25, 2018 (18 days)
- *Structures Damaged/Destroyed:* 19 531
- *Population Displaced:* over 50 000
- *Fatalities:* 85
- *Persons Located:* 3266







The NIST Camp Fire Case Study

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- ✓ Report #1: Camp Fire Preliminary Reconnaissance (TN 2105)
- ✓ Report #2: Preliminary Data Collected from the Camp Fire Reconnaissance (TN 2128)
- ➡ ***Report #3: Fire Progression Timeline*** (TN 2135)
- ➡ ***Report #4: Notification, Evacuation, Temporary Refuge Areas, and Burnovers*** (TN 2252 & TN 2252sup)
- ✓ ESCAPE: WUI Fire Evacuation and Sheltering Considerations—Assessment, Planning, and Execution (TN 2262)
- Report #5: Emergency Response and Defensive Actions
- Data Visualization Tool

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

Intro and Previous Case Studies

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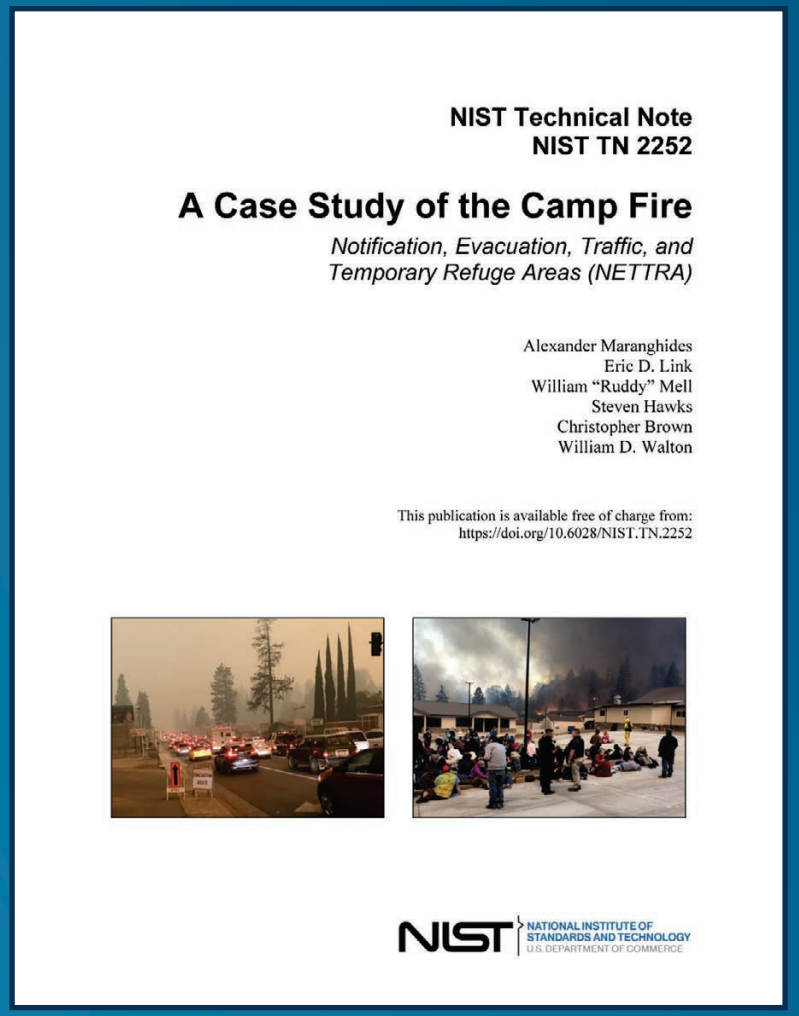
Summary of Findings:

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

Key Takeaways:

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

NETTRA Case Study Overview



NIST Technical Note
NIST TN 2252

A Case Study of the Camp Fire

Notification, Evacuation, Traffic, and Temporary Refuge Areas (NETTRA)

Alexander Maranghides
Eric D. Link
William "Ruddy" Mell
Steven Hawks
Christopher Brown
William D. Walton

This publication is available free of charge from:
https://doi.org/10.6028/NIST.TN.2252

Module 1: Introduction and Pre-Fire Conditions and Planning for Notification and Evacuation

Module 2: Notification Timeline, Evacuations, Traffic Flow and Road Closures

Module 3: Burnovers and TRAs

Module 4: Rescues

Module 5: NETTRA Summary

Module 1 Presentation Themes

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Module 1a: Camp Fire Introduction and Fire Spread

- Intermix community with limited fire history
- Rapid fire spread to and within Paradise
  - Impact on life safety, response and losses

Module 1b: Pre-Fire Conditions and Planning for Notification and Evacuation

- Fully-developed notification and evacuation plan
- Comprehensive training exercise before fire
- Communication
- Road network and egress characteristics

Module 1a

Camp Fire Introduction and Fire Spread

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

Pre-Fire Conditions

wind + drought + topography + fire history

Butte County Fire Hazard Severity

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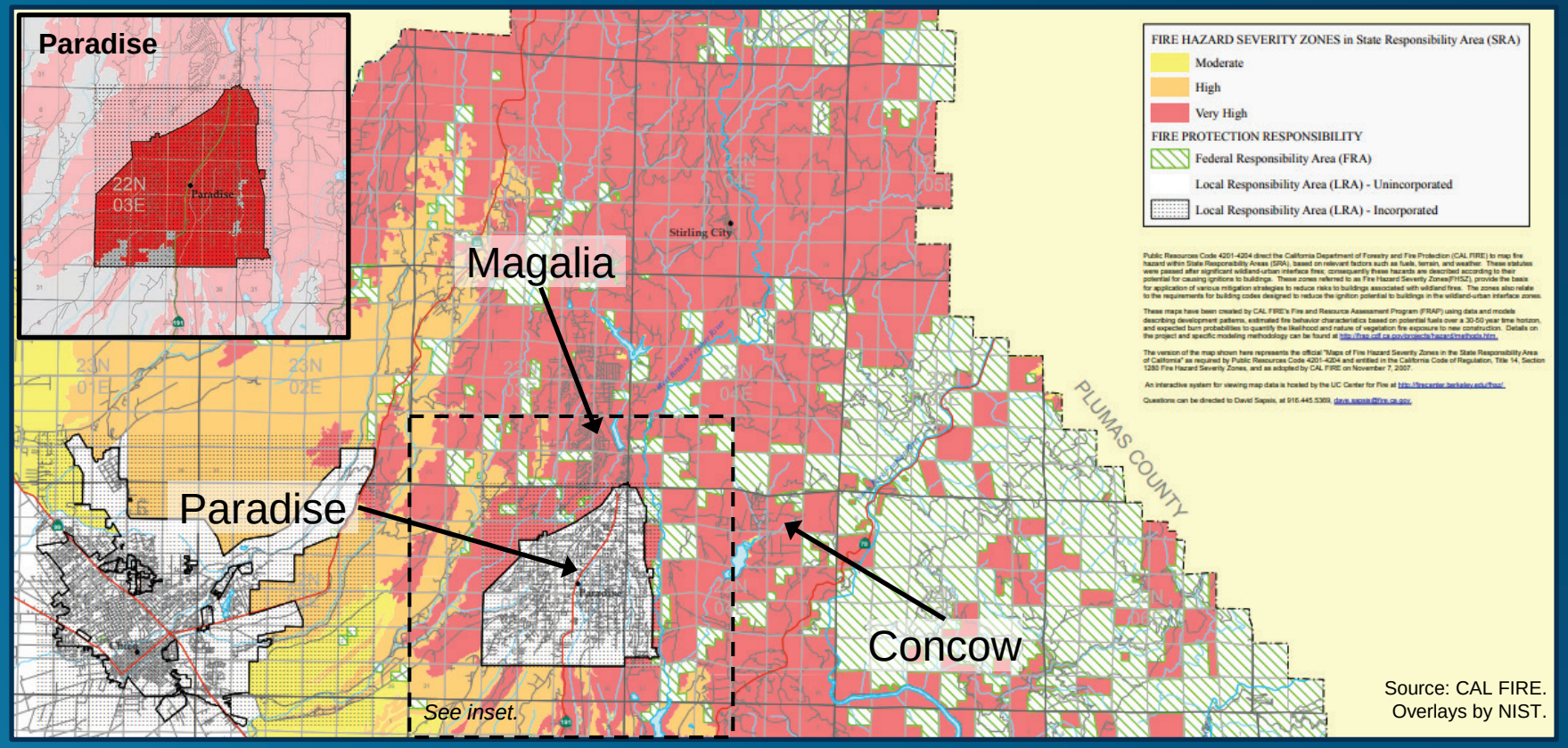
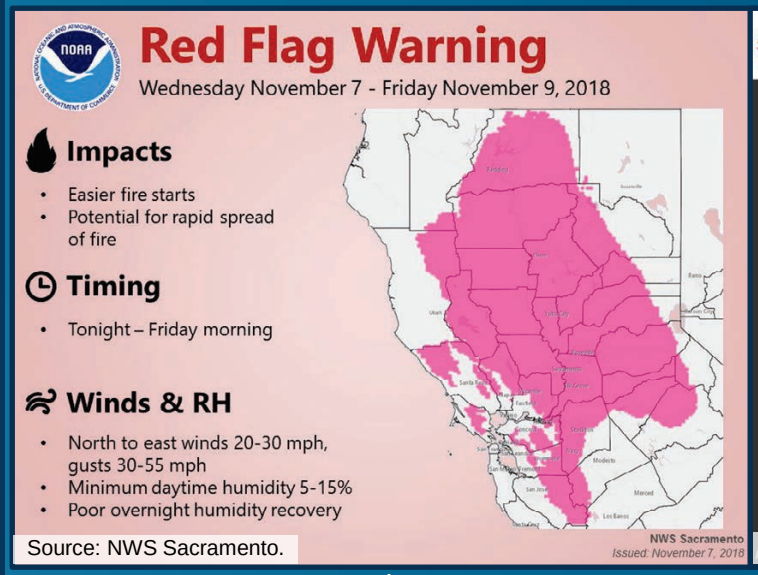


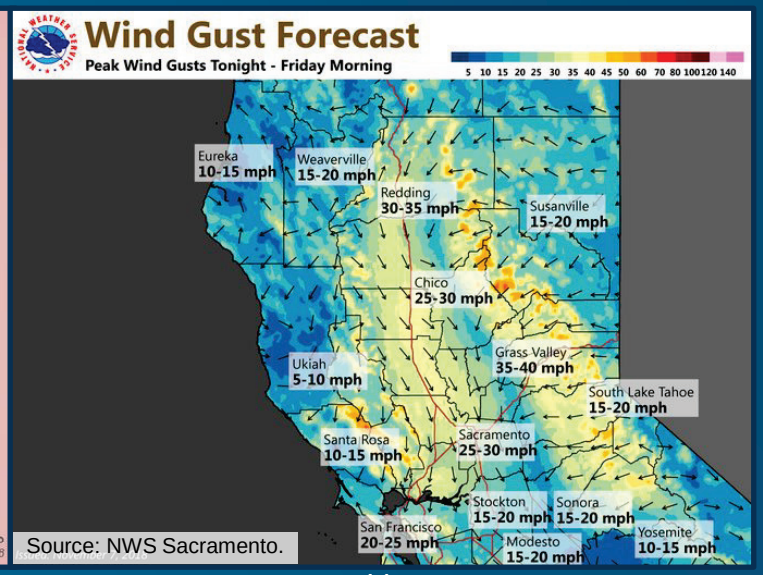
Majority of area Very High Fire Hazard Severity Zone

NIST TN 2135, Figure 3.

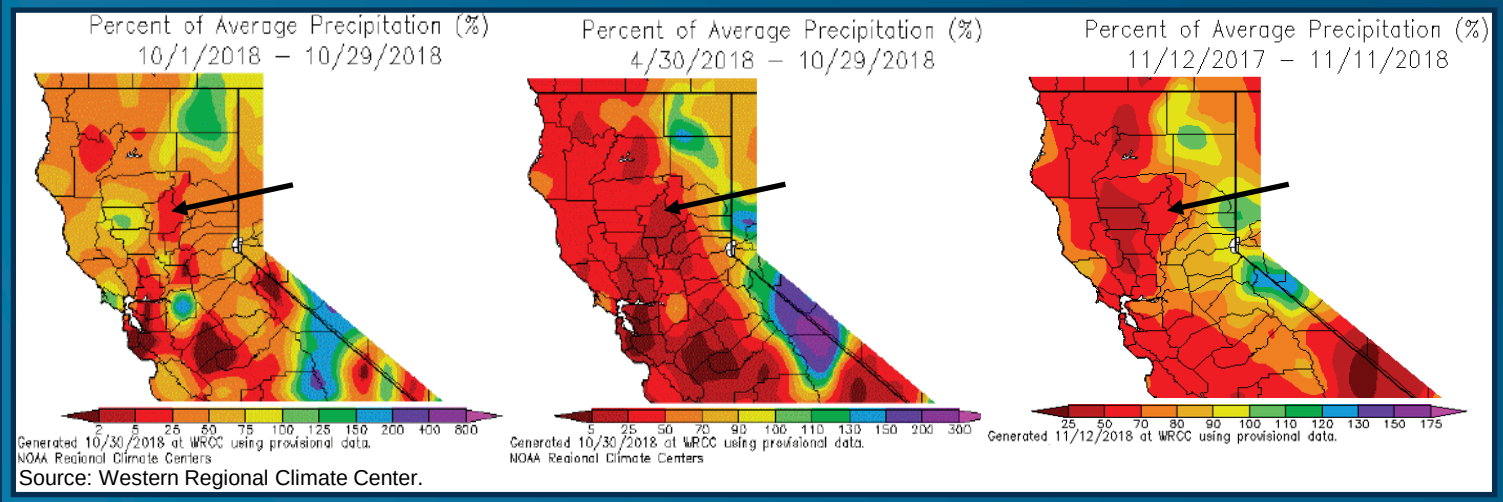
Red Flag Warning and Drought



a)



b)

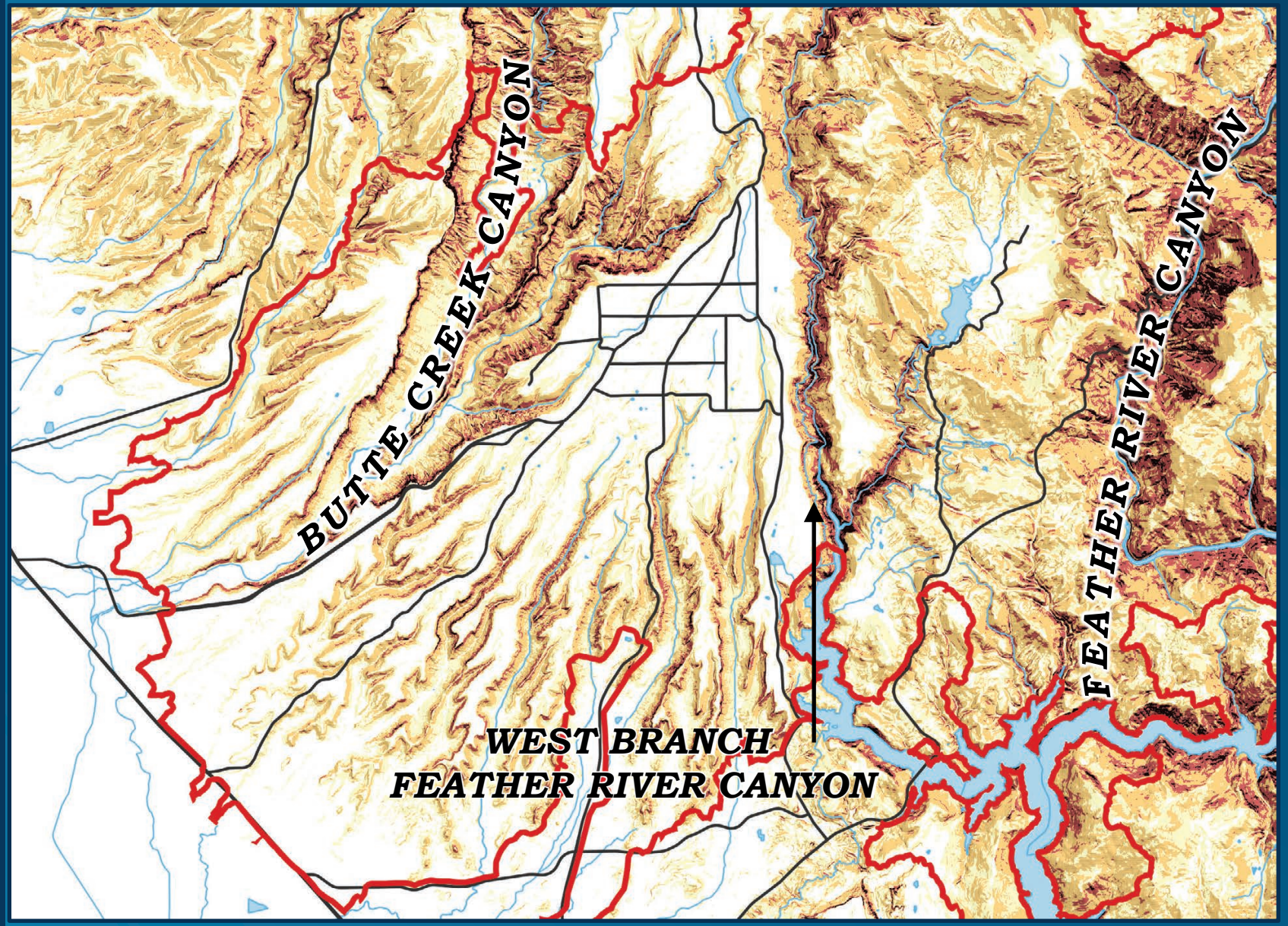


a) 1-month b) 6-month c) 1-year

- 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 TN 2135, Figure 7.

Topography



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

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

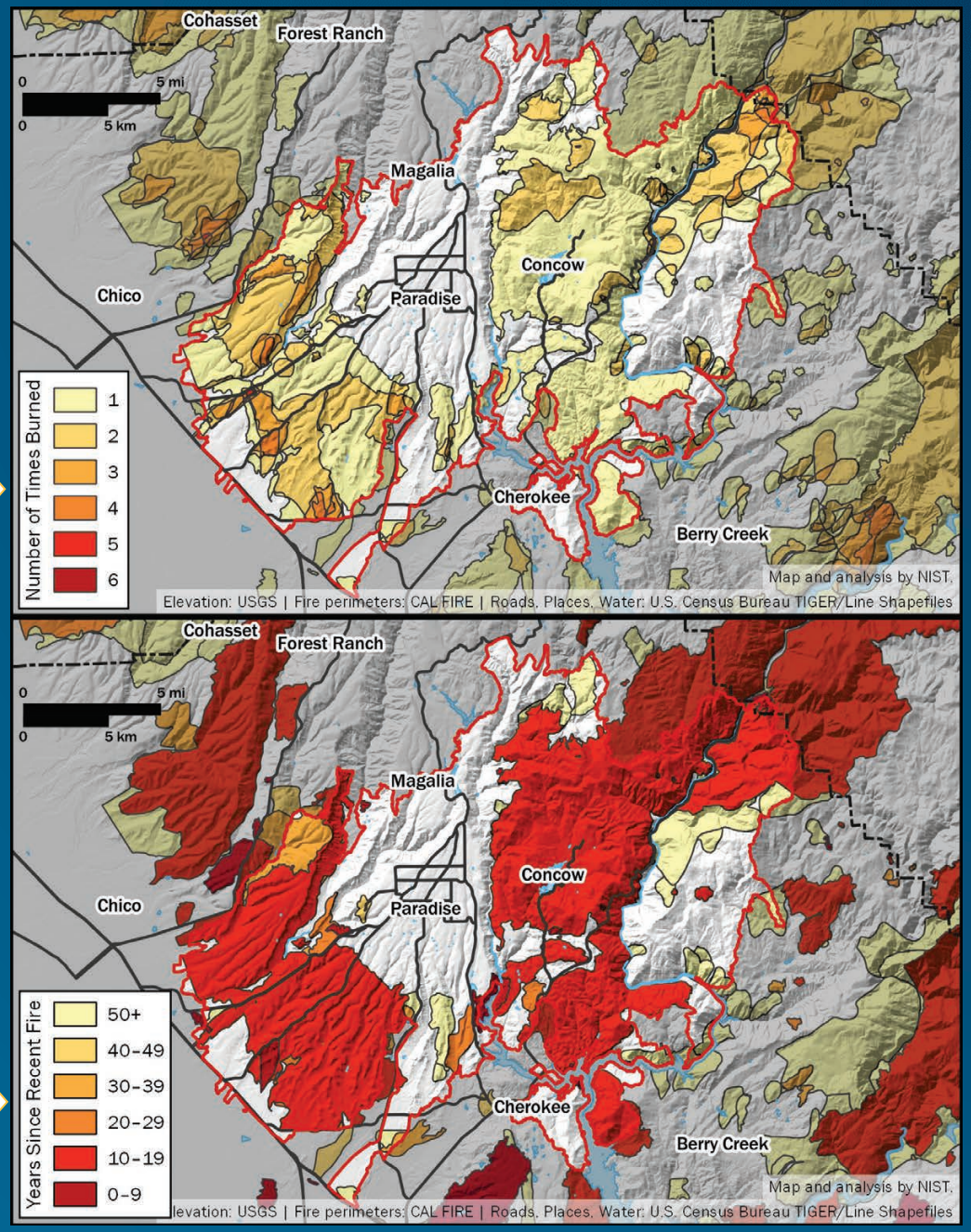
Fire History

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

Number of times each area has burned.

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

Number of years since the last fire.



NIST TN 2135, Figure 10.

Pre-fire Conditions

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Summary:

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

Implementation:

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

Fire Progression

wind conditions | timeline | maps

Early Fire Spread Conditions 07:30

Video courtesy of TD-028, 07:23.
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Composite image by NIST.

Photo courtesy of TD-143, 07:29.
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Video courtesy of TD-005, 07:32.
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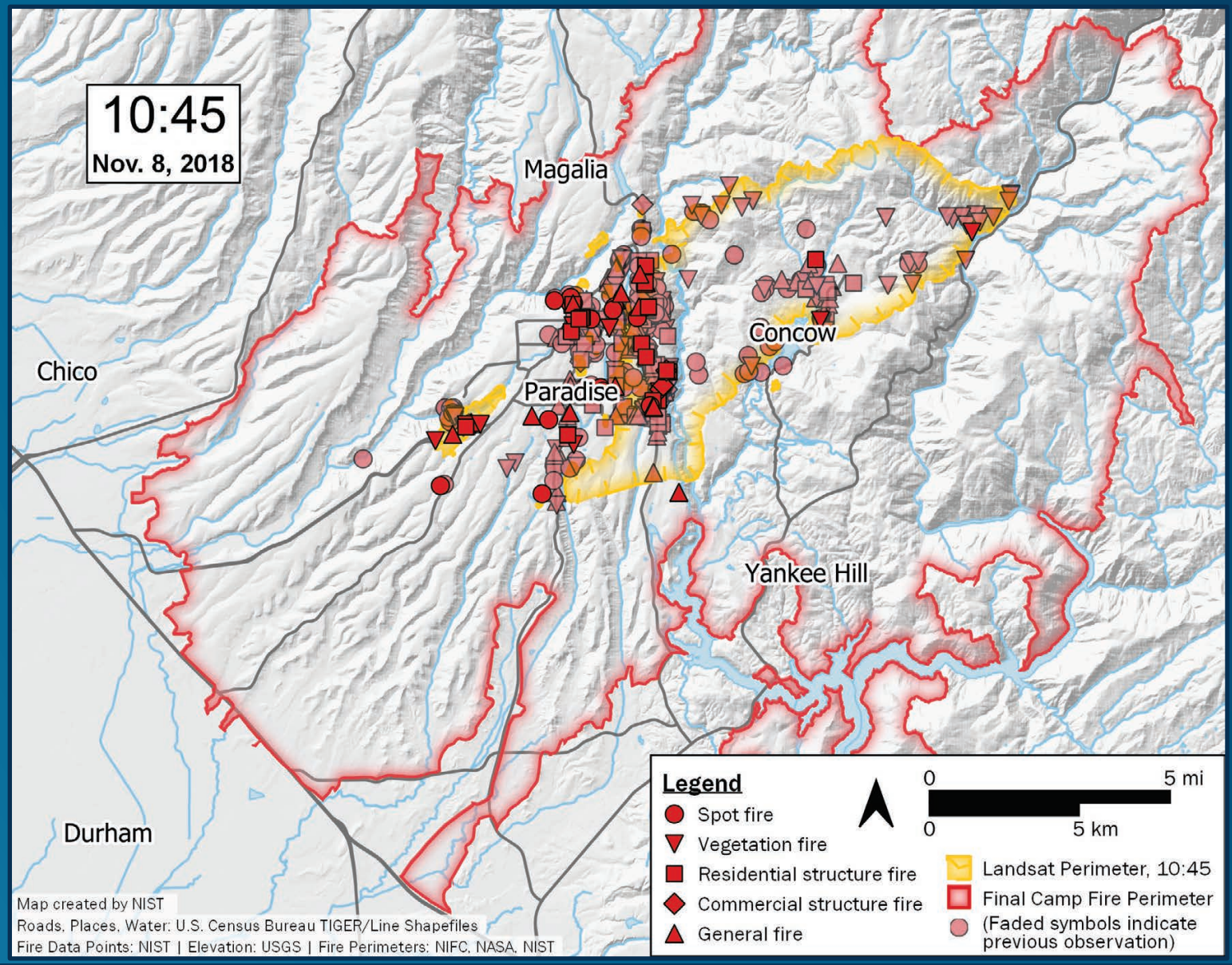
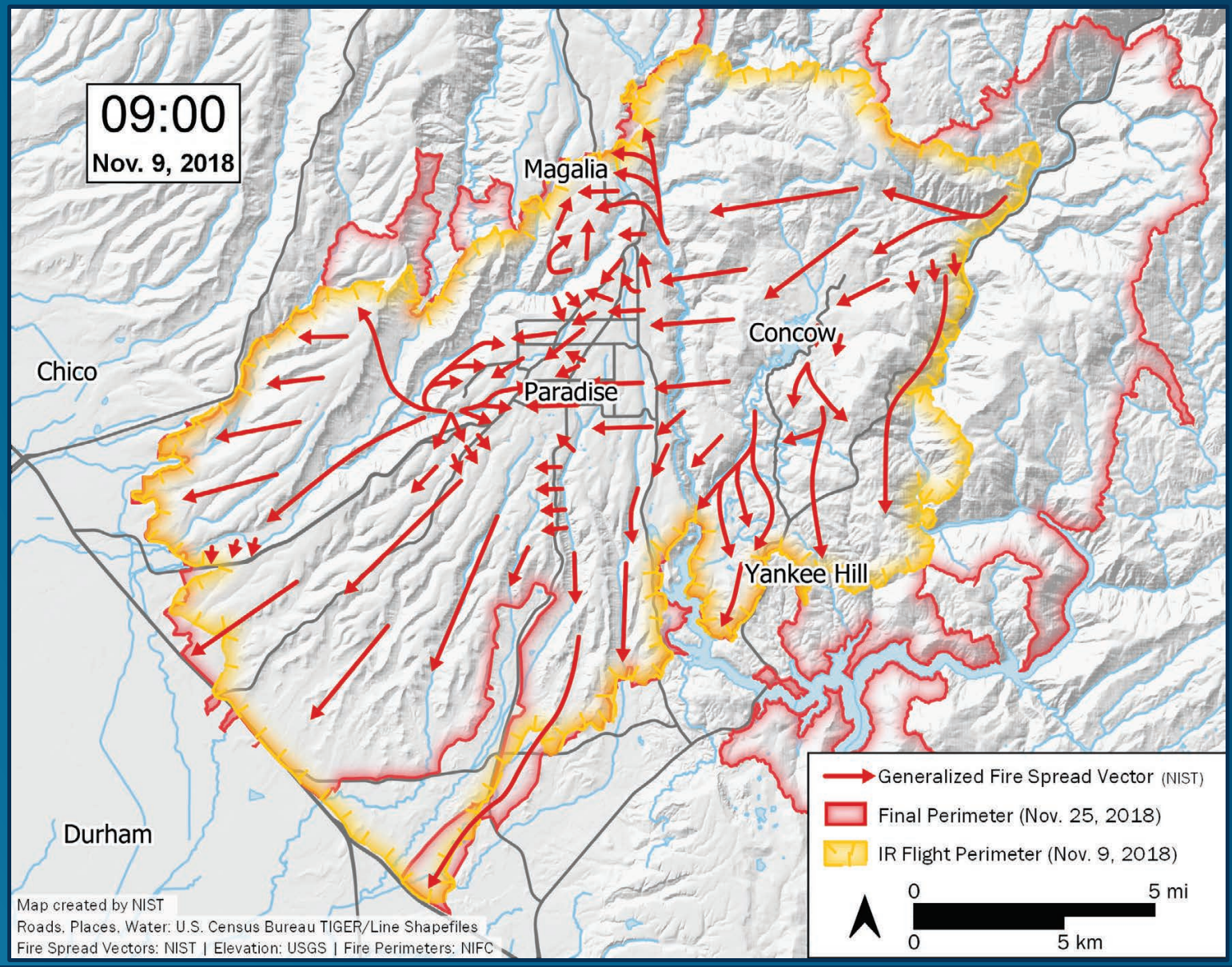
NIST TN 2135, Figure 25.

Fire Progression Summary (by 10:45)



Fire Progression Summary (Day 1)



NIST TN 2135, Figure 22.

Early Spot Fires in Paradise

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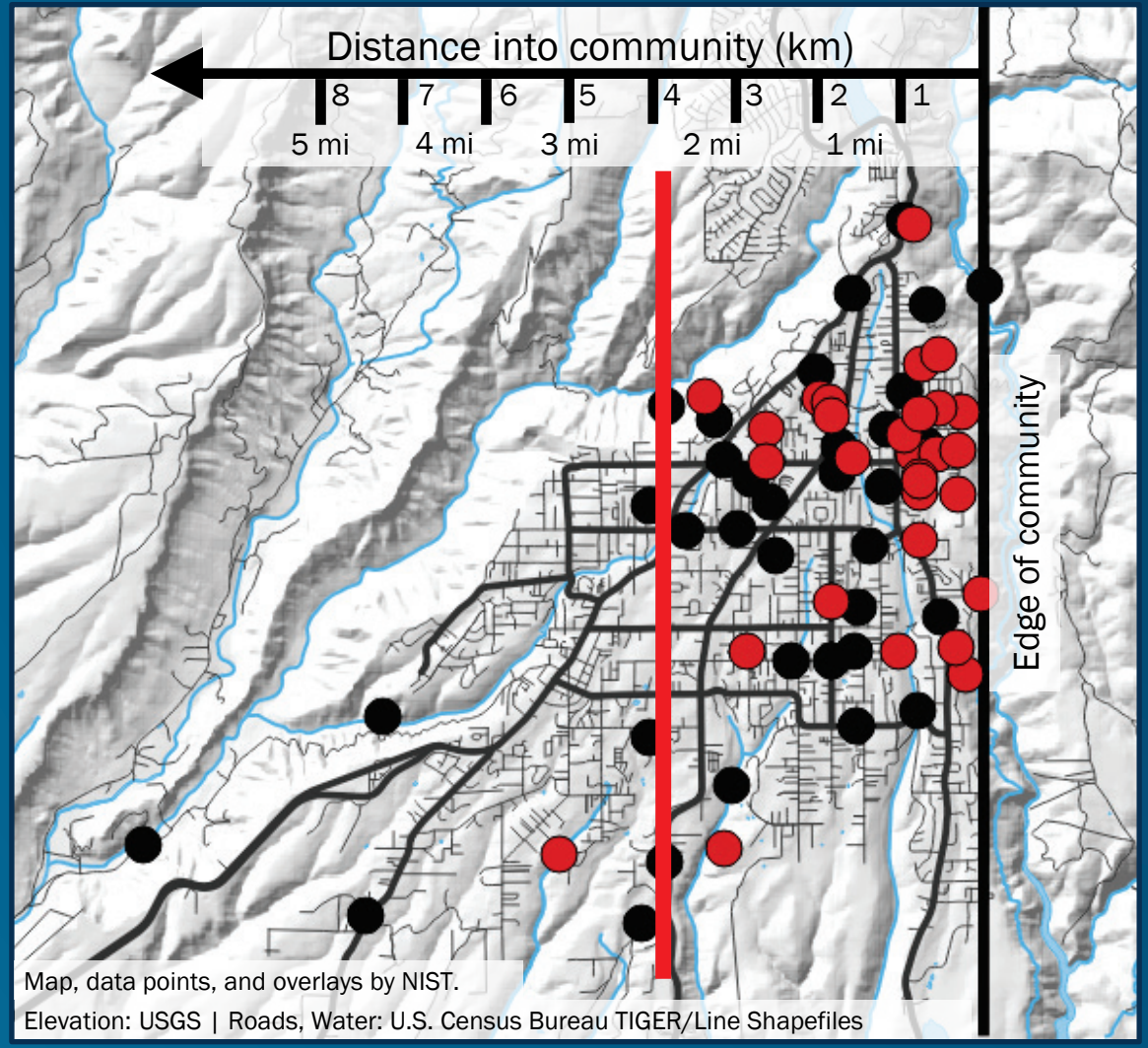
Spot Fire Ignitions

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



1 second animation = 5 minutes real time

30 identified spot fires within first 40 minutes (red)

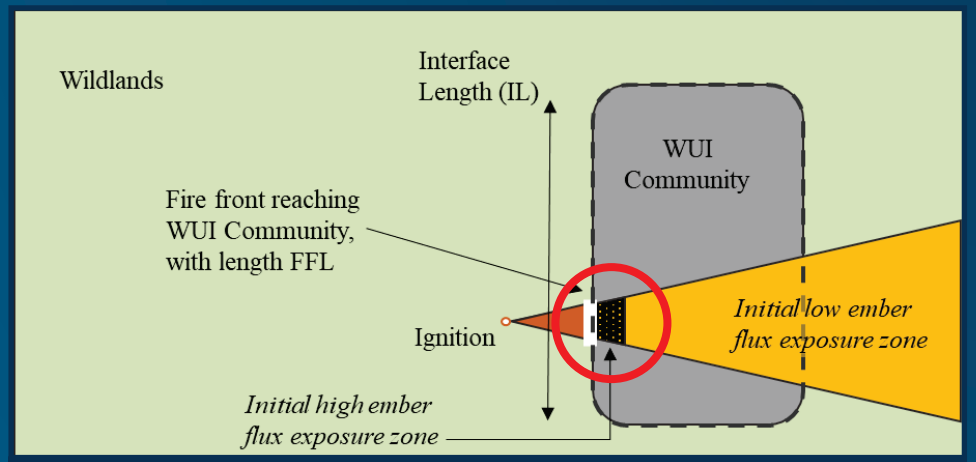
NIST 2135, Figure 51.

Extent/Size of Fire Front Reaching the Communities

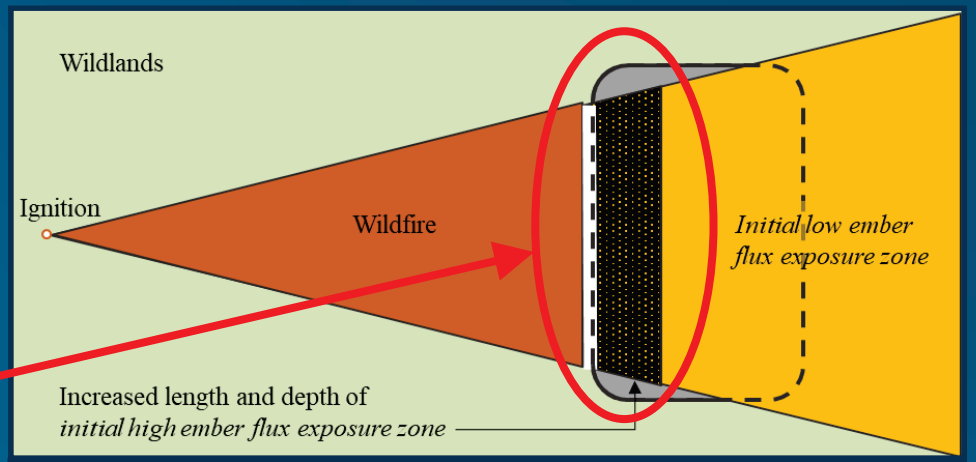
Idealized relationship between ignition location, near or far from WUI Community, and fire front and ember exposures reaching the community.

The wind is directed from left to right.

Critical difference in community-scale exposure



Ignition near WUI community



Ignition far from WUI community

NIST TN 2135, Figure 57.

Fire Progression

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Summary:

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

Module 1b

Pre-Fire Conditions and Planning for Notification and Evacuation

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Camp Fire Study Overview

Camp 3 (Fire Progression) to Camp 4 (NETTRA)

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- Fire location and behavior provide the technical foundation for developing the notification and evacuations components of the case study
- To understand incident notification and evacuation we need to characterize the systems and processes that were in place before the fire

NETTRA Research Questions

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a) What were the design parameters of the Paradise evacuation plan? ***(Sec. 5)***

b) What were the roads and access characteristics of Concow, Paradise, and Magalia? (***Sec. 4)***

c) How was the notification of civilians in Concow, Paradise, and Magalia achieved? ***(Sec. 6)***

d) When were evacuation notifications and orders issued, and how does this timing relate to fire progression? ***(Sec. 6.2 and 6.3)***

e) How did fire impact evacuations of Concow, Paradise, and Magalia? ***(Sec. 7.5, 8, and 9)***

NETTRA Research Questions

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U.S. DEPARTMENT OF COMMERCE

f) What were the primary factors that impacted traffic flow during evacuation? ***(Sec. 7.5, 8, and 9)***

g) How did the use of wildfire safety zones and the creation of TRAs impact civilian life safety and how many civilians utilized TRAs? ***(Sec. 9)***

h) When were TRAs formed and what were the physical characteristics of the TRAs used? ***(Sec. 9 and Appendix I)***

i) What were the attributes of the rescues performed and how many civilians were rescued? ***(Sec. 10)***

Methodology and Data

approach* | *uncertainties* | *statistics

Methodology and Uncertainties

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Temporal and Spatial Integration of Data

- 2664 NETTRA data points
- geolocated and timestamped
- cross-referenced
- quality control review

Table 2. Uncertainty ranges of various data sources.

Data Source	Data Attributes	Temporal Uncertainty	Spatial Uncertainty
Picture/video	Geolocated Timestamped	±1 min	±5 m
AVL position	Geolocated Timestamped	±1 min	±10 m
Radio log (fire or PPD)	Variable location Timestamped	±1 min – Variable	±0 m – Variable
Picture/video	Geolocated No timestamp	±1 min – Variable	±5 m
TD observation	Location estimated Time estimated	Variable	Variable
TD Inferred time	Time estimated	Variable	n/a
DINS post-fire damage pictures	Geolocated	n/a[a]	Linked to structure
NIST post-fire pictures	Geolocated Timestamped	n/a	±5 m
Drone and satellite imagery	Geolocated	n/a	±(1 m to 100 m)[b]

Note: Values provided are Type B uncertainties as defined in NIST Technical Note 1297 [33].
[a] Data without temporal information (such as DINS, drone, and NIST post fire images) were used as supplemental information to cross-reference and confirm events in time.
[b] For a limited area on the west edge of fire east of Chico, there was an imagery "stitching" offset.

NIST TN 2252, Table 2.

Methodology Example

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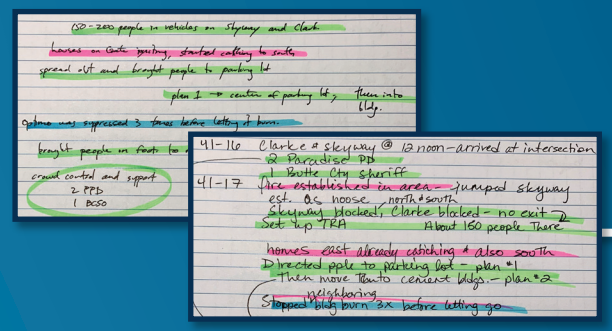


Data Coding

Fire
Notification
Evacuation
Traffic
TRAs
Rescues
Defensive Actions

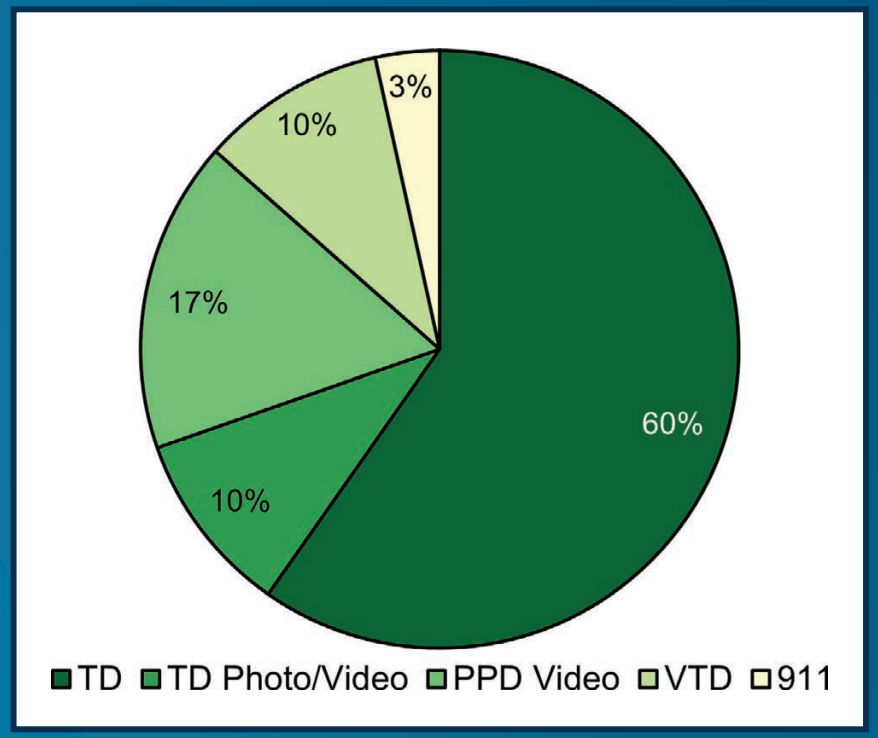
Integration and Quality Control

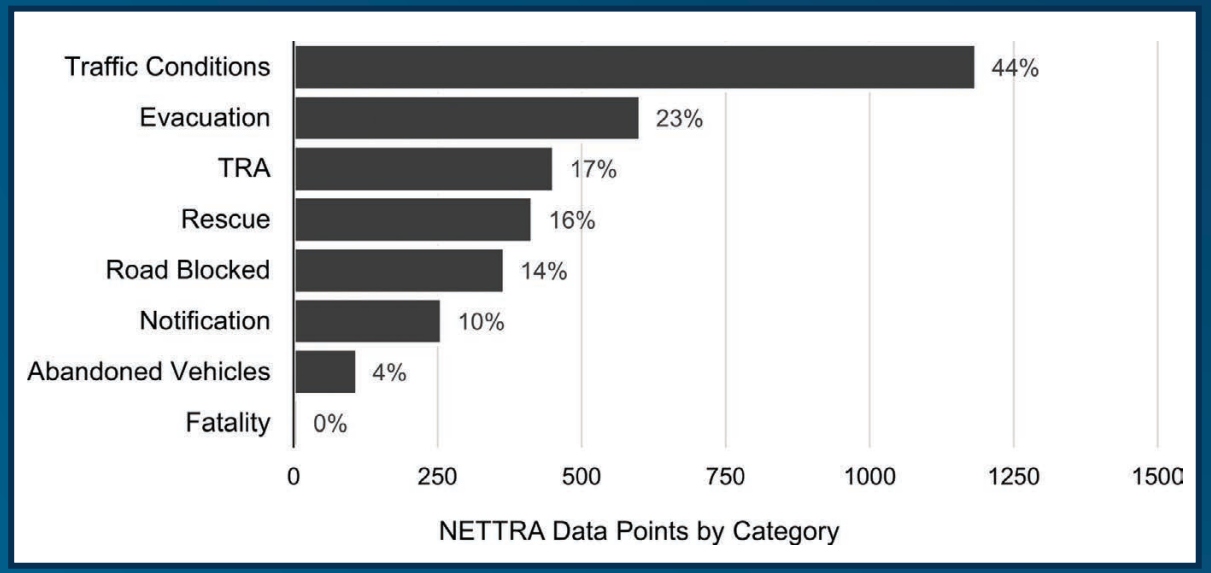
Database

Optimo TRA

AVL
911 Log
Radio Log
Photo Time, Location

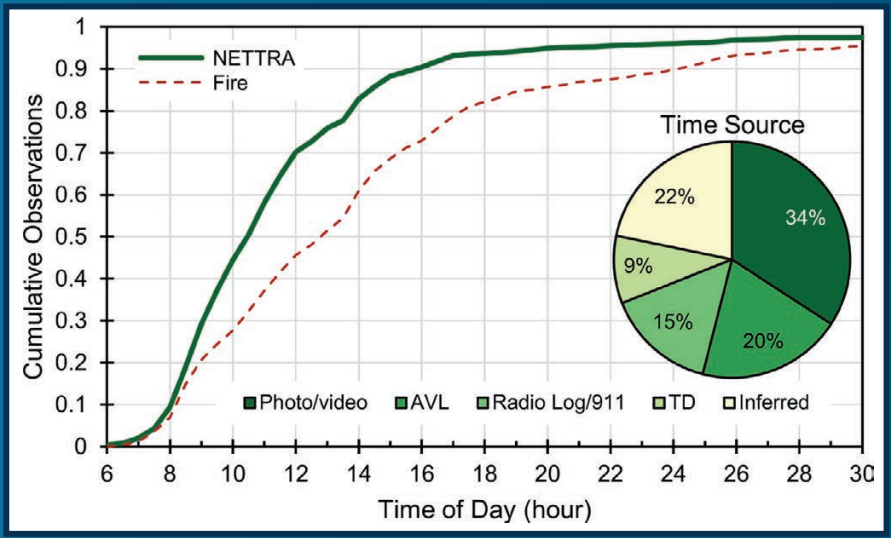
Data Sources and Categories

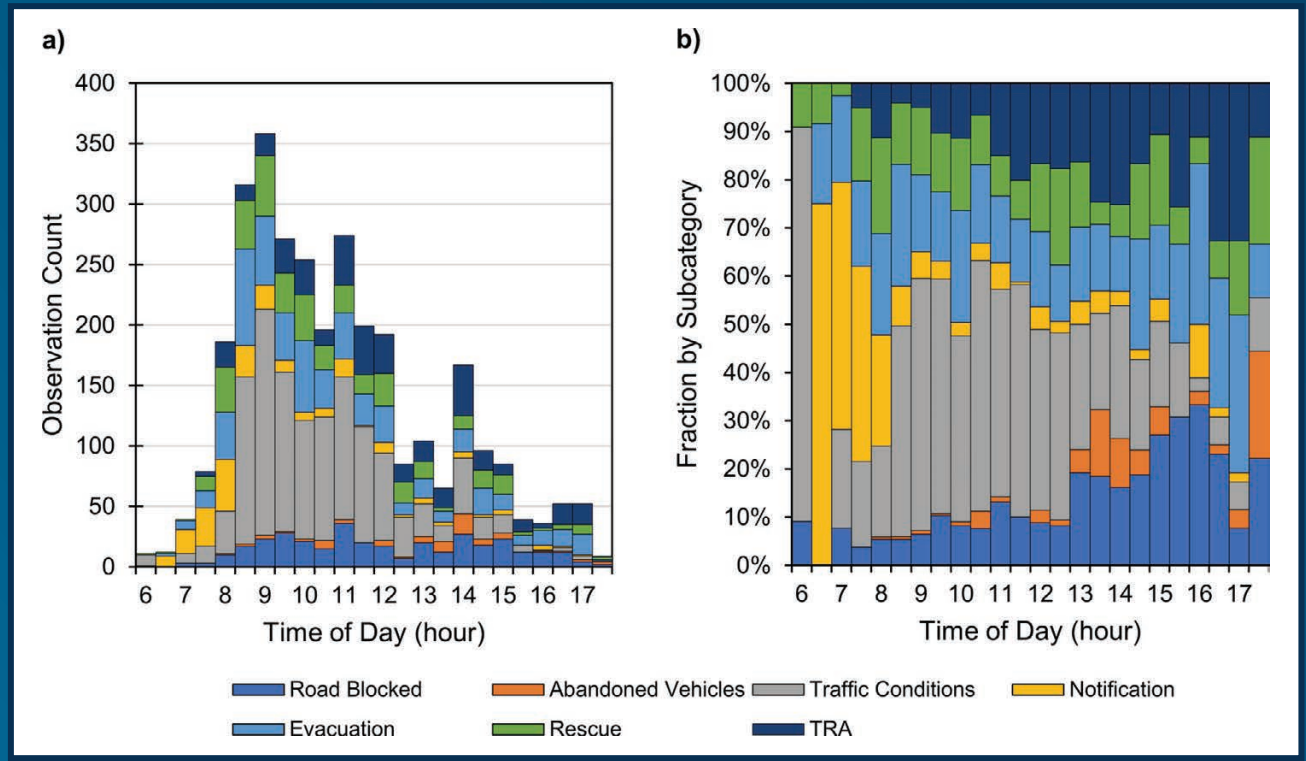




NIST TN 2252, Figure 3 and Figure 4.

NETTRA Data Over Time



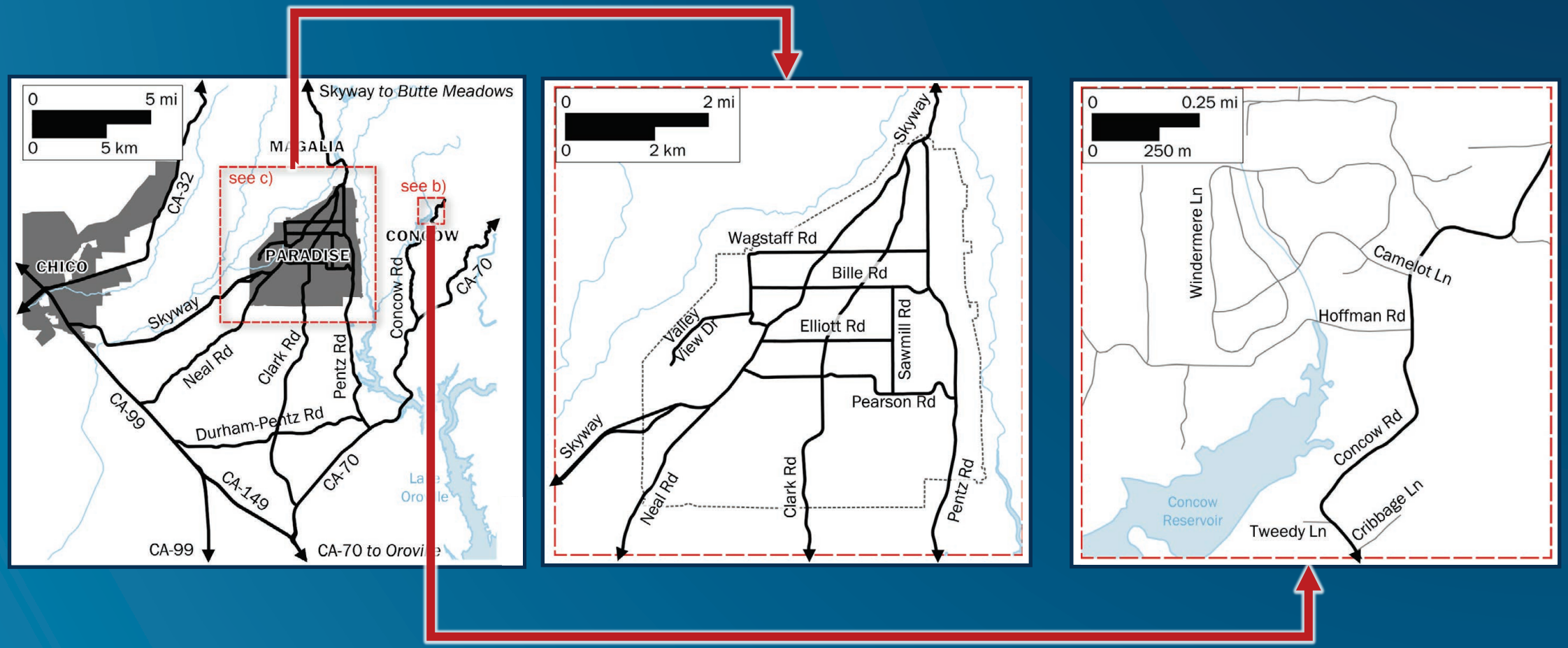


NIST TN 2252, Figure 5 and Figure 6.

Road Network and Egress Characteristics

routes* | *capacity* | *population

Road System in and Around Paradise



NIST TN 2252, Figure 7.

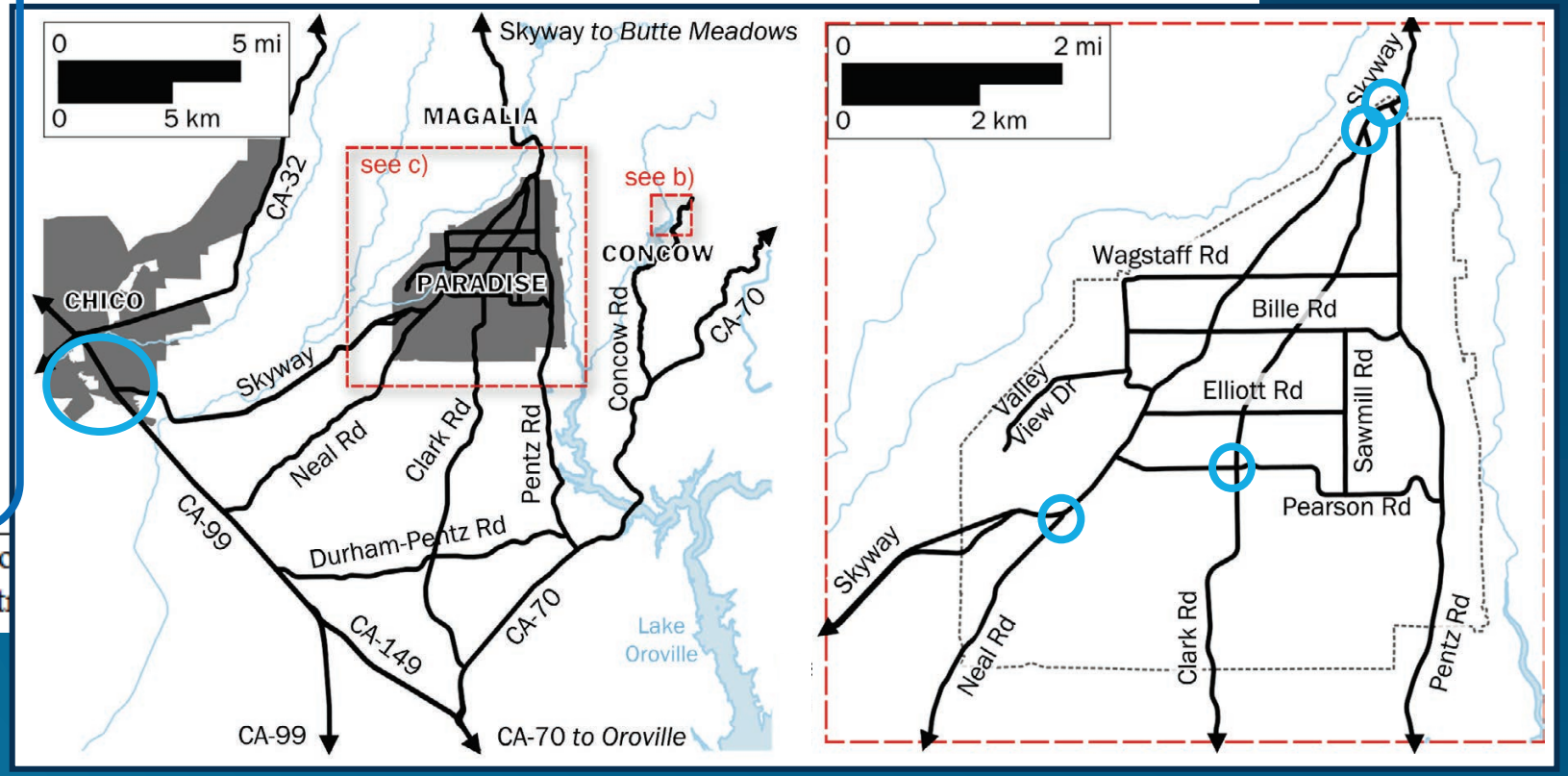
Road System in and Around Paradise

Table 3. Egress routes and primary road arteries leaving Paradise.

Roadway	Total Lanes[a]	Pavement Width, m (ft)	Notes
Skyway (SB)	4	2× 8.5 (28)	Divided roadway, 2 lanes inbound, 2 lanes outbound. Leads through Chico and CA-99.
Clark Road	2		
Pentz Road	2		
Neal Road	2		
Skyway (NB)	2		

Note: SB – southbound, NB – nc

[a] Total number of lanes in both t



NIST TN 2252, Table 3 and Figure 7.

Road Capacity and Population

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Table 4. Total population and egress lanes per community.

Location	Pop.	Area, km² (mi²)	Pop. Density, p/km² (p/mi²)	DINS Residential Struct. [35]	Occupied Housing Units (OHU) [34]	Max. Egress Routes	Max. Egress Lanes	OHU / Egress Lane
Paradise	26543	47.5 (18.3)	559 (1450)	12198	11118	5[a]	12	927
Magalia	12671	36.3 (14.0)	349 (905)	2753[b]	5054	2[a]	4	1264
Concow	743	72.0 (27.8)	10 (27)	429	327	1	2	164

[a] The only Paradise egress route to the north must travel through Magalia. The Magalia egress route to the south must travel through Paradise.

[b] 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.

interdependence

NIST TN 2252, Table 4.

Egress Routes and Lanes

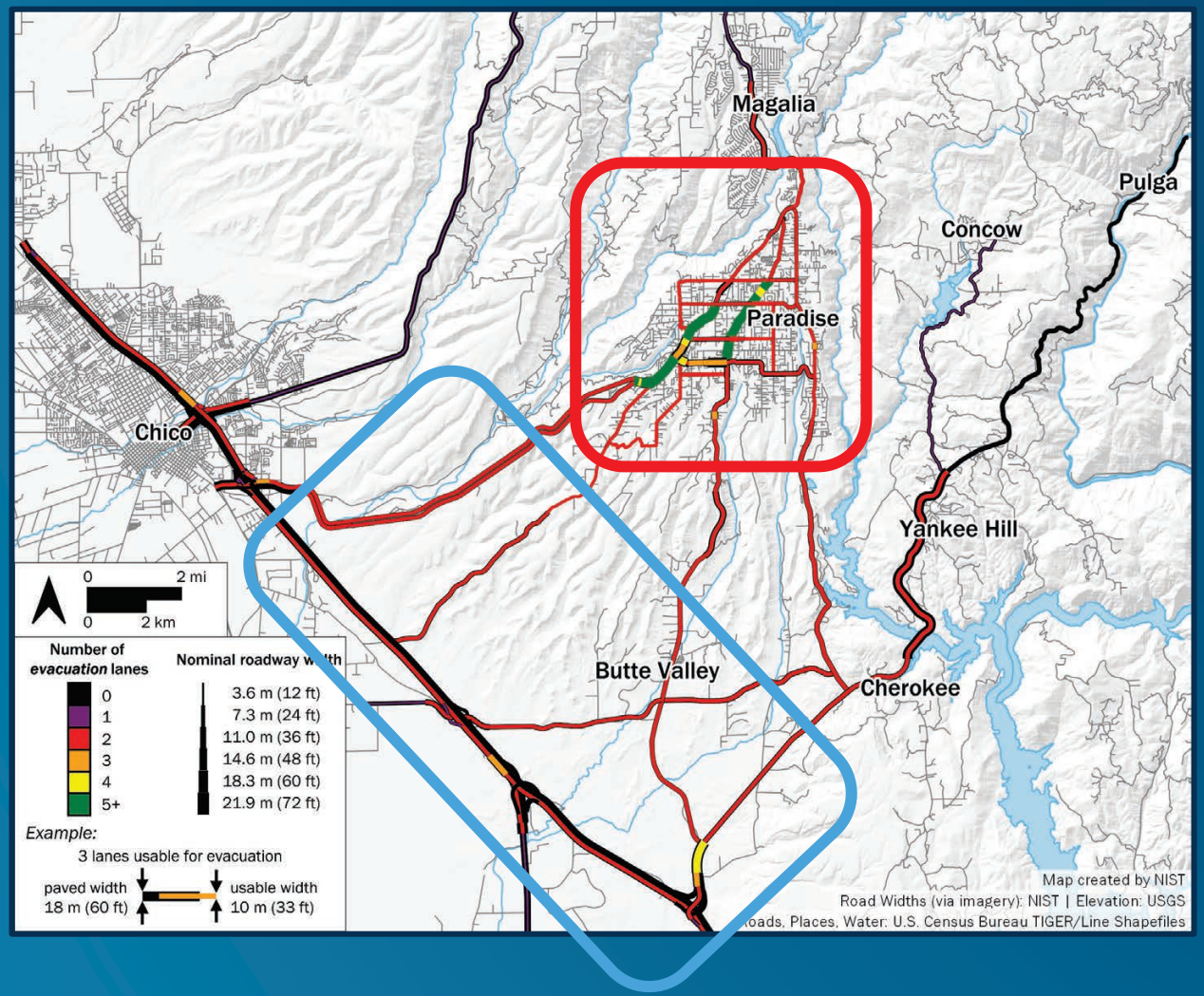


Table 6. Maximum number of egress routes and lanes used during the Camp Fire evacuation per community and/or subregion.

Selected Subregion	Occupied Housing Units (OHU) [34]	Egress Routes	Total Lanes Used[a]	OHU / Egress Lane
Concow	327	1 *Concow Rd*	1	327
Magalia	5054	2 *Skyway (NB)* *Skyway (SB)*	2	2527
Paradise	11118	4 *Skyway (SB)* *Clark Rd* *Neal Rd* *Pentz Rd*	7 *(4)* *(1)* *(1)* *(1)*	1588
Paradise and Magalia	16172	5 *Skyway (SB)* *Clark Rd* *Neal Rd* *Pentz Rd* *Skyway (NB)*	8 *(4)* *(1)* *(1)* *(1)* *(1)*	2022
Paradise, Magalia, Butte Valley, and Butte Creek merging into highways south of Paradise	17700[b]	3[c] *Skyway (SB)* *CA-99 (SB)* *CA-70 (SB)*	6 or 7 *(2 or 3)* *(2)* *(2)*	2950 or 2529

[a] Number of lanes used during Camp Fire evacuation accounting for contraflow and open lanes for first responder access and other local conditions.
[b] estimated via OHU and DINS from foothills north of CA-70 and Butte Creek.
[c] majority of civilians evacuating Paradise evacuated south; northern route was blocked by fire early

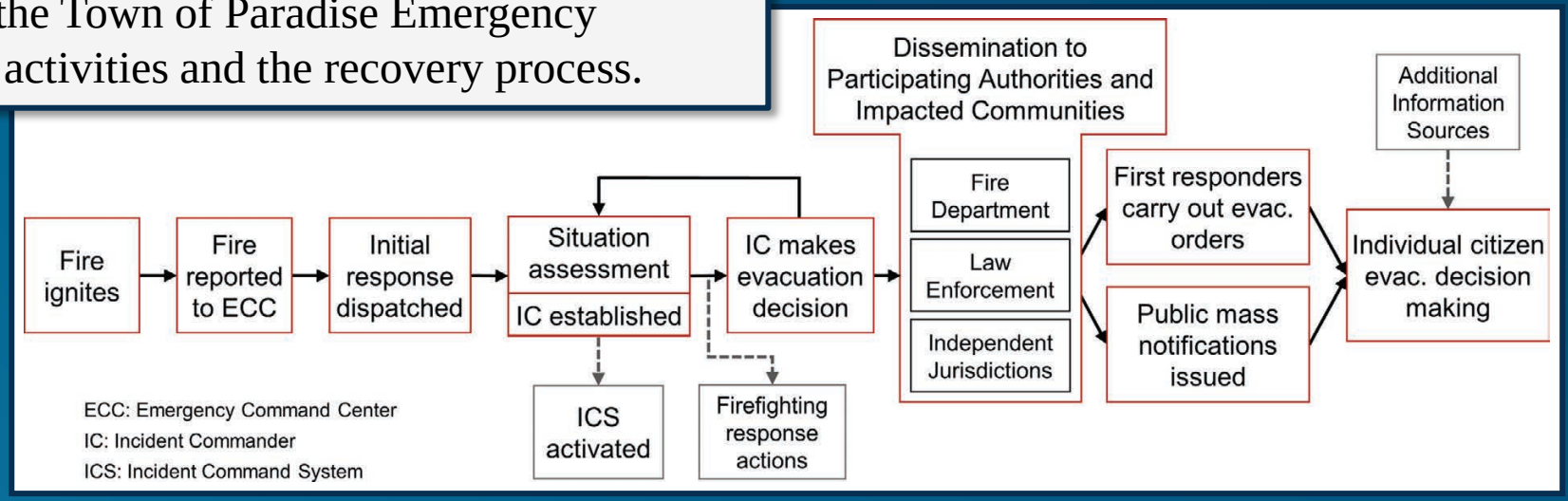
NIST TN 2252, Figure 10 and Table 6.

Notification and Evacuation Plan

EOP* | *zones* | *training

Paradise Emergency Operations Plan

- Establishes the emergency management organization required to mitigate any significant emergency or disaster affecting the Town of Paradise.
- Identifies the roles and responsibilities required to protect the health and safety of Paradise residents, public and private property and the environmental effects of natural and technological emergencies and disasters.
- Establishes the operational concepts associated with a field response to emergencies, the Town of Paradise Emergency Operations Center (EOC) activities and the recovery process.



NIST TN 2252, Figure 12.

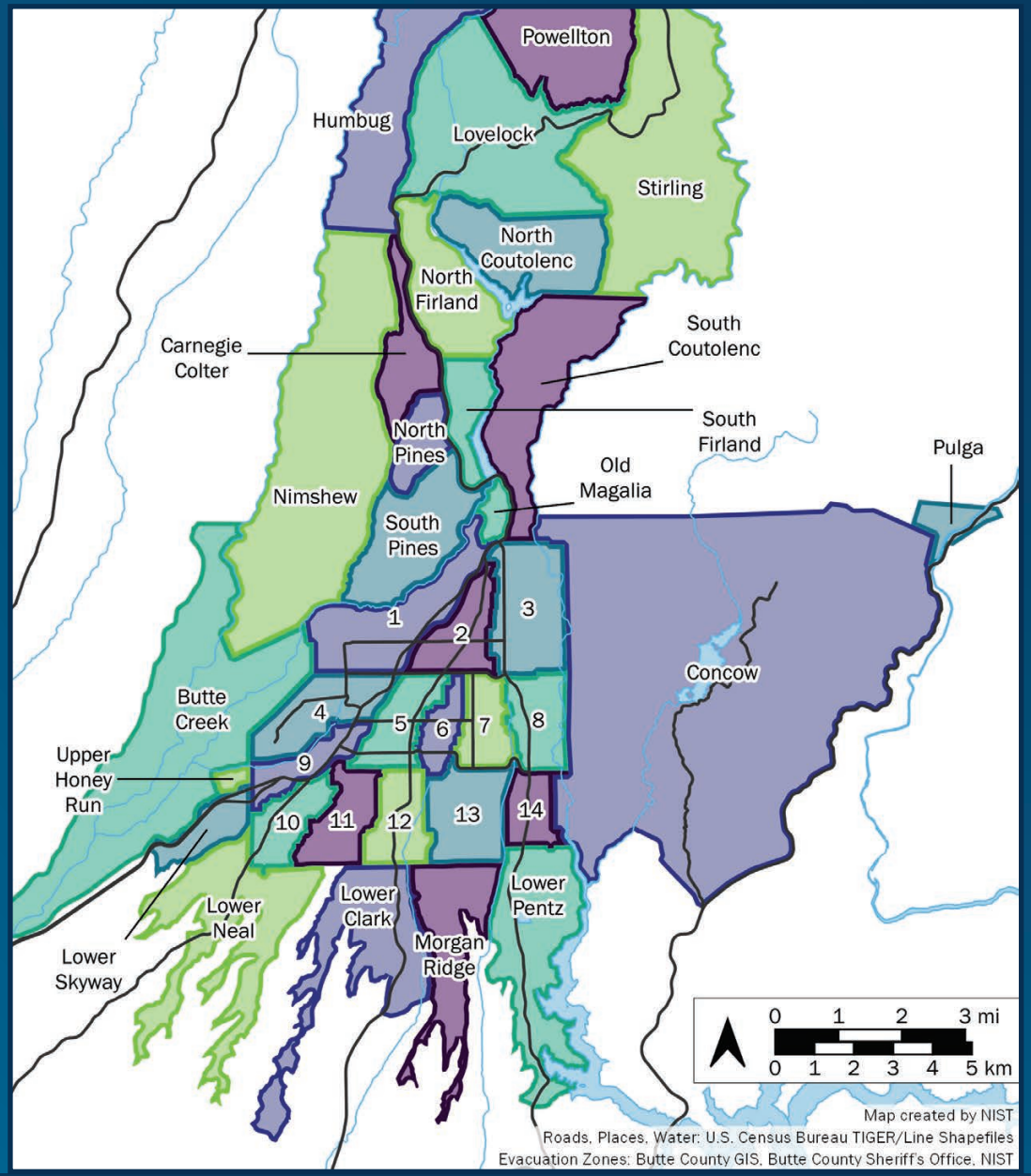
Notification and Interagency Communication

- Notifications and evacuations required the coordination of many different departments including but not limited to:
  - CAL FIRE
  - Butte County Sheriff's Office
  - Town of Paradise (Town Hall, Public Works)
  - Paradise Police Department
  - Paradise EOC
  - Butte ECC
  - Chico Police Department
  - Caltrans
  - B-Line (public transportation)
  - California Highway Patrol
- A Sheriff's Office representative was on location with the IC beginning at approximately 08:00.
- Radio logs indicate rapid information exchange between the IC, ECC, and BCSO.

BCSO representative at ICP facilitated efficient and timely communication to LE organizations involved in notifications/evacuations

Evacuation Plan

- Zoned system designed for partial evacuations
- Plan designed to utilize contraflow on Skyway and Pentz Road
- Included a limited number of pre-designated public assembly areas
- Pamphlets/mailers sent to residents
- Complex and extensive multiagency training exercise in 2016



NIST TN 2252, Figure 11.

Comparing Partial and Full Evacuation Road Capacities

Table 5. Egress capacity for evacuation of selected zones in Paradise via southbound routes only.

Selected Zones/Subregion	DINS Residential Struct. [35]	Potential Egress Routes	Potential Egress Lanes	OHU / Egress Lane
Zones 3, 8, 14 (Pentz Road corridor)	2210	4 *Pentz Rd* *Clark Rd* *Skyway* *Neal Rd*	7 *(2)* *(2)* *(2)* *(1)*	316
Zones 10, 11, Lower Neal (southeast Paradise)	1391	3 *Neal Rd* *Skyway* *Clark Rd*	5 *(1)* *(2)* *(2)*	278
Valley View and Valley Ridge (part of Zone 4)	560	2 *Valley View Dr* *Elliott Rd*	3 *(2)* *(1)*	187

OHU/Egress Lane increased by 3 to 5 times between *Partial* and *Full* evacuation scenarios

NIST TN 2252, Table 5.

Preplanned Safety Zones and Public Assembly Points

- Three used by civilians together with first responders
- Five used only by first responders

Table 7. List of pre-designated Public Assembly Points in the Butte County Evacuation Plan.

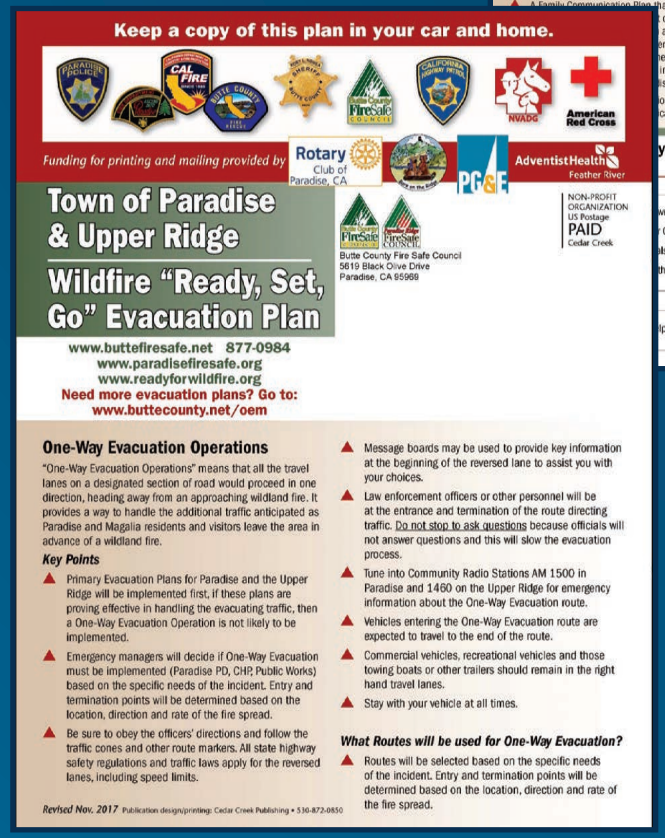
ID[a]	Name[a]	Description	Capacity[a] Vehicles	Capacity[a] People	Use During Camp Fire
Pulga, Concow, Yankee Hill					
1	Shady Rest Area	Widened highway shoulder along river	15	30	No data (inaccessible, outside fire area)
2	Flea Valley	0.8 ha (2 ac) cleared dirt area surrounded by shrubs; via dirt road on ridge above Concow	50	200	No data (inaccessible, inside fire area)
3	Caltrans Pulga Maintenance Yard	Paved area of highway maintenance facility and expanded highway shoulder	50	100	No data (inaccessible, outside fire area)
4	Camelot Meadow Wild Fire Safety Zone	3.3 ha (8 ac) field surrounded by trees and shrubs	400	500	**TRA-A**
5	Crain Memorial Park Wild Fire Safety Zone	0.8 ha (2 ac) field with a gravel parking area, surrounded by trees and shrubs	100	200	No data
6	Concow School Wild Fire Safety Zone	0.8 ha (2 ac) area of small, paved parking lot and athletic field	200	500	FF staging
7	Seventh-Day Adventist Church	0.1 ha (0.25 ac) paved parking lot surrounded by trees and veg.	50	100	No data
8	Pines Yankee Hill Hardware Wild Fire Safety Zone	0.6 ha (1.5 ac) gravel lot	100	200	ICP and FF staging
9	Dome Store (Canyon Lakes Market)	0.26 ha (0.6 ac gravel lot) plus expanded highway shoulder nearby	100	200	FF staging
10	Spring Valley School	0.25 ha (0.6 ac) paved parking area	100	300	FF staging
Paradise					
A	Paradise Alliance Church	Large, paved parking lot	500[b]		**TRA-V**
B	Paradise Auditorium/Senior Center	Large, paved parking lot	250[b]		No data
Upper Ridge (Magalia)					
A	Pine Ridge School	Paved parking lot and school grounds	125[b]		**TRA-DD**
B	Paradise Pines Property Owners' Association	Paved parking lot surrounded by trees, shrubs, nearby structures	150[b]		No data
C	Magalia Community Church	0.5 ha (1.3 ac) gravel parking lot	150[b]		**TRA-U**
D	Old Mill Site/Stirling City	1.3 ha (3 ac) clearing surrounded by trees	250[b]		No data (outside fire area)
Butte Creek Canyon					
	Honey Run Bridge Park	0.1 ha (0.25 ac) gravel parking area within tree covered park	25[b]		No data
Butte Valley					
	Earthwork Soil Factory	Gravel lot surrounding commercial building	100[b]		No data

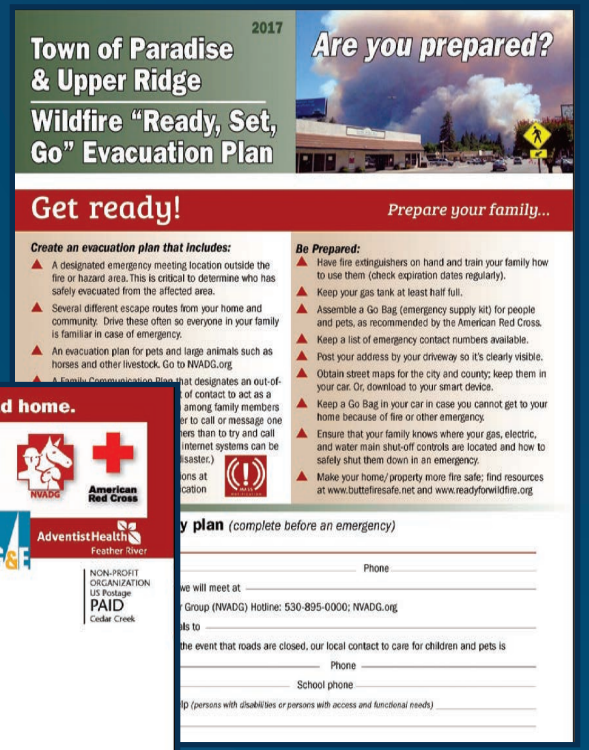
[a] As listed in the Butte County Evacuation Plan [36].
[b] Approximate number of marked parking spaces or capacity estimated by NIST.

NIST TN 2252, Table 7.

Pre-Fire Emergency Notification and Evacuation Plans

- Information that was distributed to citizens of the area, including via a public information brochure containing:
  - the CAL FIRE “Ready, Set, Go!” wildfire evacuation preparation concept
  - a detailed map identifying the evacuation route.
  - maps identified routes not recommended for use in evacuations, locations of locked gates.
- More specific implementation and planning details for emergency responders.





Complex and Comprehensive Multiagency Exercise (2016)

1. One-way southbound traffic (**contraflow**) was implemented on Skyway between Elliott Road and Pearson Road between 07:00 and 08:00.
2. **Simulated WUI fire scenario** in the area of Neal Road, including actual dispatch of fire equipment (engines, hand crews, dozers, and aircraft) and a dynamic incident escalation.
3. Town of Paradise Emergency Operations Center **(EOC) was activated**.
4. **Simulated activation** of one-way southbound traffic on Pentz Road from Pearson Road to CA Highway 70.

Training exercise enhanced multiagency communication and coordination and built “muscle memory”

Technical Findings & Recommendations

Technical Findings
Evacuation Planning

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TF-EP 1. An evacuation plan, developed with input from previous fires and training exercises, was in place and communicated to first responders and the community before the incident.

TF-EP 2. The evacuation plan included coordination among multiple regional first responder agencies (fire departments, law enforcement, and public works).

TF-EP 3. The Paradise evacuation plan was conceived and designed for a zoned/partial evacuation; it was not designed for a complete simultaneous evacuation of the town.

TF-EP 4. Including an evacuation component in the 2016 WUI fire training exercise built “muscle memory” of first responders for integrating evacuation into the response component of WUI fire incidents.

TF-EP 5. The 2016 training exercise was used to practice key evacuation elements, including traffic contraflow on Skyway. This served as direct experience to Paradise Public Works.

Recommendations
Evacuation Planning

In planning for WUI fire evacuations, communities should consider:

R-EP 1. Developing an evacuation plan in collaboration with nearby first responder organizations/agencies.

R-EP 2. Creating a realistic training exercise that includes fire, rescue, evacuation, and traffic components.

R-EP 3. Practicing training exercises with collaborating fire, law enforcement, and public works agencies.

R-EP 4. Revising the evacuation plan based on lessons learned from training exercises and other WUI fires.

WUI Fire Days: Camp Fire NETTRA

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- *Module 1: Notification and Evacuation Pre-Fire Conditions and Planning*
- Module 2: Notification Timeline, Evacuations, Traffic Flow and Road Closures
- Module 3: Burnovers and TRAs
- Module 4: Rescues
- Module 5: NETTRA Summary

next week, Nov 8

Thank You

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Contact Information:

Alexander Maranghides
alexm@nist.gov

Eric Link
eric.link@nist.gov

Camp Fire

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

Direct links to NETTRA reports:

https://doi.org/10.6028/NIST.TN.2252

https://doi.org/10.6028/NIST.TN.2252sup