Using CASE and Intersect Geoprocesses to Calculate Wildfire Impacts on Incorporated Cities

By: Devin Cormia, May 2019

Project Summary

This project developed a ARCMAP mxd file and file geodatabase for analysis of fire perimeters provided by CALFIRE through their Fire Resource and Assessment Program (FRAP). The primary focus of analysis was quantifying the impacts of wildfire on WUI communities by mapping both fire perimeters and incorporated areas in California.

Project Purpose

California wildfires are increasing in size and severity due to several factors including a warming climate, dense forest conditions due to forest management and fire suppression activities, and a significant conifer mortality event driven by drought and pest infestations. At the same time, California's population continues to grow, with a significant portion of new housing being built in the Wildland Urban Interface (WUI). Under the wrong conditions, such as low humidity and high winds, wildfires can grow quickly and burn catastrophically into WUI communities with little warning. This project seeks to build a tool to quantify and analyze locations of wildfire occurrence where they enter WUI communities.

Process

Fire perimeters and boundaries of incorporated areas in California were downloaded from CALFIRE FRAP (http://frap.fire.ca.gov/data/frapgisdata-subset) and loaded into ARCMAP. Data tables were analyzed for attributes, and a new field was created in the incorporated areas dataset for calculated acreage. This field will be used to calculate percentage of an incorporated area burned in a wildfire later in the process.

Next, an intersect geoprocess was conducted on the fire perimeters and incorporated area layers. This process finds overlapping polygons and clips them, combining the attributes to create a new polygon with both datasets intact. Figure 1 below shows the Camp Fire perimeter in red, incorporated areas with hash lines, and the intersect in yellow where the Camp Fire overlapped with both a portion of Chico and the entirety of Paradise.

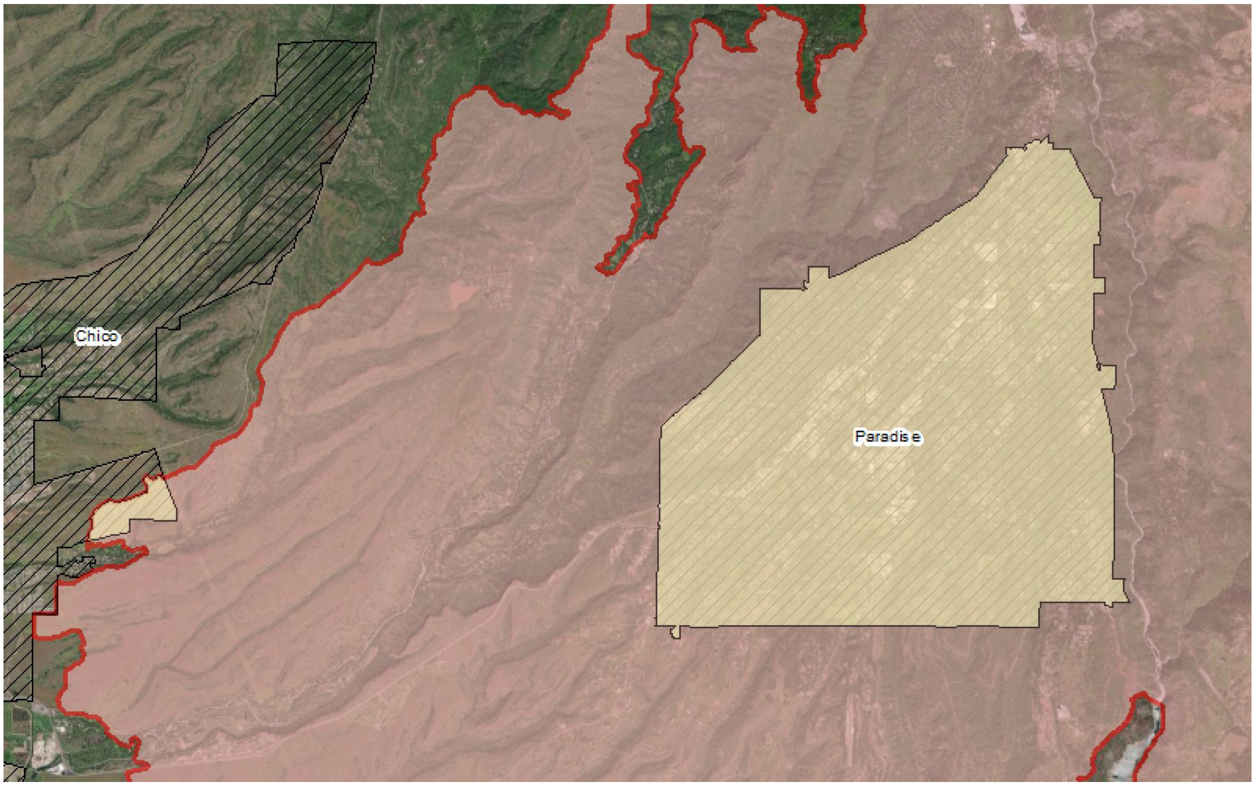
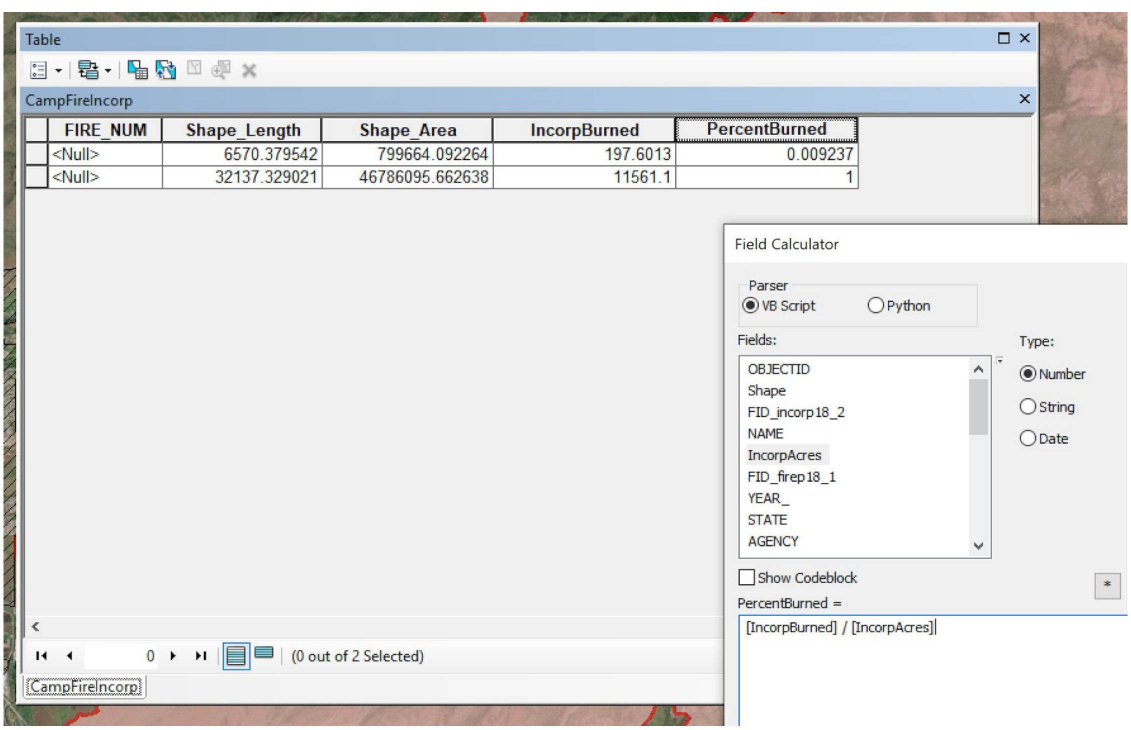


Figure 1 - Camp Fire (Red), Chico & Paradise(Hashed Area), Intersect (yellow).

With the intersect complete, two additional columns were created in the new feature class: IncorpBurned and PercentBurned. IncorpBurned was another calculated geometery of the acreage of each new polygon, while IncorpBurned calculated the percentage of an incorporated area which burned in that fire by dividing the burned area by the total acreage of the incorporated area.

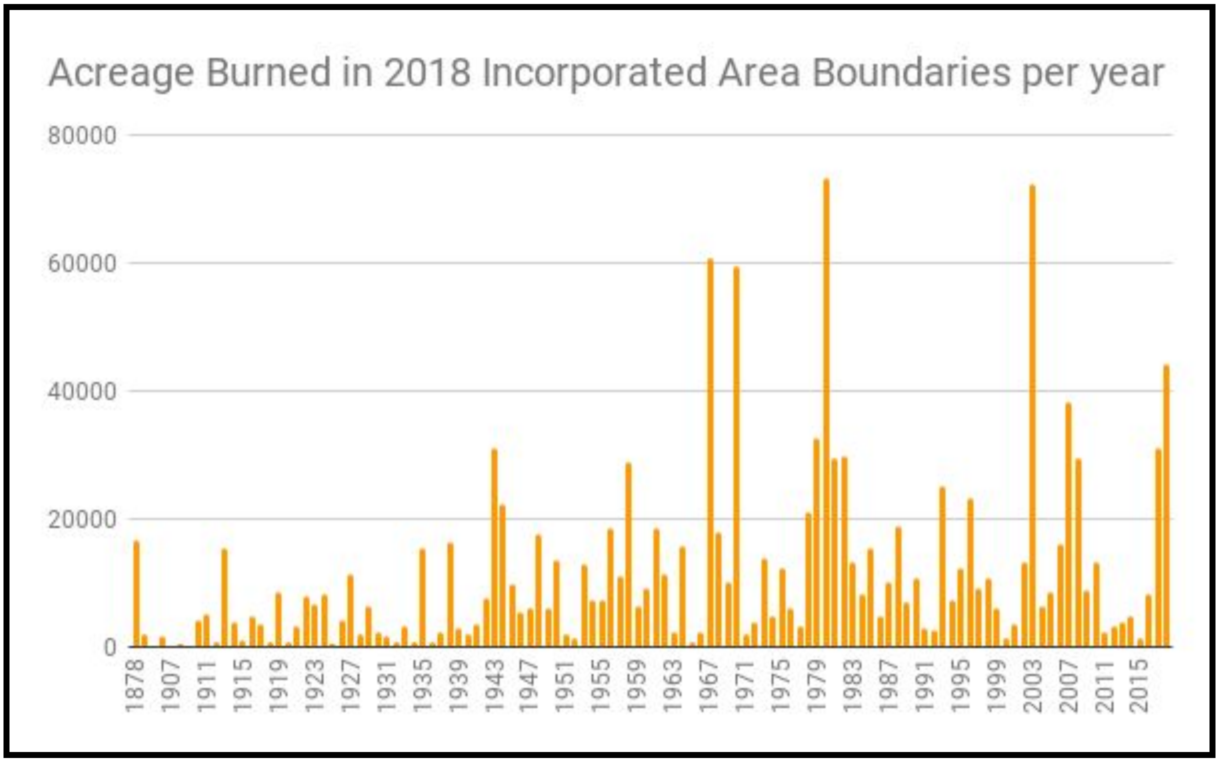


FIRE_NUM	Shape_Length	Shape_Area	IncorpBurned	PercentBurned
<Null>	6570.379542	799664.092264	197.6013	0.009237
<Null>	32137.329021	46786095.662638	11561.1	1

Analysis

After completing those steps for the statewide dataset, the resulting data table was exported to Google Sheets to complete the numerical analysis. Using sumif and sumifs equations (CASE), a number of tables and charts were generated.

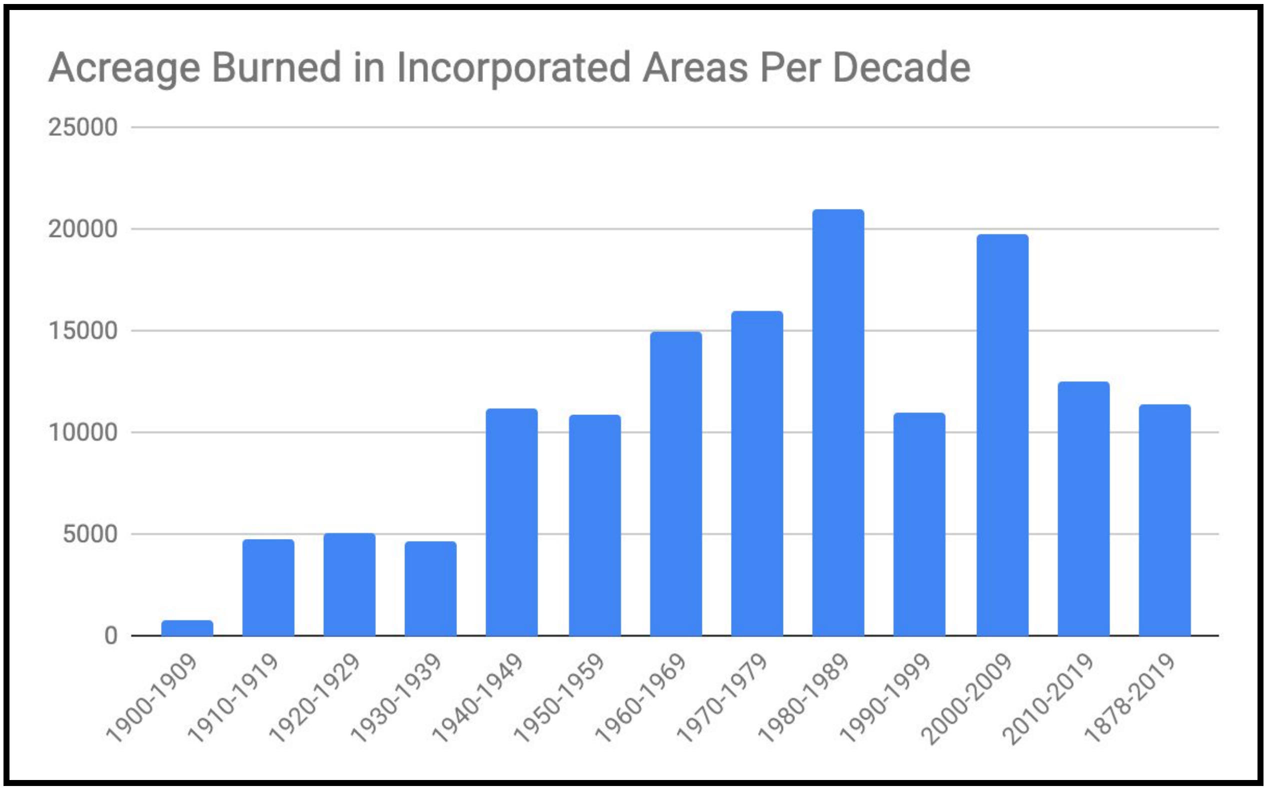
Are incorporated areas burning at an increased rate?



An important note to consider: these incorporated area perimeters are for incorporated areas in 2018. They do not represent historic incorporated areas. That being said, it is still useful to compare the total acreage which is burning each year in these areas to quantify increases if they exist.

The first thing I noticed when I generated this chart from yearly acreage burned in incorporated areas was the cyclical nature. I had anticipated seeing a positive linear increase as the climate warms and wildfires grow larger. Instead, I was surprised to see that there are distinct cycles lasting about a decade typically with a peak year with burned acreage far above the average. Periods of drought typically correspond with very low acres burned in WUI (https://en.wikipedia.org/wiki/Droughts_in_California)

To better answer my question, I grouped each year by decade to see if a clearer trend would present itself. While the trend line is still positive, total acres per decade are down from a peak of 1980-1989. However, 2019 fire season has not yet occurred and those totals will increase the final decade sum.

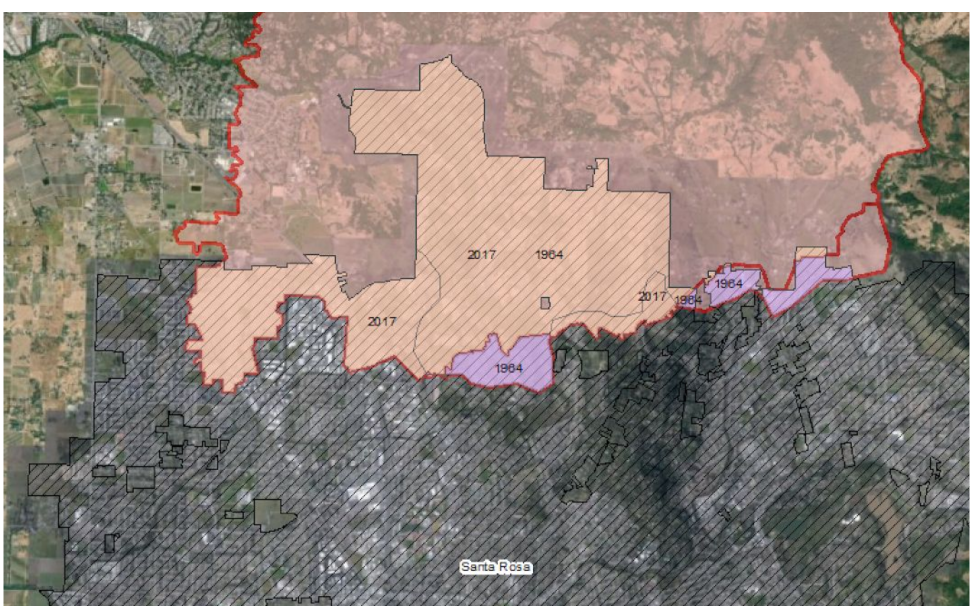


What are the primary ignition causes of wildfires which burn incorporated areas?

My second question was if there was a predominant cause of wildfires which burn acreage in incorporated areas. Generating a table to compare on a year by year basis, I identified equipment use, arson, vehicles, and powerlines as occasional primary causes, but it varies year by year and all are far outpaced by the unknown category. However, fires from powerlines were the leading known source of incorporate acreage burned in 2018, and the Tubbs fire which burned into Santa Rosa was recently ruled as caused by faulty electrical wiring on private property. With several devastating mega fires started by powerlines in the past few years, utilities are doing more to reduce the risk including preemptive outages to prevent arcing, and forestry along their powerlines.

Year	Lightning	Equipment Use	Smoking	Campfire	Debris	Railroad	Arson	Playing with Fire	Miscellaneous	Vechicle	Powerline	Firefighter Training	Non Firefighter Training	Unknown
1990	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,333.60	0.00	0.00	0.00	0.00	9,304.51
1991	0.00	50.40	0.00	0.00	0.00	0.00	222.07	0.00	0.00	0.00	0.00	0.00	0.00	2,679.42
1992	0.00	0.00	0.00	0.00	0.00	0.00	68.18	0.00	299.65	0.00	0.00	0.00	0.00	2,141.68
1993	0.00	5,182.57	0.00	0.00	0.00	0.00	7,364.07	0.00	141.11	0.00	2,778.55	0.00	0.00	9,739.46
1994	2,231.54	4.54	0.00	498.06	0.00	0.00	677.21	0.00	219.86	0.00	0.00	0.00	0.00	3,722.46
1995	0.00	2,154.26	511.40	420.99	0.00	0.00	1,633.41	200.61	577.78	209.53	46.51	0.00	0.00	6,525.68
1996	0.00	7,967.89	4,863.22	154.65	403.27	0.00	87.97	501.71	387.98	0.00	515.88	0.00	0.00	8,534.91
1997	65.00	897.99	0.00	0.00	0.00	0.00	3,460.42	477.49	1,360.62	51.76	361.93	0.00	0.00	2,523.63
1998	435.93	1,855.63	0.00	228.69	0.00	0.00	6,833.29	0.00	0.00	0.00	13.64	0.00	0.00	1,477.82
1999	1,752.53	28.87	0.00	0.02	0.00	0.00	537.51	0.00	1,644.18	0.00	3.25	0.00	0.00	2,045.22
2000	0.00	354.23	0.00	0.00	0.00	235.57	11.41	198.61	17.71	0.00	0.00	0.00	0.00	611.32
2001	0.00	23.82	0.00	0.00	0.00	0.00	714.29	0.84	88.35	375.84	25.58	0.00	0.00	2,296.29
2002	0.00	4.69	7.25	0.00	0.00	74.26	8,396.17	710.91	2,032.52	425.73	571.74	0.00	0.00	946.67
2003	0.00	37,997.10	68.42	0.00	0.00	0.00	24,166.30	50.36	20.26	455.01	810.12	0.00	722.90	8,023.69
2004	0.00	454.05	0.00	0.00	0.00	0.00	3,209.32	1,409.75	0.00	60.11	458.50	0.00	0.00	947.35
2005	0.00	59.62	0.00	2,851.13	0.00	137.13	537.55	140.36	101.63	19.93	375.09	0.00	0.00	4,229.10
2006	1,278.93	71.75	0.00	0.00	0.00	0.00	8,006.54	0.00	597.15	9.49	677.92	0.00	0.00	3,689.91
2007	3,583.22	373.72	785.06	26.59	117.88	0.00	555.53	1,434.24	27,208.60	167.16	991.49	0.00	0.00	2,907.25
2008	160.49	175.78	0.00	935.67	0.00	0.00	61.07	493.85	356.72	20,295.34	0.20	0.00	0.00	4,474.56
2009	19.09	498.23	130.80	0.00	0.00	0.00	6,641.24	43.90	107.86	291.50	563.82	0.00	0.00	707.09
2010	0.00	12,063.05	126.98	0.00	0.00	2.22	67.00	38.91	23.67	106.98	37.93	0.00	0.00	704.71
2011	1,398.37	152.16	0.00	1.13	17.14	0.00	77.73	0.00	527.62	14.24	0.38	0.00	0.00	174.46
2012	14.77	136.90	0.00	0.00	0.00	0.00	6.45	0.00	1,874.79	19.86	42.79	0.00	0.00	1,116.48
2013	0.00	89.84	7.17	0.00	87.72	0.00	352.31	91.45	75.06	49.78	45.61	0.00	0.00	3,184.11
2014	0.00	1,081.01	0.00	1,749.65	0.00	0.00	287.16	0.00	60.92	13.36	0.09	0.00	0.00	1,670.27
2015	148.55	33.69	0.00	193.48	0.00	0.00	0.00	0.04	63.19	2.50	6.11	0.00	0.00	574.77
2016	0.00	2,709.43	0.00	16.98	0.00	0.00	304.19	0.00	3,215.23	55.35	4.19	0.00	0.00	2,111.90
2017	0.36	1.33	0.00	371.31	3,850.20	0.00	557.64	0.12	5,281.42	4,923.95	0.00	0.00	0.00	16,011.70
2018	0.00	242.39	0.00	1.21	0.00	0.00	0.66	0.00	1,580.81	1,934.05	11,758.71	0.00	0.00	28,806.51

After answering my primary questions, I also identified a use of the tool which was developed: analyzing recurrence rates of fires around WUI communities. Because I had chosen not to perform a dissolve on my intersect function by specific fire, the generated polygons were split into overlapping polygons which was well suited to identify areas which had previously burned. See figure 2 below where the tool identified two fires burning along similar paths into Santa Rosa. Using the identify features tool I identified the second fire as the Hanly (1964) fire which had burned into Santa Rosa along very similar path as the Tubbs fire (figure 3).



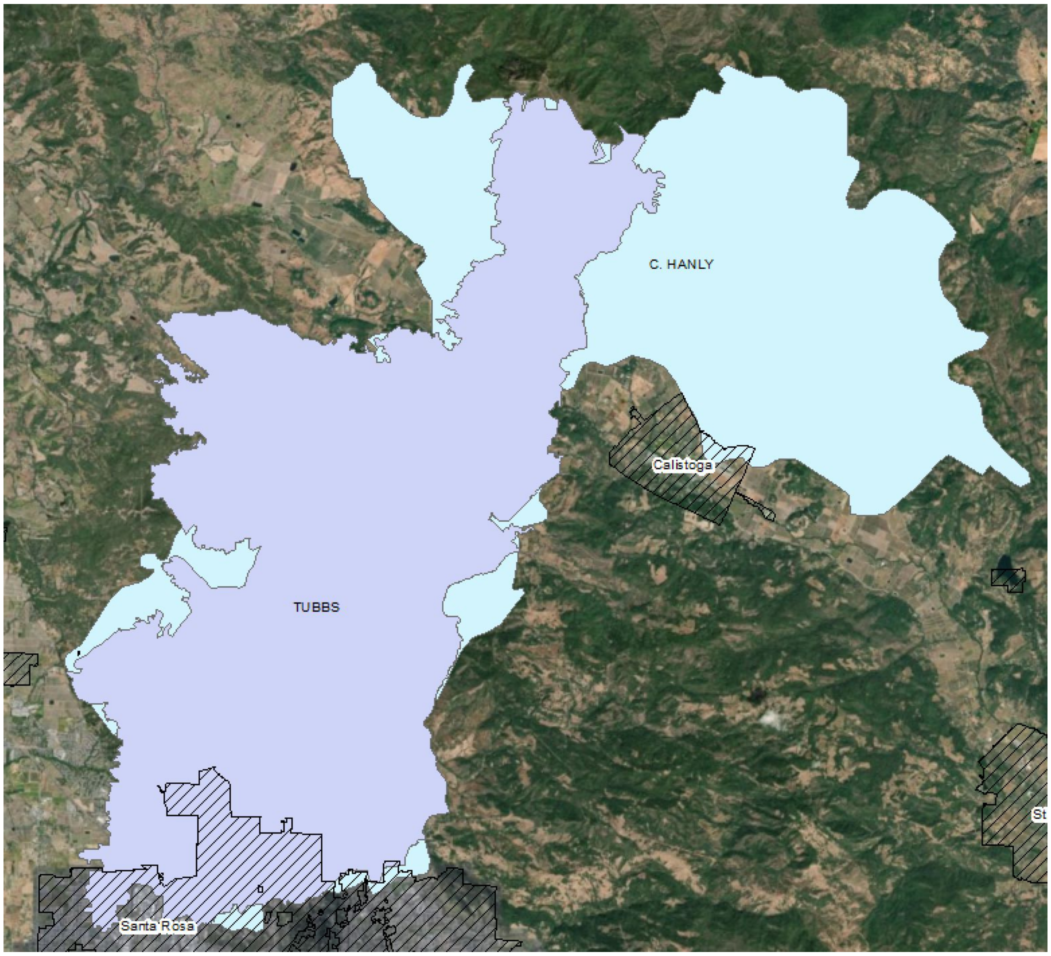


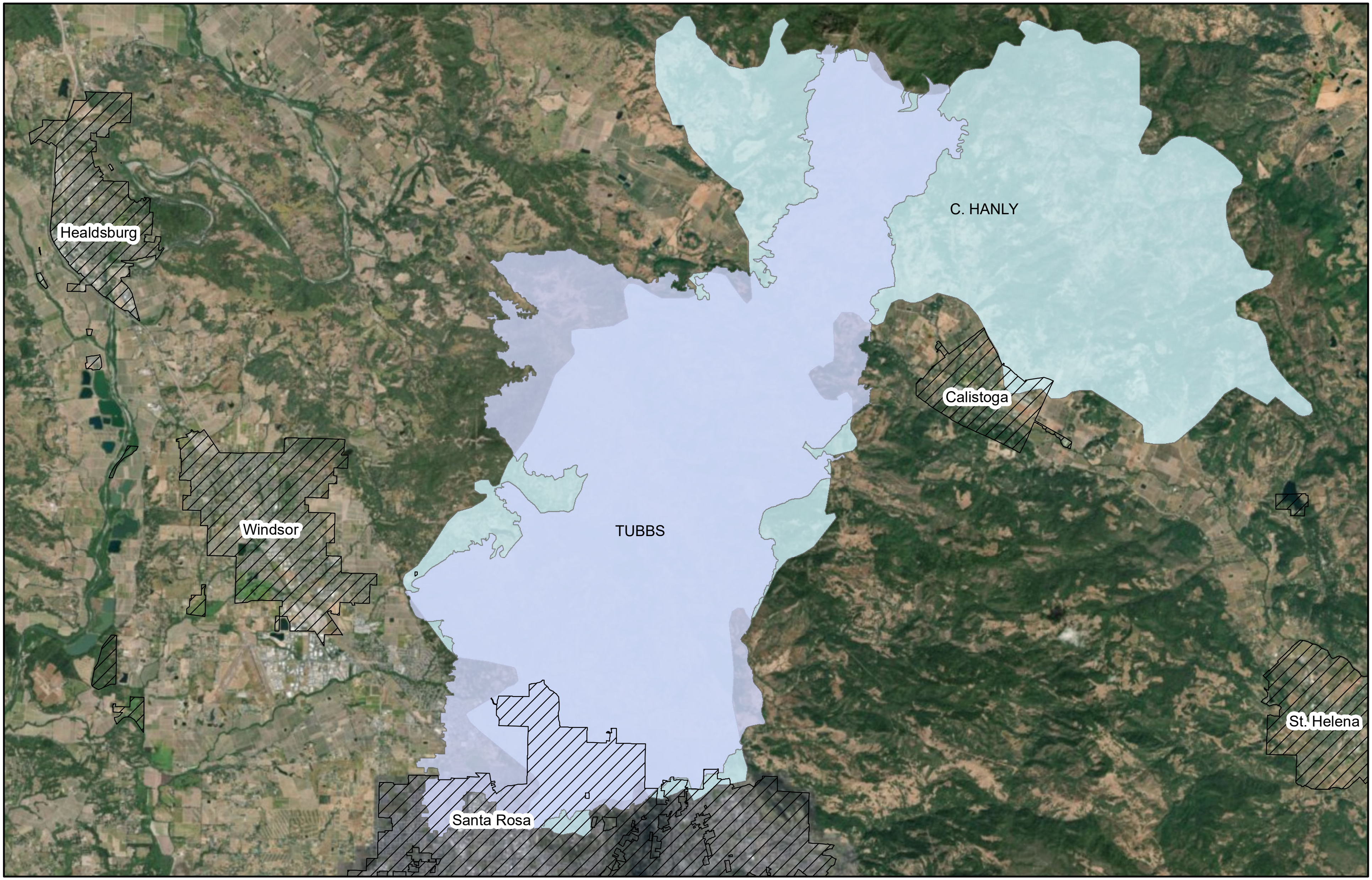
Figure 3: Tubbs (2017) and Hanly (1964) fires.

Conclusion

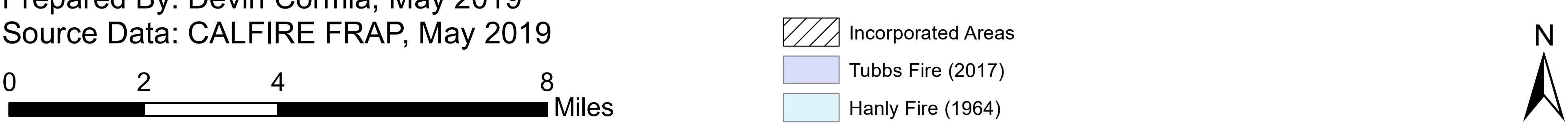
While fire perimeters don't tell us the severity of fire or impacts to both humans and the environment, they can give us an idea of where fires have burned historically as we work to protect our communities. For regions where wildfire is historically present such as in Grass Valley where I live, being aware of the size of prior fires can motivate communities to work together to reduce fuel loads on their properties, as well as partner with large landowners such as CA STATE PARKS, USFS, and BLM to create strategic fuel breaks around communities.

After completing this project I know that I have barely scratched the surface of the thousands of 34,453 polygons generated by the tool and the potential lessons that can be learned from past wildfires in WUI areas. I am realizing that my skills in statistics could be further developed to help with the analysis of the large datasets generated through GIS models.

Comparison of the Tubbs and Hanly Fire Perimeters



Prepared By: Devin Cormia, May 2019
Source Data: CALFIRE FRAP, May 2019



Comparison of the Camp and Humboldt Fire Perimeters