Vegetation Cover and Structure Loss in Four Northern California Wildfires: Butte, Tubbs, Carr, and Camp

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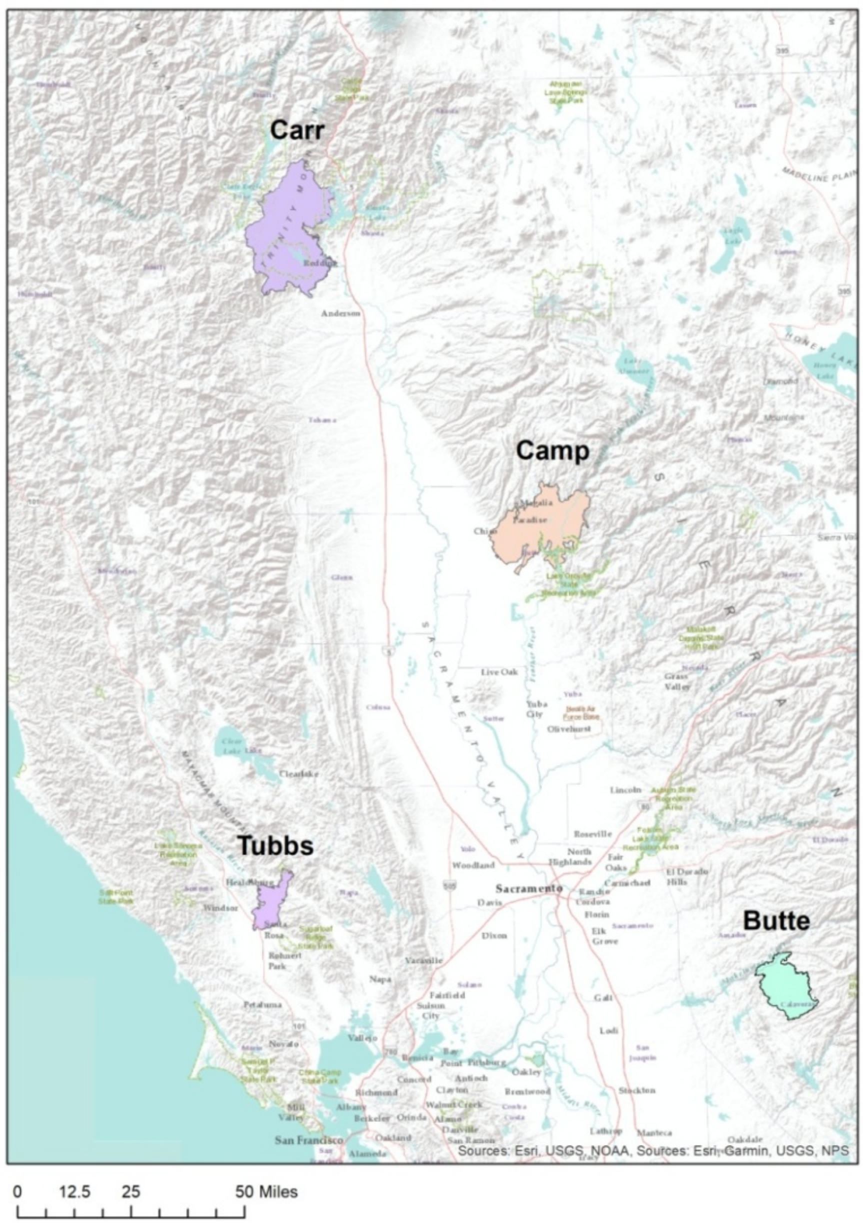
Abstract: This study examines the effect of vegetation cover near structures on the loss rate for single family residences (SFR's) in four recent northern California wildfires: the Butte fire (September, 2015), the Tubbs fire (October, 2017) , the Carr fire (July, 2018) , and the Camp fire (November, 2018). (See map below).

Fires Examined



In total, 19,508 destroyed and 5,208 surviving SFR's were included in the study. The proportion of pre-fire vegetation cover within 25 meters of a central point representing each structure was estimated using high-resolution infrared aereal imagery. For each fire, structures were grouped into 10 vegetation cover classes, based on the proportion of cover, and loss rates were calculated by class. Linear regression was applied to estimate the effect of vegetation cover on loss rates. Loss rates were found to increase in proportion to vegetation cover in three of the four fires. For the two fires in the Sierra Nevada foothills (Butte and Camp) the slope of the loss rate regression line was similar, around 0.9. That is, the probability of loss increased by 0.9 % for every 1% increase in vegetation cover in the 25-meter zone. For the Carr fire, the loss rate slope coefficient was estimated to be 0.4, about half of the value for the Sierra fires. Structure loss rates in the Tubbs fire were uncorrelated with vegetation cover.

The effects of wind speed, vegetation type, and housing density on loss rates were also examined. Loss rate regression lines tended to shift upward in concert with the maximum wind speeds encountered on each fire. In the case of the Tubbs fire, high winds appeared to completely negate the influence of vegetation cover on loss rates. Structures located in conifer vegetation types had a higher loss rate when compared to those located in hardwood types for the Sierra fires, but that pattern did not hold for the Tubbs or Carr fires, located in more coastal mountain ranges. Loss rates did not differ significantly by Wildland Urban Interface zones as mapped by the University of Wisconsin's SILVIS lab.

Sources and Methods: Post-fire Damage Inspection reports (DINS) compiled by CAL FIRE, the California Department of Forestry and Fire Protection, were the primary source for structure losses. In the DINS data, each structure is classified by structure type and damage level and is represented by a single point, located on or near the structure. For purposes of this study, only structures identified as "Single Family Residences" were included. To improve location accuracy, each structure point in the DINS data was moved to the centroid of a mapped structure polygon, where one could be identified . In the case of the Butte fire, structure polygons were derived from pre-fire LIDAR data and aerial imagery. For the remaining fires, the Microsoft building footprint dataset (https://www.microsoft.com/en-us/maps/building-footprints) was the primary source of structure polygons, but aerial imagery was also used as a supplemental source. If no structure polygon could be located, (most often due to heavy canopy), the original structure point recorded by the CAL FIRE Damage Inspection team in the DINS database was used to represent the structure location.

Structures with less than 10% recorded damage in the DINS data were counted as a surviving structure. Structures with damage levels greater than 10% were counted as a loss. Single family dwellings that appeared to have been destroyed based on post-fire imagery, but which were not included in the DINS inventory, were added to the dataset as a loss.

Undamaged structures were comprehensively recorded in the DINS data for the Camp fire, but were not generally recorded in the other fires. For the Butte, Tubbs, and Carr fires aerial imagery was used to identify those structures which appeared to be undamaged single family residences.

For purposes of calculating loss rates, only surviving structure points within 25 meters of a mapped burned area were included. Burned areas for the Butte, Camp, and Carr fires were derived from initial burn severity maps developed by post-fire emergency response teams. These maps, created immediately after the fires, tended to better capture areas that were lightly burned, such as areas of dry grass. For the Tubbs fire, the burn severity map from the Monitoring Burn Severity Trends data site https://www.mtbs.gov/ was used to identify burned areas, as an initial burn severity map was available for only part of the fire.

Table 1 shows the number of single family residences mapped for each fire and the overall estimated loss rate:

Table 1. Single Family Residence Loss Rates by Fire

Fire	Single Family Structures	Percent Destroyed
Butte	1186	55.3
Tubbs	5179	84.1
Carr	2233	48.8
Camp	16116	83.1
Total	**24714**	**78.9**

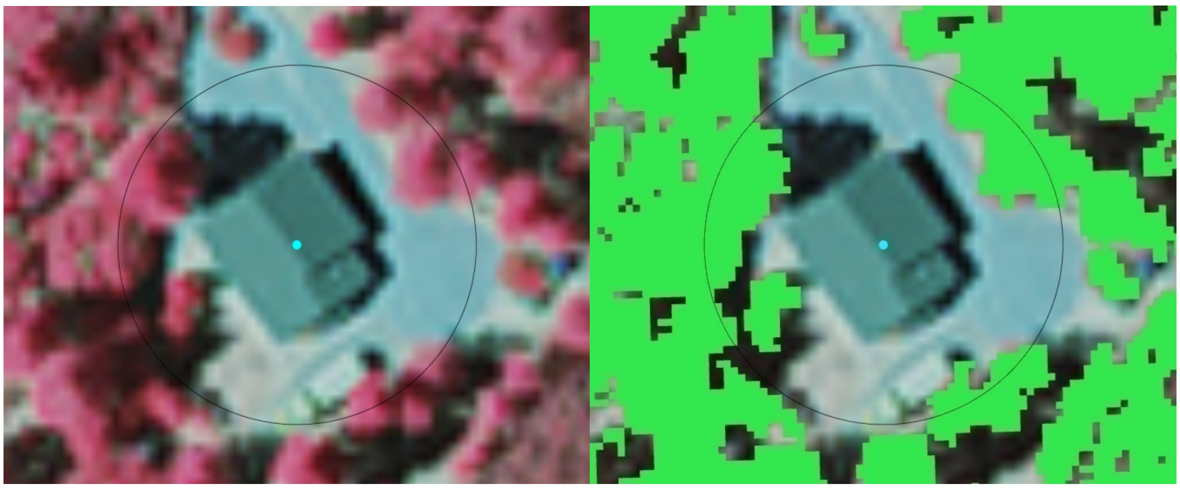
Table 2 displays the source for the structures included in the study. Maps in the Appendix show the location of structures included for each fire.

Table 2. Single Family Residences Included by Damage Level and Source

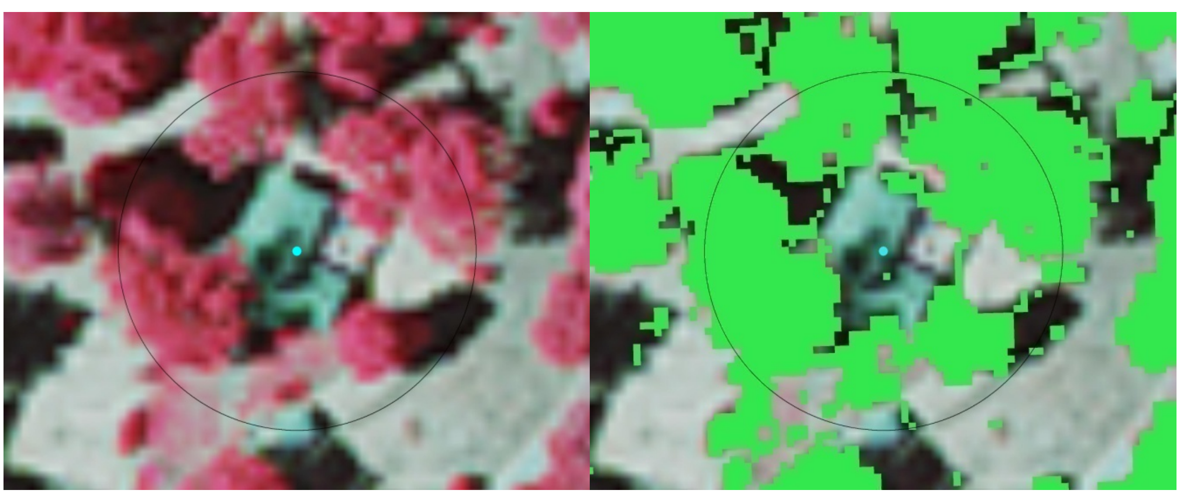
Fire	No Damage DINS	< 10% Damage DINS	> 10% Damage DINS	No Damage-Added	Destroyed - Added	Total
Butte	0	13	540	516	117	1186
Tubbs	35	130	4359	654	1	5179
Carr	0	131	1091	1011	0	2233
Camp	2283	433	13400	0	0	16116
Total	**2318**	**707**	**19390**	**2181**	**118**	**24714**

Vegetation cover around each SFR was estimated by creating a Normalized Difference Vegetation Index (NDVI) image for each fire using pre-fire infrared imagery from the National Agricultural Imagery Program (NAIP). For the Tubbs, Carr and Camp fires, 0.6 meter resolution imagery was available. For the Butte fire, 1-meter resolution NAIP imagery was used. Pixels in the images were counted as vegetation if they had an NDVI index of 0.25 or greater. The 0.25 limit was intended to exclude areas of dry grass and weeds as vegetation cover.

Vegetation cover was estimated for a 25-meter circle around each structure central point by calculating the proportion of the area covered by pixels with an NDVI value exceeding 0.25. The area of the structure was included in the total area for which the proportion was calculated.



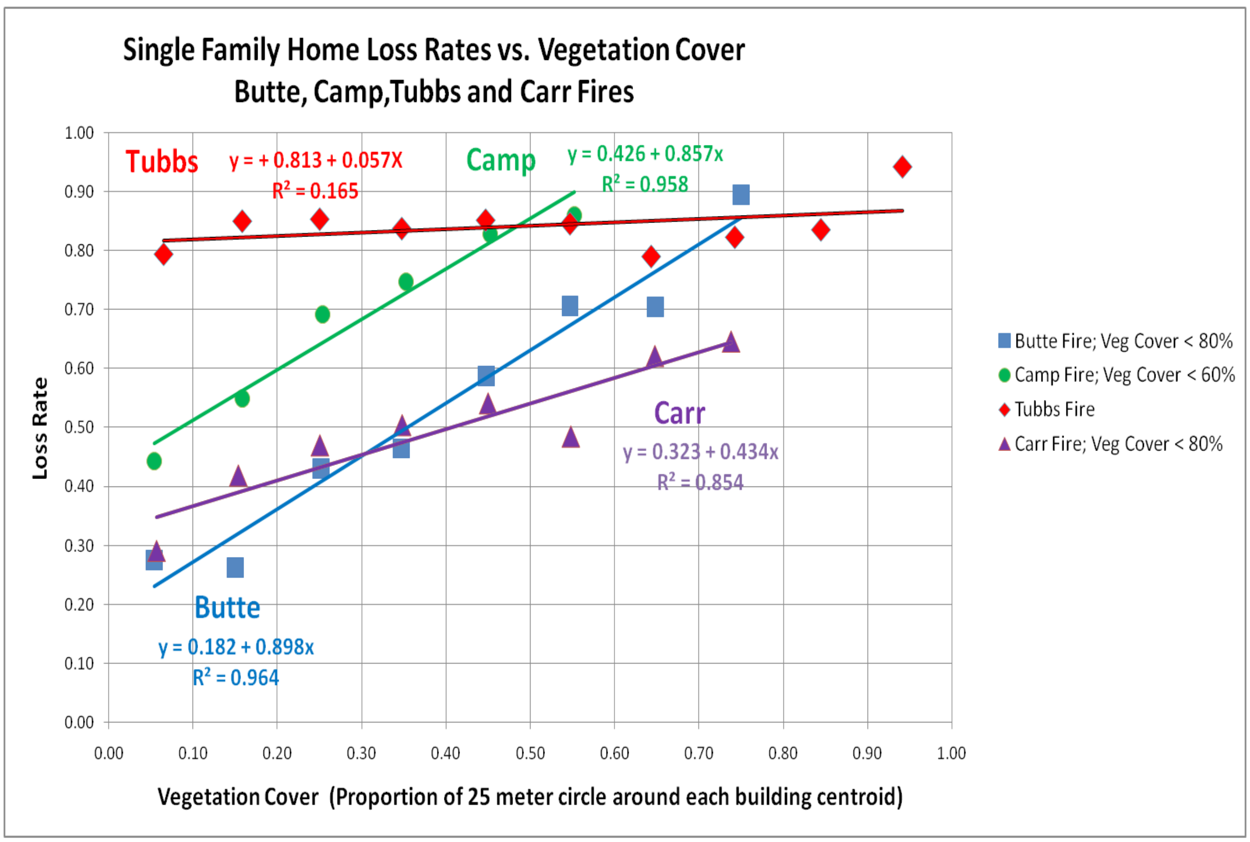
Infrared image showing a 25 meter circle around a structure central point. Image on the right shows the pixels classified as vegetation in green, based on an NDVI value greater than 0.25. This example has an estimated ***vegetation cover proportion of 0.20.***



Infrared image showing a 25 meter circle around a structure central point. Image on the right shows the pixels classified as vegetation in green, based on an NDVI value greater than 0.25. This example has an estimated ***vegetation cover proportion of 0.60.***

Structures were grouped into 10% vegetation cover classes and the average loss rate was calculated by cover class. Class 1 included structures having 0 – 10% cover within the 25-meter circle, Class 2: 10 -20% cover, etc.. Charts and tables showing the number of structures and loss rates for each vegetation class in each fire are included in the Appendix.

Results: For three of the four fires, loss rates appeared to rise at a linear rate with respect to vegetation cover until a maximum loss rate was reached. Beyond that point, increasing vegetation cover seemed to have little effect on losses. For the Butte fire a maximum loss rate of 90% was reached when vegetation cover approached 75%. For the Camp fire, the maximum loss rate of 90% was reached at a lower vegetation cover percentage – about 55%. In the Carr fire losses topped out at around 65% when vegetation cover reached 75%. The Tubbs fire, in contrast, showed a loss rate that exceeded 80% for nearly all vegetation cover classes. A linear regression line was estimated for each fire where loss rate is a function of the average cover proportion by cover class. Only data points for the vegetation classes where the loss rate is below the maximum rate were included in the regression estimate. The exception is the Tubbs fire where all points were used to estimate the regression line. Results are shown in the following graph:



Note: Regression lines for the Butte and Carr fires are based on Vegetation Cover classes from 0 to 80%. The Camp fire regression line is based on Vegetation Cover classes from 0 to 60%. The Tubb fire regression line includes all cover classes from 0 to 100%.

The estimated regression line for the Butte fire was **y = 0.182 + 0.898x,** where y is the loss rate and x is the proportion of vegetative cover**.** The slope value of 0.898 indicates that a 1% increase in vegetation cover in the 25-meter zone would increase loss rates by about 0.9%. The y-intercept value of 0.182 implies that 18.2% of the structures would have burned regardless of the vegetative cover.

For the Camp fire, the regression estimate was: **y = 0.426 + 0.857x** . The slope of the line (0.857) is close to that of the Butte fire (0.898), but the line is shifted upward by the higher intercept value (0.426 vs. 0.182). The upward shift of the regression line causes the maximum loss rate in the Camp fire to be reached at a lower vegetation cover class than was the case for the Butte fire.

The estimated regression line for the Carr fire is: **y= 0.323 + .434x**. A 1% increase in vegetation cover results in a .434% increase in the loss rate, approximately half the rate of the Butte and Camp fires. The y-intercept value of 0.323 is about midway between the Butte fire (0.182) and the Camp fire (0.426).

In the Tubbs fire, vegetation cover seems to have little influence on structure loss rates, as evidenced by the low slope coefficient and low R-squared value of the regression line: **y= 0.813 + .057x,** R-squared = 0.165. Loss rates are about the same for all vegetation cover classes: 81% or higher.

Wind effects: The y-intercept values in the linear regression equations for each fire give an estimate of the losses not accounted for by the vegetation cover variable. Other factors which may contribute to structure loss include weather, structure characteristics, vegetation types, the availability of defensive resources, terrain, etc.. In the case of these four fires, wind speeds seem to account for a large part of the difference in loss rates, as reflected in the shifting y-intercept values.

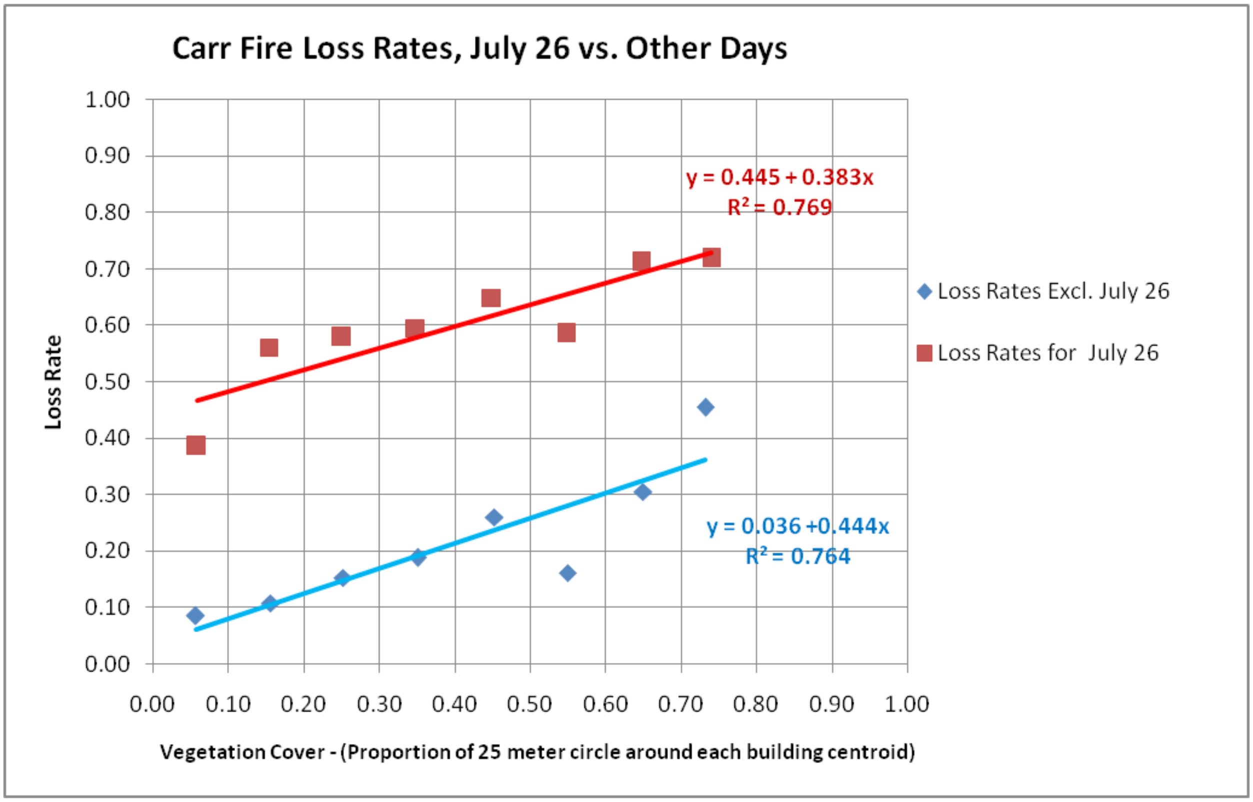
The following table summarizes weather variables from nearby weather stations for the day when each fire had its maximum growth:

FIRE	DATE	STATION	AVE TEMP	MAX TEMP	AVE HUMIDITY	AVE WIND	MAX WIND	AVG FUEL MOISTURE
BUTTE	Sept. 11, 2015	BANNER ROAD 2803 FT.	81.4	101	23	5.8	20	4.3
CAMP	Nov. 8, 2018	JARBO GAP 2490 FT.	54.3	63	16	18.8	52	4.7
TUBBS	Oct. 9, 2017	SANTA ROSA 576 FT.	70.2	91	18	8.8	68	6.1
CARR	July 26, 2018	MULE MOUNTAIN 2044 FT.	94.5	111	20	4.4	21	3.5

The fires with the lowest y-intercept values (the Butte and Carr fires at 0.182 and 0.323 respectively) also had the lowest maximum wind speeds – around 20 mph. The Camp fire, with maximum wind speeds of 52 mph, has a y-intercept value of 0.426. For the Tubbs fire, with maximum winds of 68 mph, the y-intercept value increases to 0.813. (Hourly maximum wind graphs for the nearest weather station for each fire are included in the Appendix.) As y-intercept values increase, the share of losses attributable to vegetation cover decreases and maximum loss rates are reached at lower vegetation cover percentages.

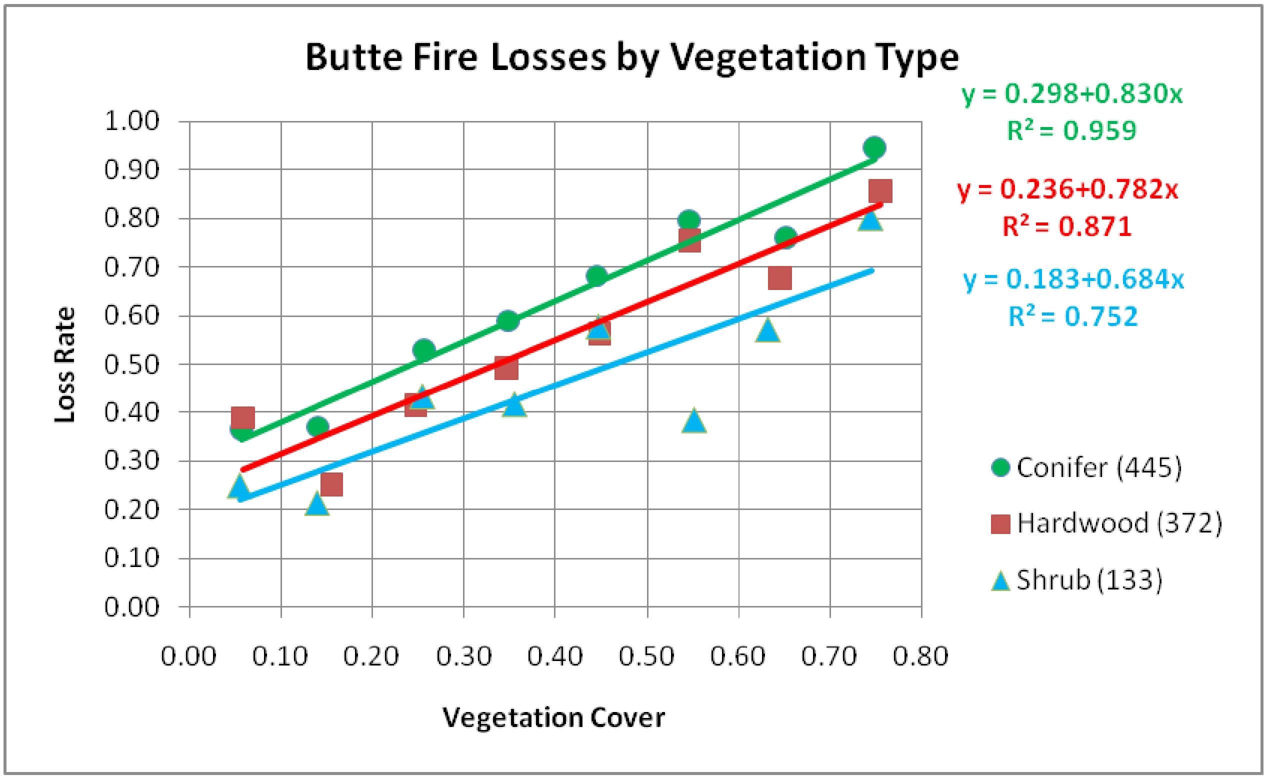
The maximum wind speeds measured by the Mule Mountain weather station in the Carr fire (around 21 mph) do not fully reflect the actual conditions on the fire itself. On July 26, the day of maximum fire growth and structure loss for the Carr fire, the wind graph for the Mule Mountain weather station does not show a dramatic increase in wind speeds. However, around 7:00 PM a fire whorl generating hurricane force winds occurred over a portion of the fire just as it reached more densely populated areas of west Redding. [(CAL FIRE Carr Fire Greensheet, July 26. 2018)]()

Those fire-generated winds likely had a strong impact on structure losses. With the aid of infrared maps produced by fire personnel, the structures burned on July 26 were identified. Approximately 90% of the single family residences that burned in the Carr fire were lost on that day. The graph below compares the loss rate on July 26 with the loss rate on all the other days of the fire. The y-intercept value of the loss rate regression line for July 26 is 0.445, close to that of the Camp fire (0.426). The y-intercept for the other days of the Carr fire drops to 0.036.

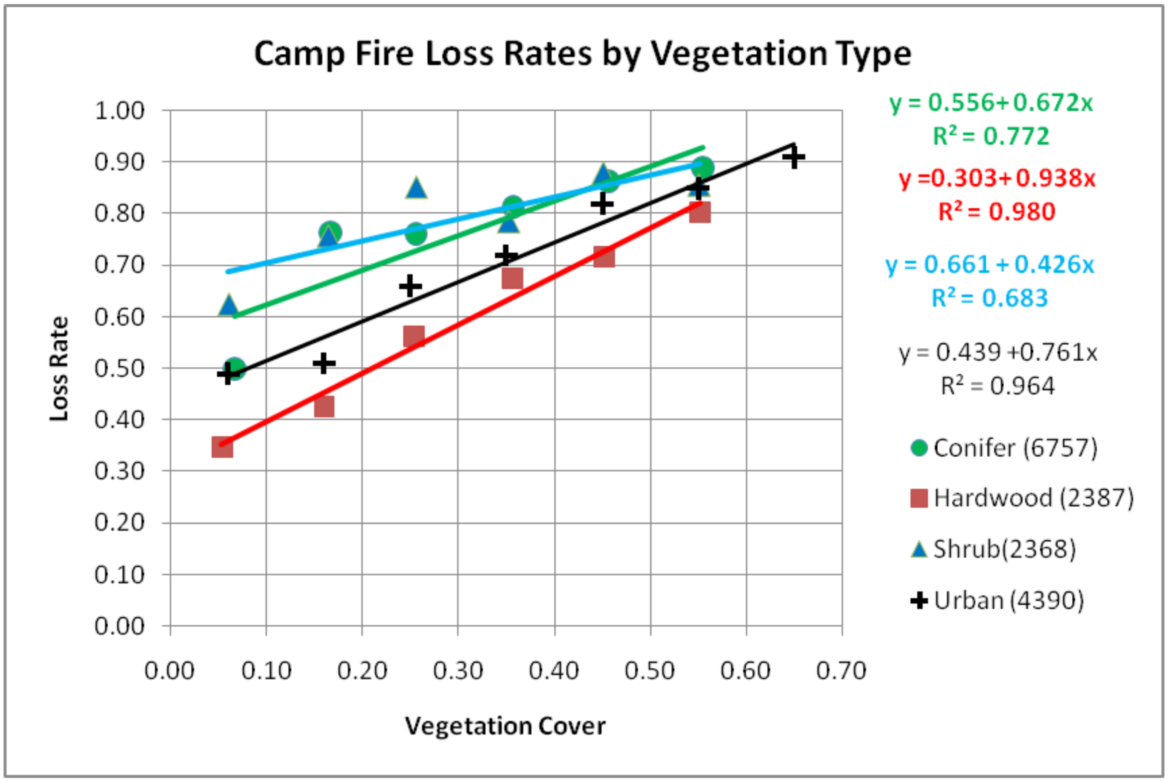


Vegetation Type Effects: Vegetation type was also examined to assess the impact on loss rates. The statewide vegetation map produced by the California Fire and Resource Assessment Program (FRAP) [FVEG (https://map.dfg.ca.gov/metadata/ds1327.html)](https://map.dfg.ca.gov/metadata/ds1327.html) was used to categorize SFR's by vegetation "lifeform".

For the Butte Fire, the conifer vegetation type shows a slightly elevated y-intercept and slope when compared to the hardwood or shrub types. (See graph below).

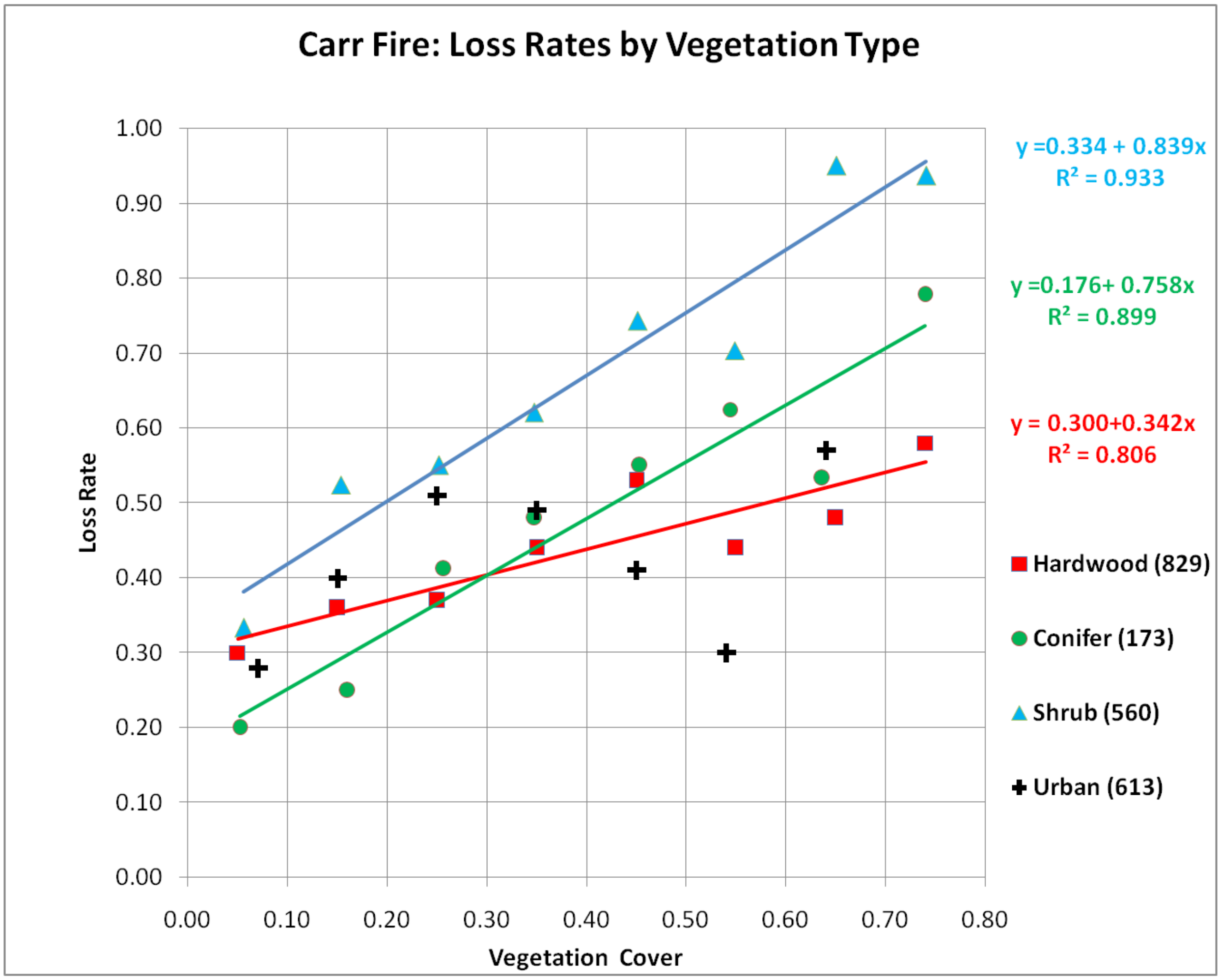


For the Camp fire, structures in the conifer type still have a higher loss rate than those in the hardwood type, but losses in the shrub type are higher than both. (See graph below). The Urban cover type, which did not occur in the Butte fire, has a loss rate line that falls between the hardwood and conifer lines. Both the conifer and shrub types have a lower slope coefficient than in the Butte fire, while the hardwood type is higher. The lower slope as the regression lines shift upward may be a consequence of nearing the upper limit on loss rates. Loss rates that are already high have less room to increase as y-intercept values rise. In effect, the higher wind speeds in the Camp fire reduce the importance of vegetation cover in structure loss.



In the Carr fire, as in the Camp fire, the loss rate line for the shrub type is higher than either the conifer or hardwood lines. (See graph below). The loss rate regression line for the hardwood type, however, has a much lower slope (0.342) than either the shrub type (0.863) or the conifer type (0.758). The urban\barren cover type exhibits a relatively low loss rate compared to the other cover types and losses seem not to have a strong relationship to the proportion of vegetation cover near the structures.

The low slope for the hardwood line (0.342) is the primary cause for the lower overall slope of the Carr loss rate line (0.434) compared to the slopes seen in the Butte and Camp fires (0.898 and 0.857 respectively). In contrast, the conifer and shrub types in the Carr fire have slope values as high or higher than those vegetation types in the Sierra fires. The Carr fire did occur earlier in the year (July) than either the Butte (September) or Camp (November) fires. Several months of additional drying and the beginning of fall could possibly have increased the flammability of the hardwood types in the Sierras. Also, the structures in the Carr fire were, on average, about 1000 feet lower in elevation than those in the two Sierra fires, resulting in a different mix of hardwood types. The most common hardwood type for the structures in the Carr fire was the Blue Oak-Foothill Pine. For the Butte and Camp fires, the Blue Oak Woodland and Montane Hardwood types predominated. "Hardwood" may be too general a category to use in measuring the risk of loss by vegetation type.



In the Tubbs fire, the relationship between vegetation type and structure loss was relatively weak across all vegetation types with the exception of the shrub type, but that type had relatively uncommon (238 out of 5179 total SFR's).

Wildland Urban Interface Effects: Loss rates do not appear to be greatly affected by housing density, as measured by the Wildland Urban Interface zone maps produced by the SILVIS Lab at the University of Wisconsin. (http://silvis.forest.wisc.edu/data/wui-change/) Very low density areas, in general, have a lower rate of loss, but there are relatively few structures that fall into that category. Loss rates are higher in the Interface zone in the Camp and Tubbs fires, but lower in the Carr fire. Urban zones were only mapped in the Tubbs fire and exhibit about the same loss rate as the Interface zone.

Table 3: Single Family Residences by Wildland Zones*

Fire		Urban	Interface	Intermix	Very Low Density
Butte		0	0	825	361
	Loss rate			58.4%	48.5%
Camp		0	4441	11149	526
	Loss rate		87.8%	82.3%	62.0%
Tubbs		1468	1957	1573	181
	Loss rate	87.0%	86.2%	82.0%	57.5%
Carr Fire		0	576	1426	231
	Loss rate	NA	44.6%	51.1%	45.0%

*2010 mapping by SILVIS lab at the University of Wisconsin
http://silvis.forest.wisc.edu/data/wui-change/

Policy Implications: Using the regression equations for each fire, it is possible to estimate the potential decrease in losses that could be achieved by reducing vegetation cover around structures. Table 4 gives the estimated change in losses for each fire if the maximum cover around structures was reduced to 20% within the 25- meter zone:

Table 4: Estimated Loss Reduction with Veg Cover Reduction to 20%

Fire	Avg. Veg Cover % (Pre-fire)	SFR's with > 20% Veg Cover	SFR Losses > 20% Veg Cover	Reduction in SFR Losses	%Decrease In Losses
Butte	42.1	1003	608	227	37.3
Tubbs	34.6	4069	3431	60	1.8
Carr	36.8	1760	912	159	17.5
Camp	57.6	15288	12977	3723	28.7
Total		**22120**	**17928**	**4169**	**19.0**

For the Carr and Tubbs fires, which averaged 36.8% and 34.6% in pre-fire vegetation coverage, the reduction in losses achieved by a 20% maximum vegetation cover is estimated to be 17.5% and 1.8% respectively.

Reducing the vegetation cover has a much larger impact on the losses in two Sierra fires, Butte and Camp, which had average pre-fire vegetation cover of 42.1% and 57.6%. Reducing the vegetation cover to 20%, could have potentially reduced losses by 37.3% in the Butte fire and 28.7% in the Camp fire. Even though the Camp fire had higher overall pre-fire vegetation cover, vegetation reduction in that fire has less of an effect than in the Butte fire, where lower wind speeds prevailed.

Literature Review: This paper builds on a previous study of the Butte fire (*Schmidt, 2020*), which examined loss rates for 500 residential structures as a function of surrounding vegetation, topography, weather, and structure location. That study found that a LIDAR-derived estimate of vegetation density within 15 meters of a structure perimeter was the best predictor of structure loss. But vegetation cover within 15 meters, as measured by NDVI greater than 0.25, gave similar results. Regression analyis in the Butte fire study was applied to individual structures rather than aggregating loss rates by vegetation cover classes. Despite the differences in approach, the estimated loss coefficient for vegetative cover in the Butte fire study was 0.883, almost the same as the the 0.898 loss coefficient derived in the current study.

A 2012 study in Australia (*Gibbons et.al.,2012*) found that percent of remnant (ie. native) vegetation cover within 40 meters of the structure was one of the top two variables in predicting structure loss in the 2009 Black Saturday fires. The regression model estimated the coefficient of loss to be 0.5 for the 499 houses examined. That result is similar to the results for the Carr fire in this study with a loss coefficient of 0.434.

A 2014 study by *Syphard, et. al.* examined 1000 burned structures and 1000 unburned structures in several southern California fires and found that vegetation clearance and vegetation overhanging the roof were significant variables in explaining structure loss, but were not as important as structure density or distance to major roads. That study found that the most effective vegetative treatment distance varied between 5 and 20 meters from the structure, but that reducing woody vegetative cover to less than 40% immediately adjacent to structures did not reduce structure loss. *Note: The vegetation cover percentage referred to in the Syphard, 2014 study does not include the area of the structure itself. The 40% cover value referred to in that study is equivalent to about a 35% cover value in the current study, when adjusted for the area of the structure.*

A 2019 study by *Syphard, et. al*. used the data recorded in the CAL FIRE Damage Inspection database (DINS) to examine factors affecting structure survival for over 40,000 structures throughout California from 2013 to 2018. That study found that structure characteristics were more important than vegetation near the structures in explaining structure loss. In the DINS database, vegetation cover is recorded as the distance of "defensible space" around the structure. Syphard found that "*The relative importance of defensible space…was virtually nil statewide, and the only region in which defensible space had a deviance explained of at least 1% was the Bay Area.* That finding by Syphard suggests that post-fire defensible space estimates may be a less accurate measure of the risk of structure loss than vegetation cover estimates from pre-fire imagery.

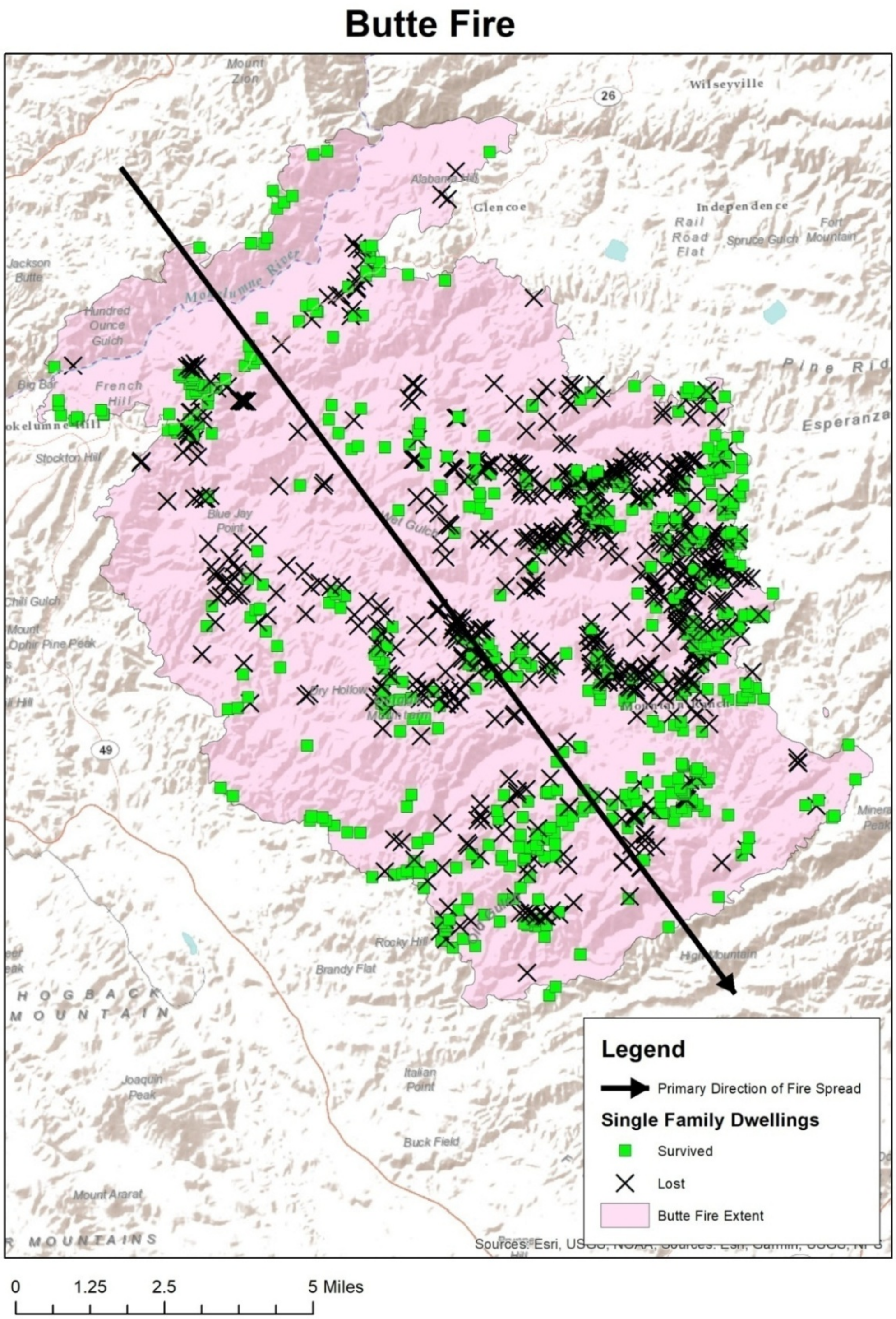
Conclusion: In three of the four fires examined, there is a proportional relationship between vegetation cover near the structure and structure loss rates. As vegetation cover increases, loss rates increase until an upper loss limit is reached: about a 90% loss rate in the two Sierra fires and about a 65% loss rate in the Carr fire. Increasing winds appear to shift the loss rate lines upward, so that the maximum loss rates are reached at lower vegetation cover classes. At the strongest wind levels (ie. the Tubbs fire), all vegetation classes have loss rates above 80%. Use of a 25-meter circle around a structure point and NDVI > 0.25 to define vegetation cover appears to offer a reasonably simple and effective method for defining the relative risk that vegetation cover contributes to wildfire losses.

Reduction of vegetation in the 25-meter zone around structures could have had a significant impact on structure losses in the Sierra fires but much less in the Carr and Tubbs fires. Reducing vegetation cover to a maximum of 20% in the 25-meter zone could have reduced losses by an estimated 29% for the Sierra fires but only 5% for the two other fires.

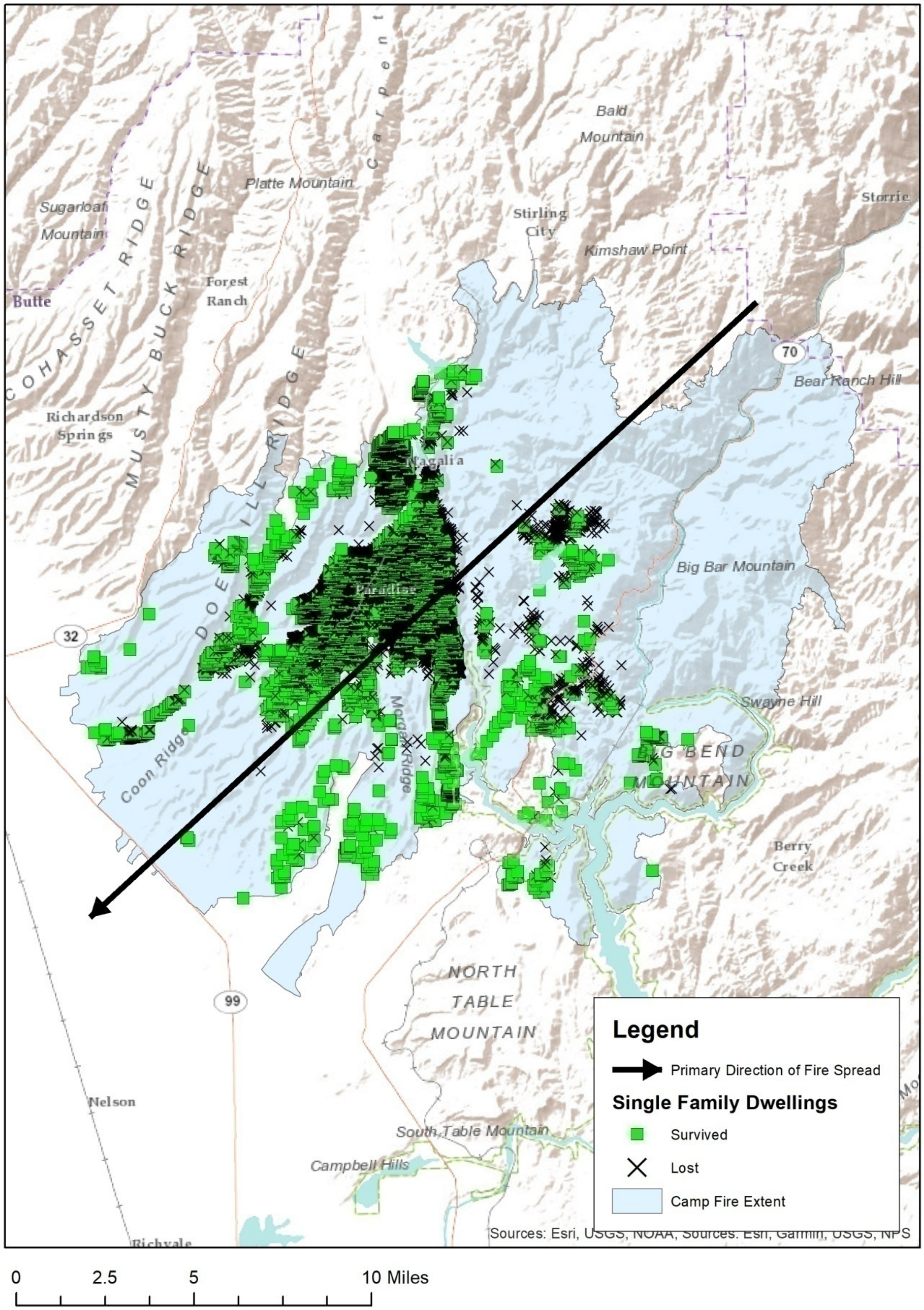
This study is limited to four fires in northern California, two in the Sierra foothills and two in more coastal mountains. Applicability to other vegetation types and to other regions has not been established.

Appendix:

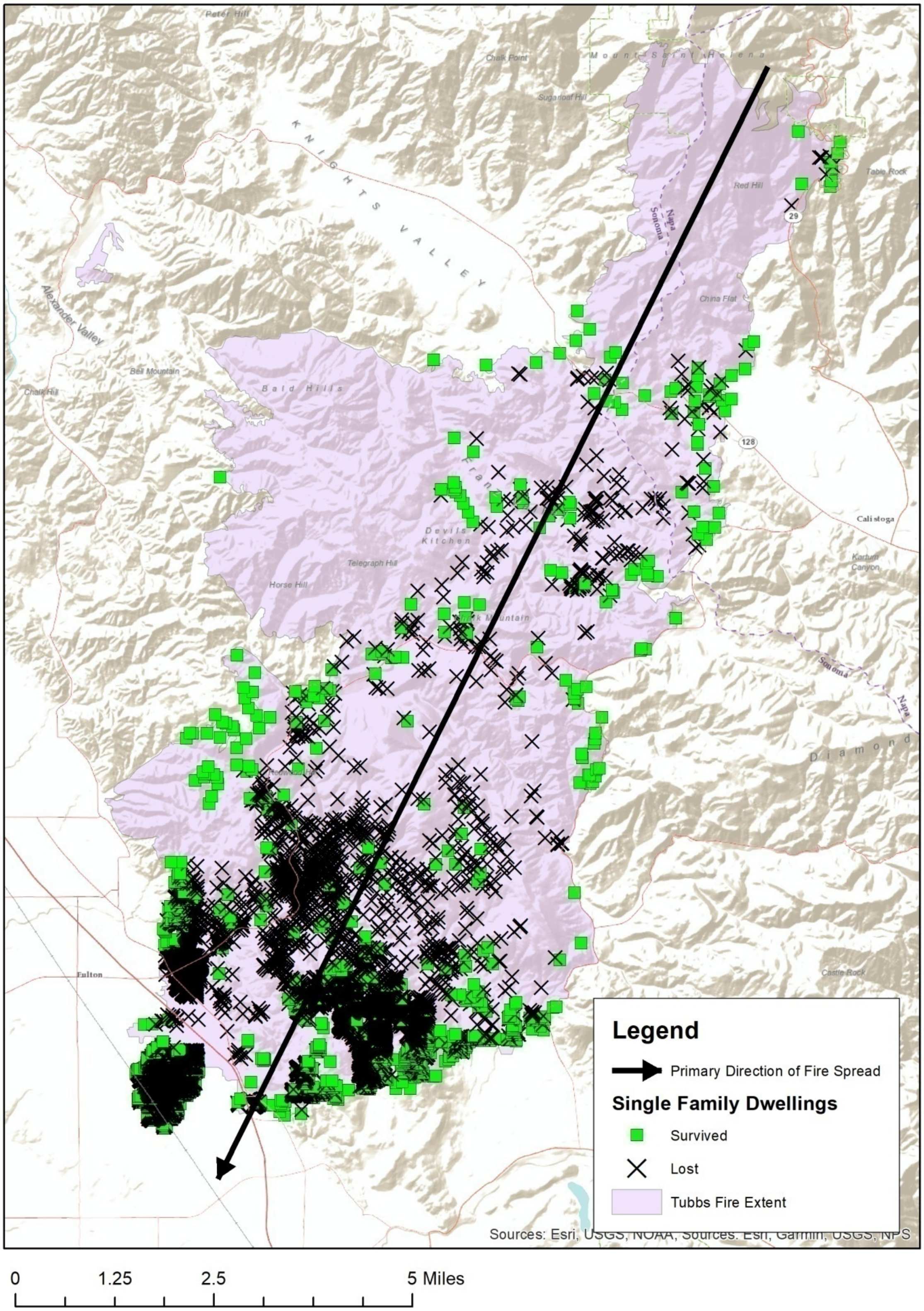
Structure Maps by Fire:



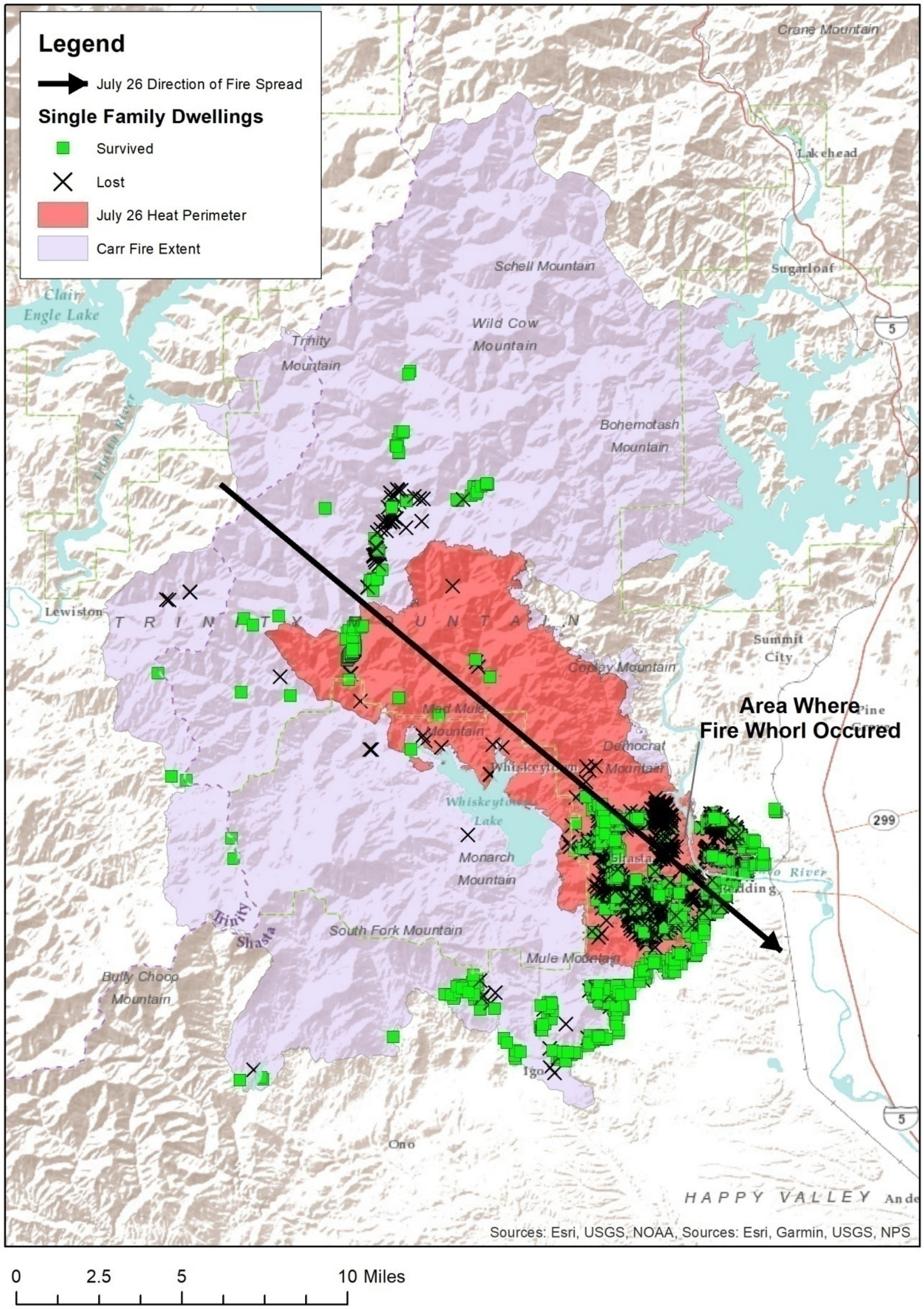
Camp Fire


Legend
Primary Direction of Fire Spread
Single Family Dwellings
Survived
Lost
Camp Fire Extent
Sources: Esri, USGS, NOAA, Sources: Esri, Garmin, USGS, NPS
Paradise
Magalia
Stirling City
Kimshaw Point
Bald Mountain
Platte Mountain
Sugarloaf Mountain
Forest Ranch
Butte
Richardson Springs
Big Bar Mountain
Bear Ranch Hill
Storrie
Swayne Hill
BIG BEND MOUNTAIN
Berry Creek
NORTH TABLE MOUNTAIN
South Table Mountain
Campbell Hills
Nelson
Richvale
Coon Ridge
70
32
99
0 2.5 5 10 Miles

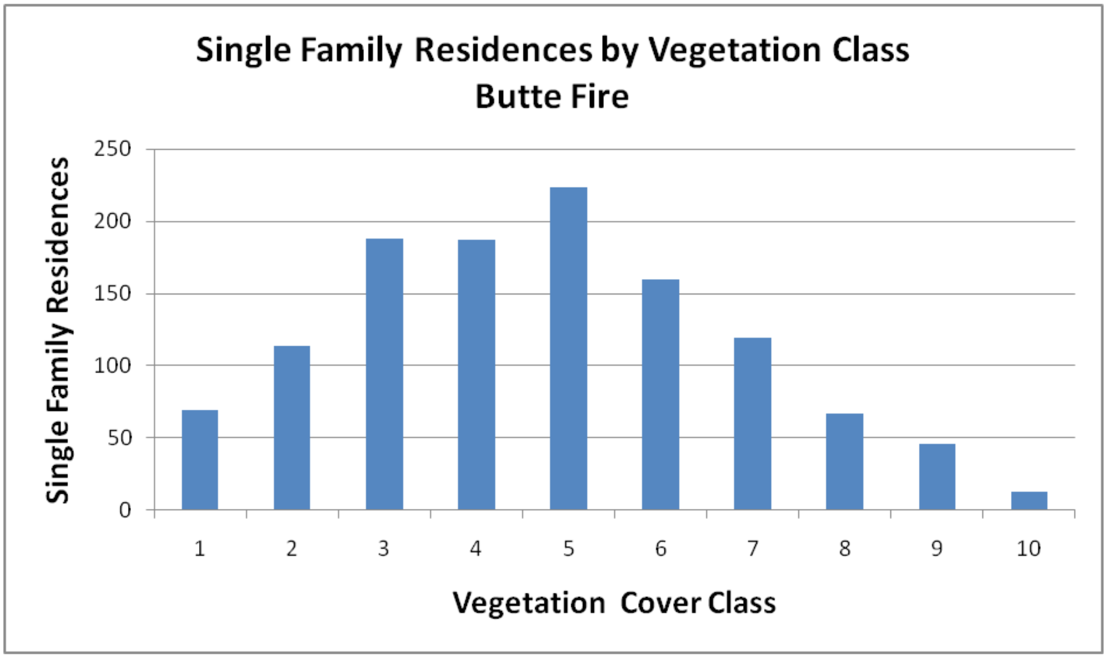
Tubbs Fire

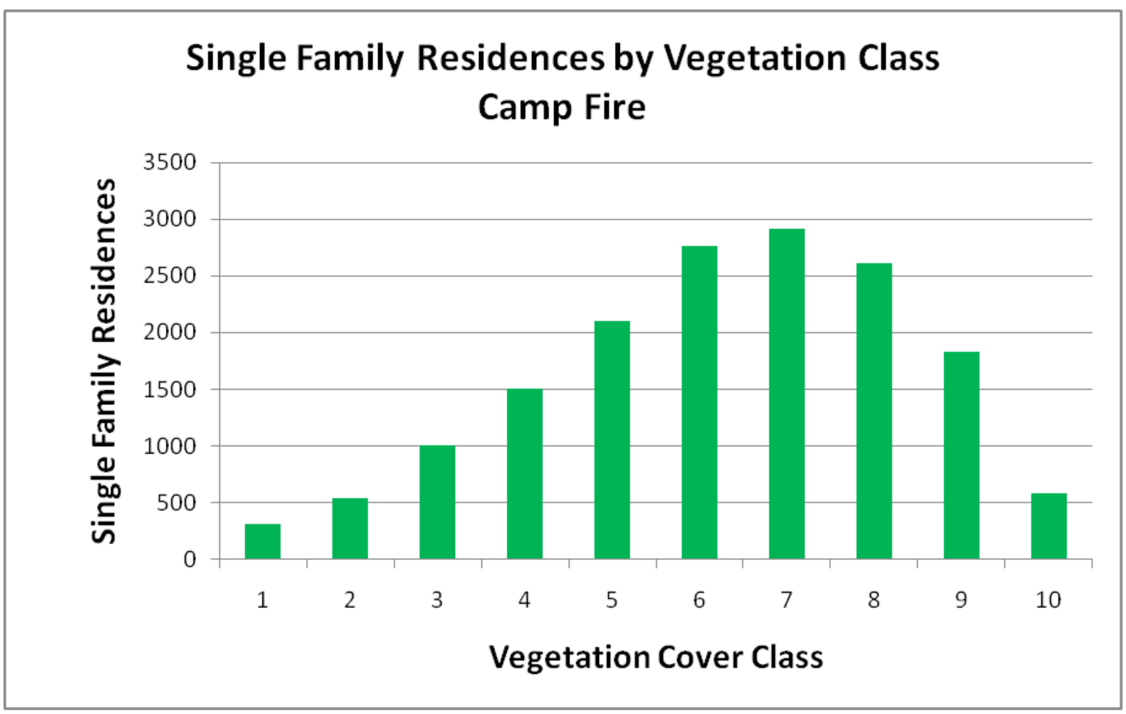

Legend
Primary Direction of Fire Spread
Single Family Dwellings
Survived
Lost
Tubbs Fire Extent
Sources: Esri, USGS, NOAA, Sources: Esri, Garmin, USGS, NPS
0
1.25
2.5
5 Miles
Knights Valley
Alexander Valley
Bald Hills
Devils Kitchen
Telegraph Hill
Horse Hill
Red Hill
China Flat
Calistoga
Fulton
Sonoma
Napa
Table Rock
Peter Hill
Chalk Point
Sugarloaf Hill
Bell Mountain
Chalk Hill
Diamond
Castle Rock
Mount Saint Helena

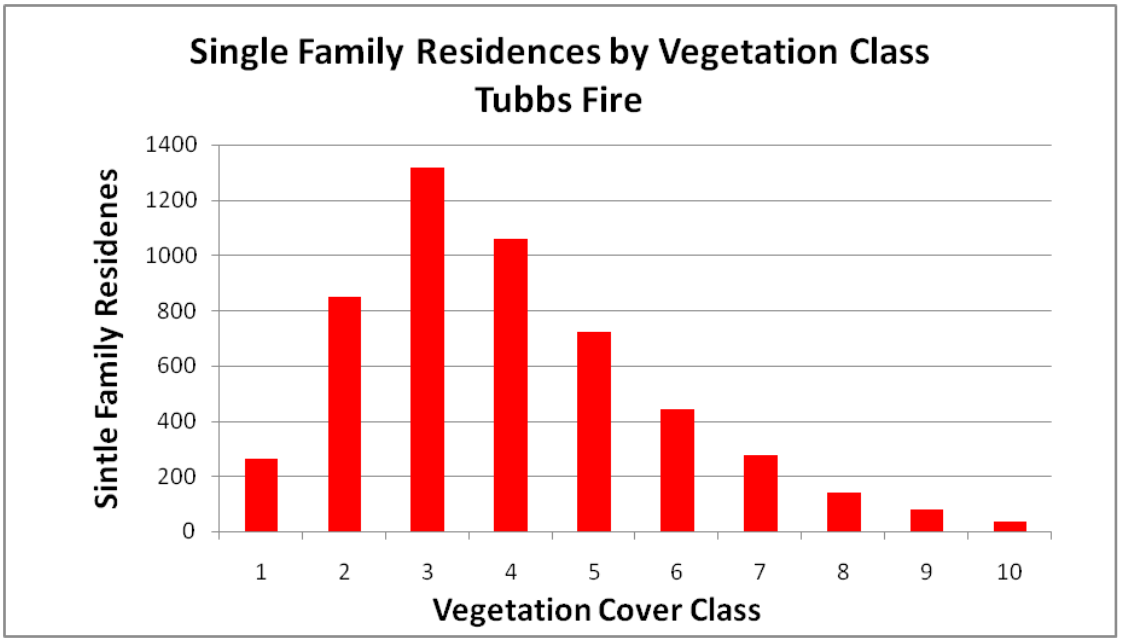
Carr Fire

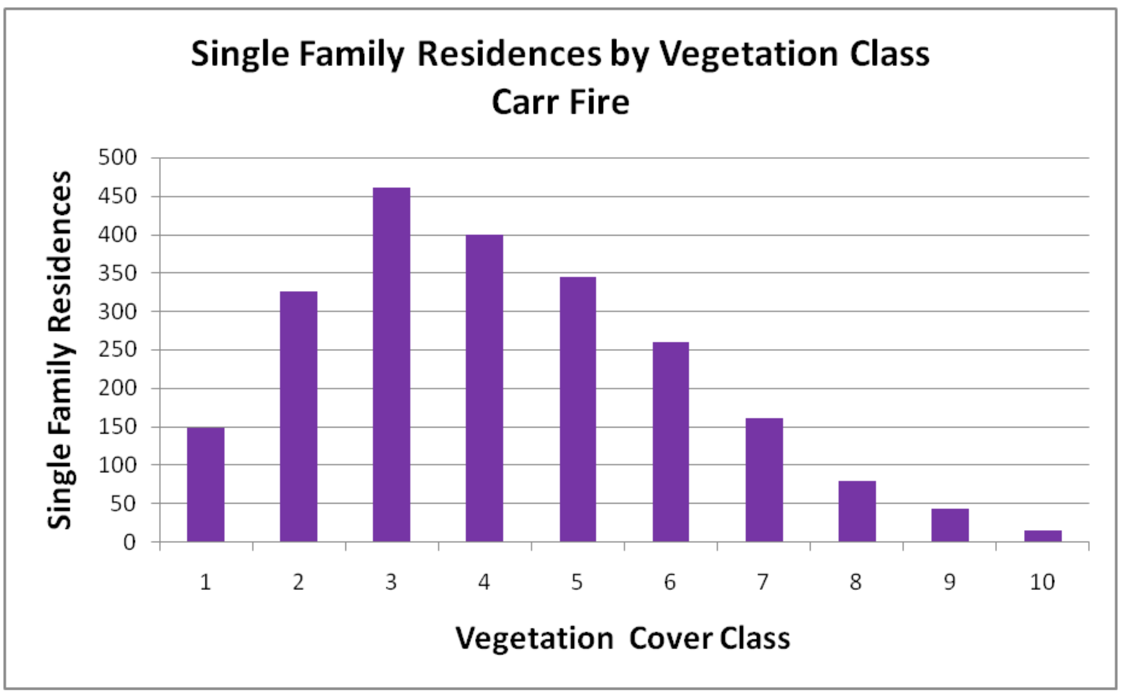

Legend
July 26 Direction of Fire Spread
Single Family Dwellings
Survived
Lost
July 26 Heat Perimeter
Carr Fire Extent
Crane Mountain
Lakehead
Sugarloaf
Schell Mountain
Wild Cow Mountain
Trinity Mountain
Clair Engle Lake
Bohemotash Mountain
Lewiston
TRINITY MOUNTAIN
Summit City
Area Where Fire Whorl Occured
Copley Mountain
Democrat Mountain
Whiskeytown Lake
Monarch Mountain
South Fork Mountain
Mule Mountain
Buffy Choop Mountain
Igo
Ono
HAPPY VALLEY
299
5
Sources: Esri, USGS, NOAA, Sources: Esri, Garmin, USGS, NPS
0
2.5
5
10 Miles

Structures by Cover Class:






Single Family Residences by Vegetation Class
Tubbs Fire
Sintle Family Residenes
Vegetation Cover Class
1400
1200
1000
800
600
400
200
0
1
2
3
4
5
6
7
8
9
10


Single Family Residences by Vegetation Class
Carr Fire
Single Family Residences
Vegetation Cover Class
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10

Loss Rates by Vegetation Cover Class:

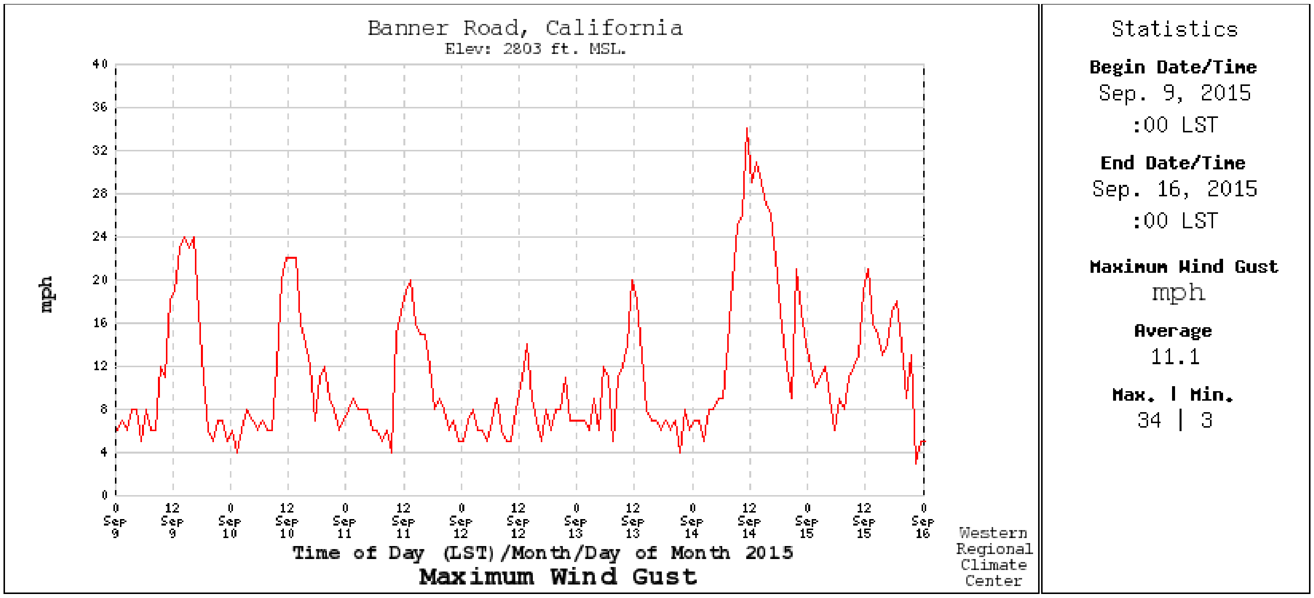
Veg Class	BUTTE FIRE Single Family Homes	Ave. Veg Cover	Proportion Lost
1	69	0.05	0.28
2	114	0.15	0.26
3	188	0.25	0.43
4	187	0.35	0.47
5	223	0.45	0.59
6	160	0.55	0.71
7	119	0.65	0.71
8	67	0.75	0.90
9	46	0.85	0.89
10	13	0.92	0.85
TOTAL	**1186**	**0.42**	**0.55**

Veg Class	CAMP FIRE Single Family Homes	Ave. Veg Cover	Proportion Lost
1	300	0.05	0.44
2	528	0.16	0.55
3	1004	0.25	0.69
4	1495	0.35	0.75
5	2102	0.45	0.83
6	2766	0.55	0.86
7	2912	0.65	0.88
8	2609	0.75	0.89
9	1824	0.84	0.89
10	576	0.94	0.92
TOTAL	**16116**	**0.58**	**0.83**

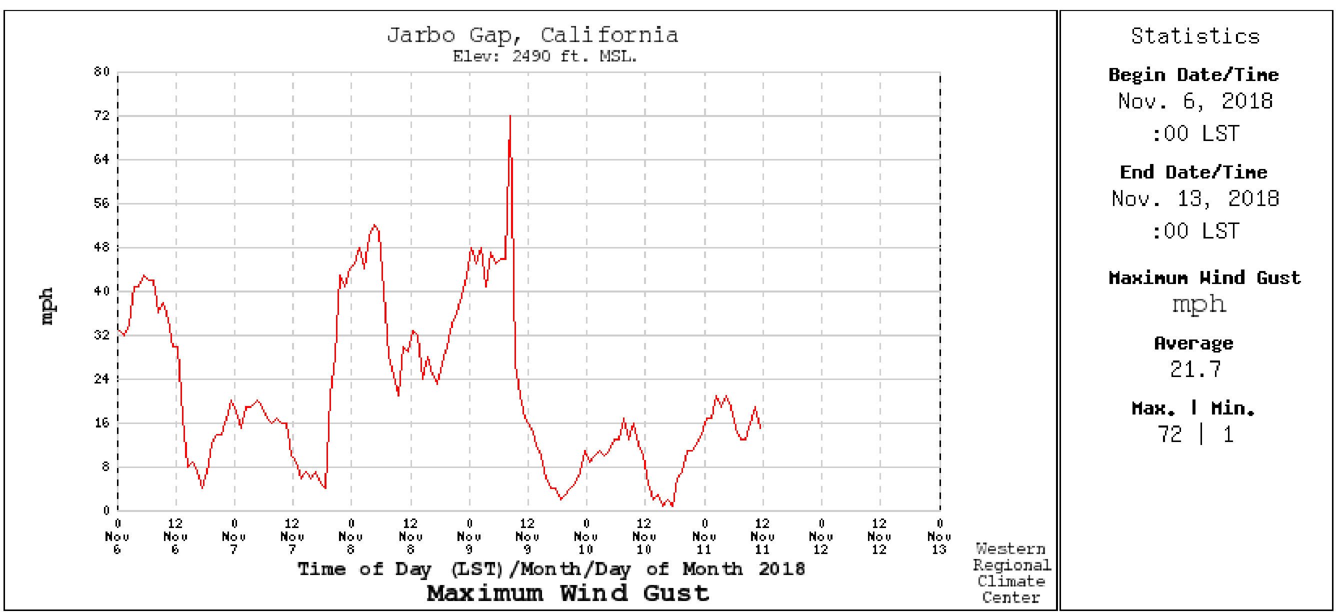
	TUBBS FIRE		
Veg Class	**Single Family Homes**	**Ave. Veg Cover**	**Proportion Lost**
1	262	0.07	0.79
2	848	0.16	0.85
3	1317	0.25	0.85
4	1058	0.35	0.84
5	722	0.45	0.85
6	441	0.55	0.85
7	276	0.64	0.79
8	141	0.74	0.82
9	79	0.84	0.84
10	35	0.94	0.94
TOTAL	**5179**	**0.35**	**0.84**

	CARR FIRE		
Veg Class	**Single Family Homes**	**Ave. Veg Cover**	**Proportion Lost**
1	148	0.06	0.29
2	325	0.15	0.42
3	460	0.25	0.47
4	399	0.35	0.50
5	344	0.45	0.54
6	260	0.55	0.48
7	161	0.65	0.62
8	79	0.74	0.65
9	43	0.83	0.63
10	14	0.95	0.36
TOTAL	**2233**	**0.37**	**0.49**

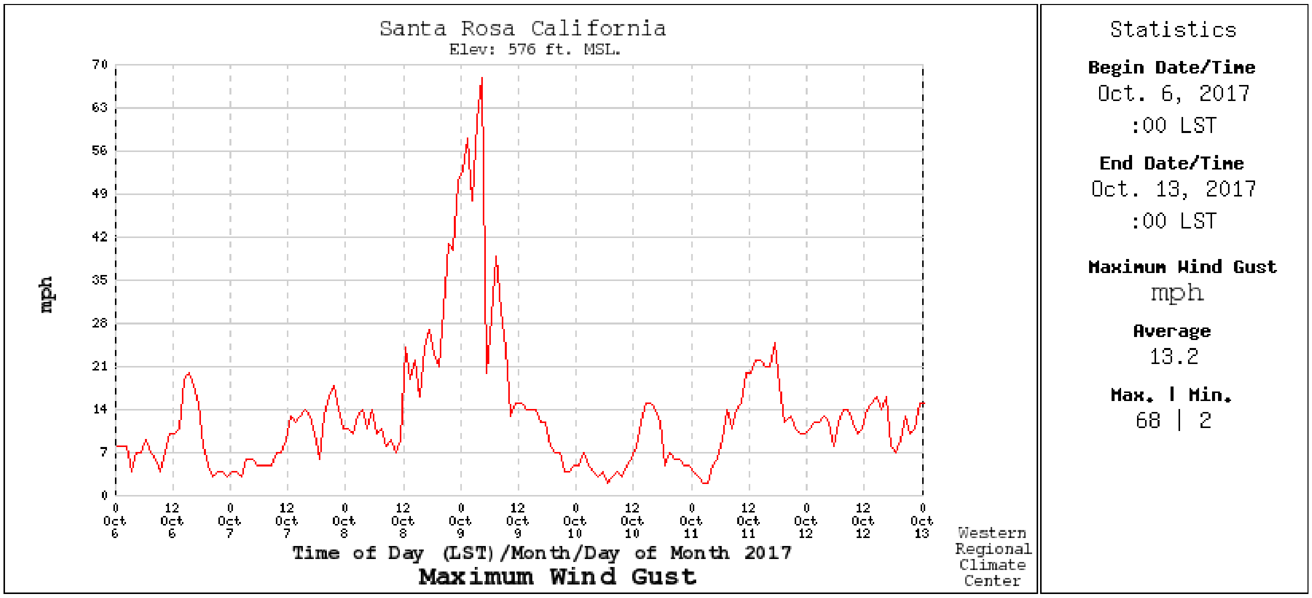
Butte Fire Maximum Winds:



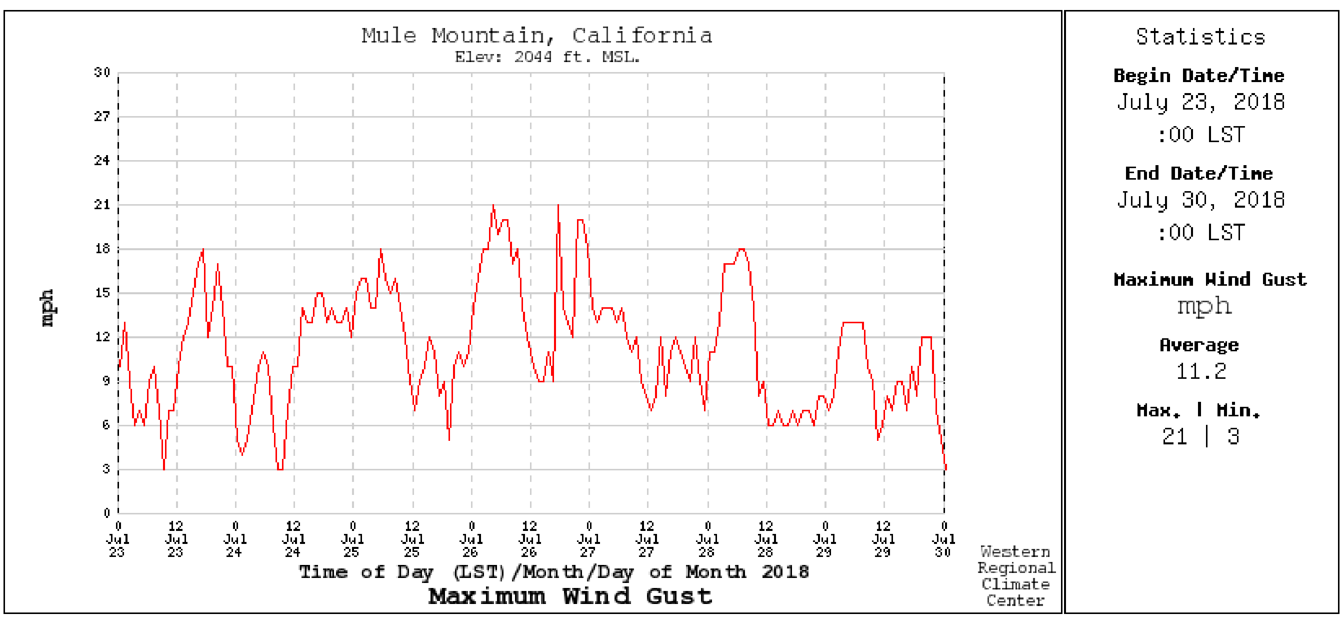
Camp Fire Maximum Winds:



Tubbs Fire Maximum Winds:



Carr Fire Maximum Winds



Source: RAWS USA Climate Archive (https://raws.dri.edu/wraws/)

Elevation Range for Structures:

Fire	Single Family Residences (SFR)	SFR Loss Rate	Average SFR Elevation (feet)	Maximum SFR Elevation (feet)	Minimum SFR Elevation (feet)	Average SFR Veg Cover
Butte	1186	55.3	2231	2981	740	0.42
Camp	16116	83.1	1868	3115	223	0.576
Tubbs	5179	84.1	427	2418	127	0.346
Carr	2233	48.8	936	4747	499	0.368

Single Family Residences by Vegetation Lifeform**

Fire	Herbaceous	Hardwood	Conifer	Urban	Shrub	Barren	Agriculture
Butte Fire	89	372	445	138	133	4	5
Loss rate	38.2%	55.1%	70.6%	29.7%	43.6%	75.0%	40.0%
Camp Fire	126	2387	6757	4390	2368	19	68
Loss rate	55.6%	79.5%	87.8%	77.5%	85.6%	73.7%	85.3%
Tubbs Fire	512	1619	420	2340	238	21	29
Loss rate	77.0%	83.7%	75.5%	88.8%	81.5%	52.4%	37.9%
Carr Fire	56	829	173	370	560	243	0
Loss rate	37.5%	44.3%	49.1%	39.1%	62.1%	50.6%	0.0%

** From CAL FIRE Forest Resource and Assessment Progam (FRAP) statewide 2015 vegetation map (FVEG) https://frap.fire.ca.gov/mapping/gis-data/

Note: Some Urban areas appear to be misclassified as Barren in the Carr Fire area. As a result, the two classes were combined for analysis purposes.

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