Investigating Wildfire Severity: Analysis of California Fire-Perimeter Data Leveraging Geographic Information Systems

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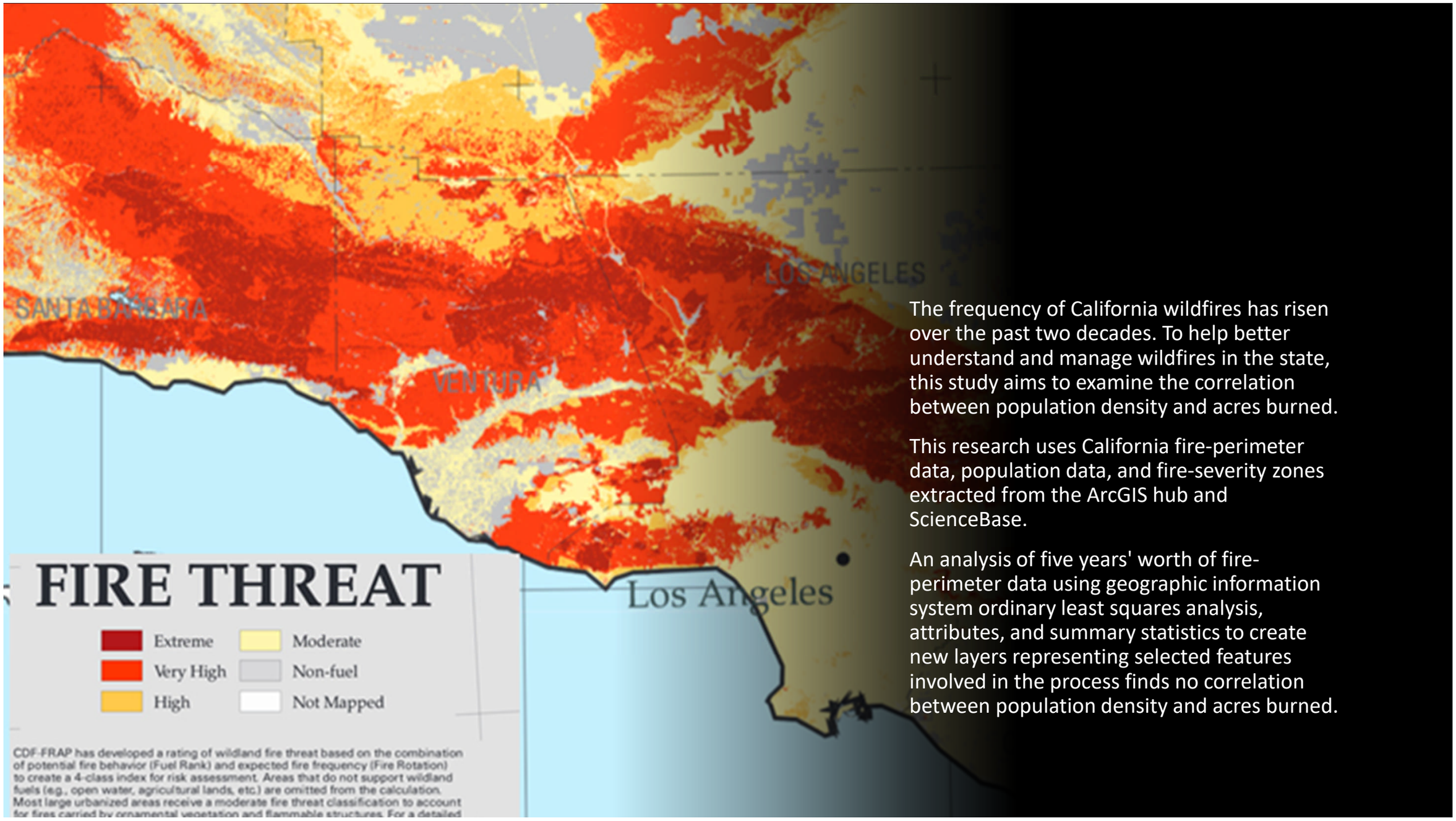
Professor of Information Systems and Business Management at California State University (CSULA). Dr. Sultan holds a PhD in Information Systems and Technology from Claremont Graduate University. She is a certified professional in supply management with experience in account product management, operations, and automated system projects development.

In addition to her current role at CSULA, Dr. Sultan serves as an Information Governance Senior Advisor at Southern California Edison, as well as a Research Fellow at the Claremont Graduate University (CGU) Center for Information Systems & Technology. She has over than twenty years of industry experience with publications focusing on energy informatics and the digital transformation within supply chains.

Dr. Sultan research primarily focuses on energy informatics and sustainability. Her areas of interest are the applications of GIS, big data analytics, as well as machine learning within the energy domain, particularly the spatial distribution of Distributed Energy Resources (DERs) and resolving grid integration challenges.

Since 2019, Dr. Sultan has been participating in IARIA conferences in various roles. She has served as a Steering Committee Member as well as offered keynotes at multiple IARIA conferences, including Energy and the Annual IARIA Congress. She has also served as an Associate Editor of Proceedings for the International Conference on Smart Grids, Green Communications and IT Energy-aware Technologies.

Currently, Sultan is working on developing Asset Data Solutions for Southern California Edison, research projects that aim for renewable energy supply and smart grid development. As an IARA Fellow, she supports IARIA's International efforts and remains in a supportive role to promote scientific and industrial interchanges.

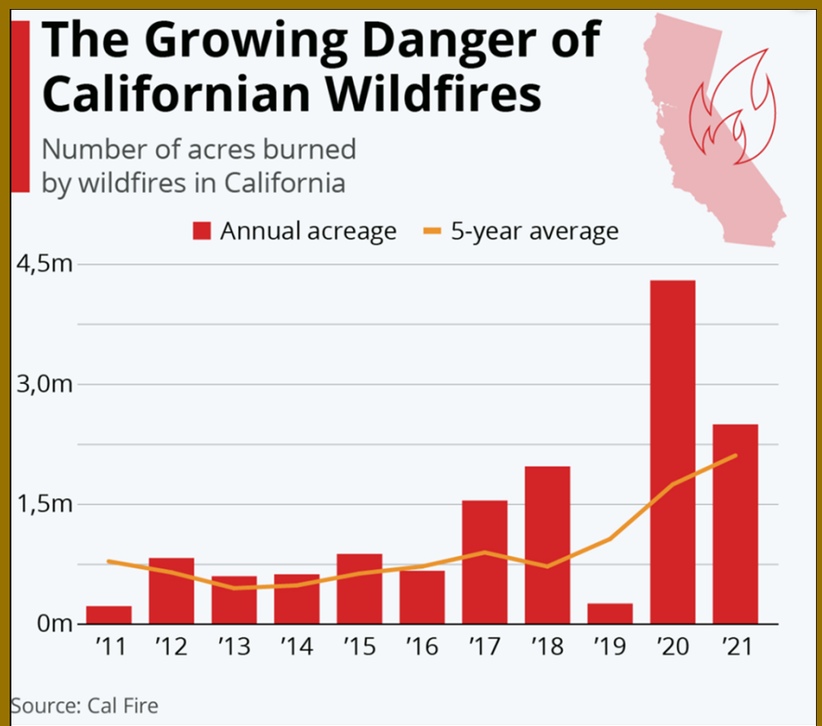


The frequency of California wildfires has risen over the past two decades. To help better understand and manage wildfires in the state, this study aims to examine the correlation between population density and acres burned.

This research uses California fire-perimeter data, population data, and fire-severity zones extracted from the ArcGIS hub and ScienceBase.

An analysis of five years' worth of fire-perimeter data using geographic information system ordinary least squares analysis, attributes, and summary statistics to create new layers representing selected features involved in the process finds no correlation between population density and acres burned.

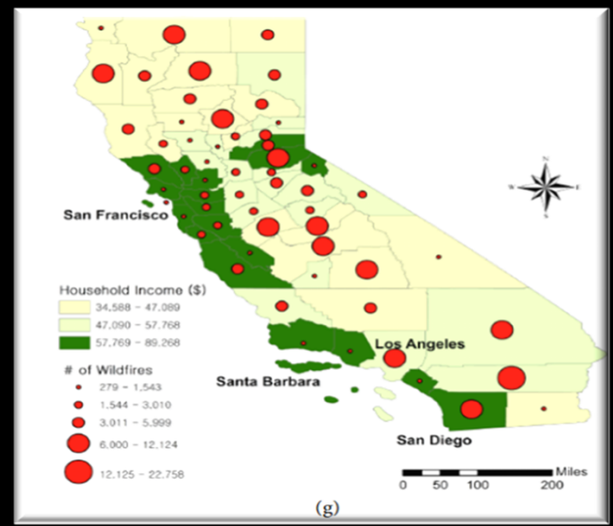
California’s wildfires are causing more and more damage (Fleck 2022)

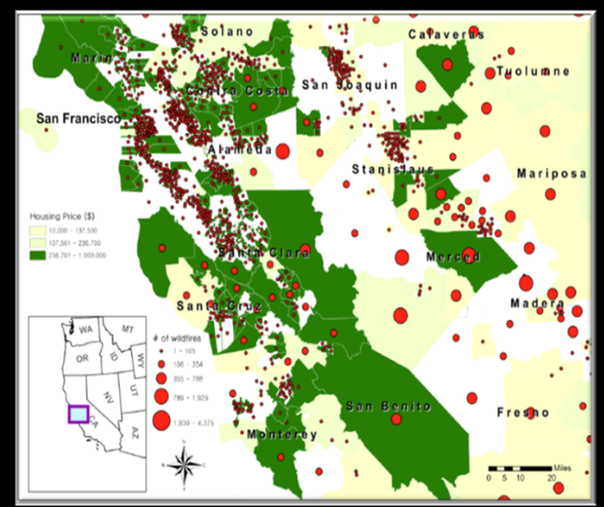


- The amount of land burned by wildfires in the state has risen dramatically
- This is costing California more and more money
- Up from $61 million in the 1990s to more than $400 million in the 2010s

Associations between Wildfire Risk and Socio-Economic-Demographic Characteristics Using GIS Technology (Hwang 2022)

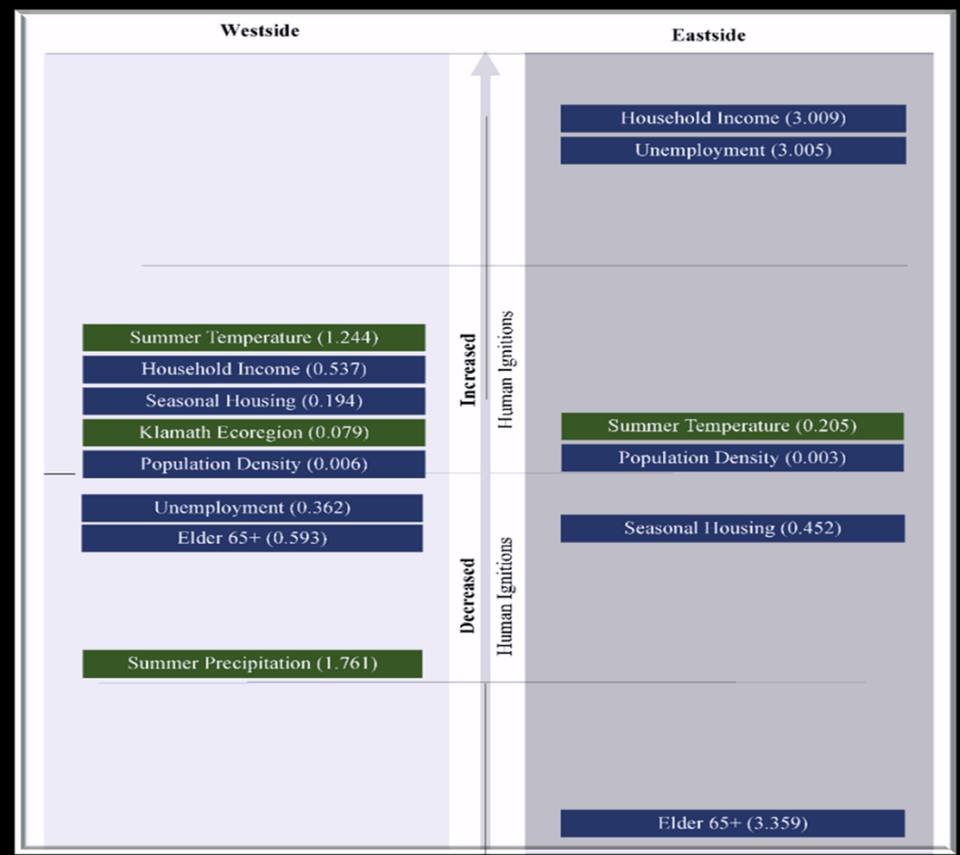
- Identified a correlation between socioeconomic status and ignitions
- Found correlation between wildfire risk and demographic characteristics at census tract level but not the county level



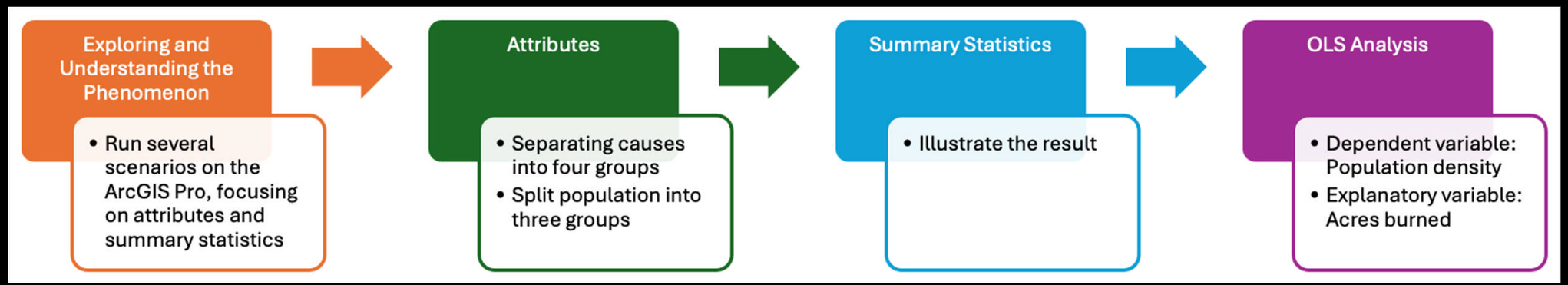


The Influence of Socioeconomic Factors on Human Wildfire Ignitions in the Pacific Northwest, USA (Reilly, 2023)

- Study area: Washington and Oregon
- Census county level
- Found correlation between household income and ignitions



Techniques and Tools Used During the Analysis Phase



OLS Analysis

- Split population density into three groups, signified by color
- One-to-many spatial-join to combine fire-perimeter and population-density layers enabling extraction of counties where fires took place
- With all the data in one layer, the analysis was conducted using OLS with population as the dependent variable and acres burned as the explanatory field

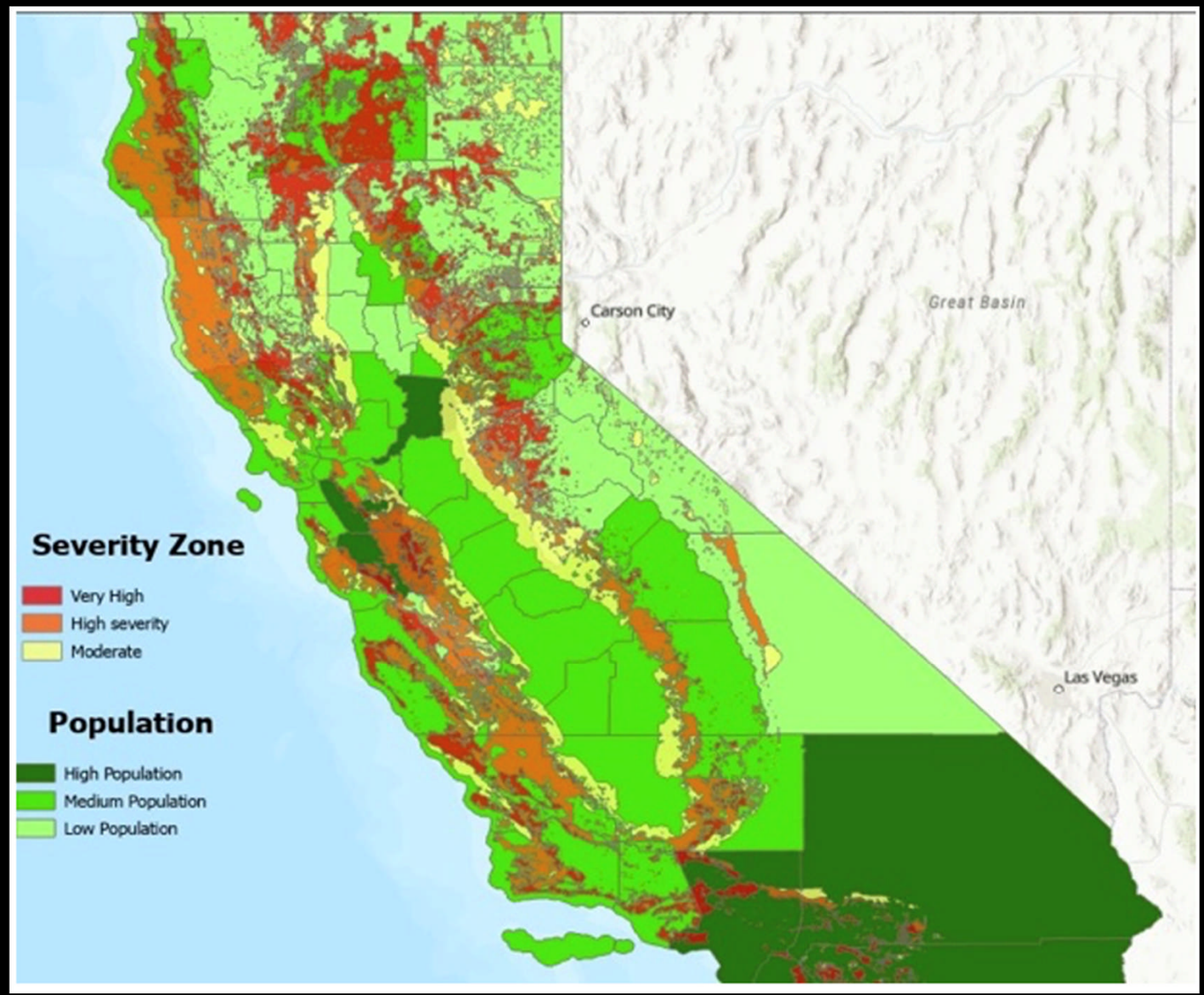
Separating Causes and Population Density

The attributes tool helped separate the causes into four groups

- Unknown other causes
- Human causes
- Natural causes
- Industrial causes

Population-density groups

- High
- Medium
- Low



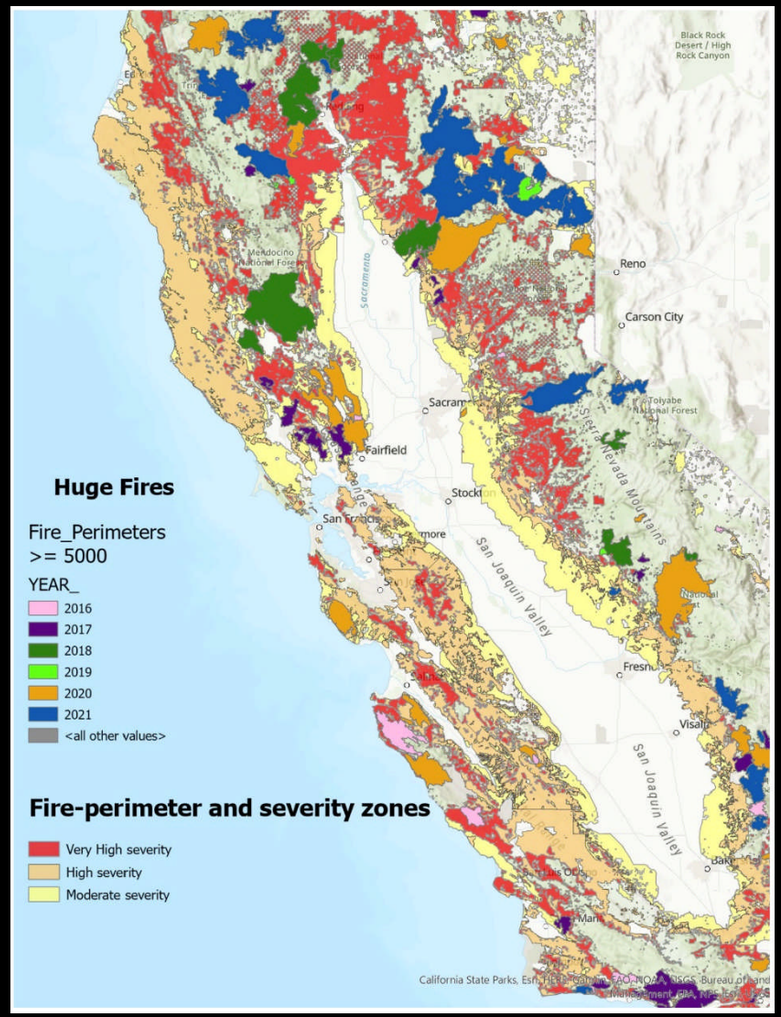
Fire-Severity Zones with the Population Data

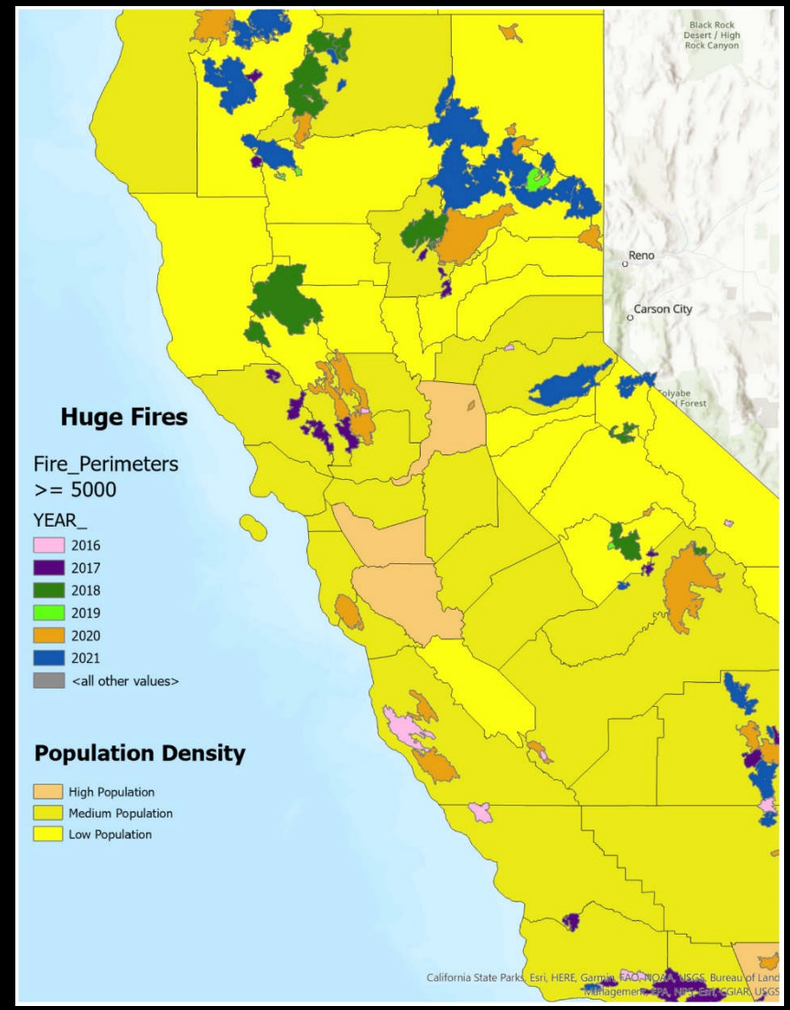
- Few patterns emerge between population and severity zones
- High and moderate fire-severity zones appear within medium and low population areas

Further Analysis

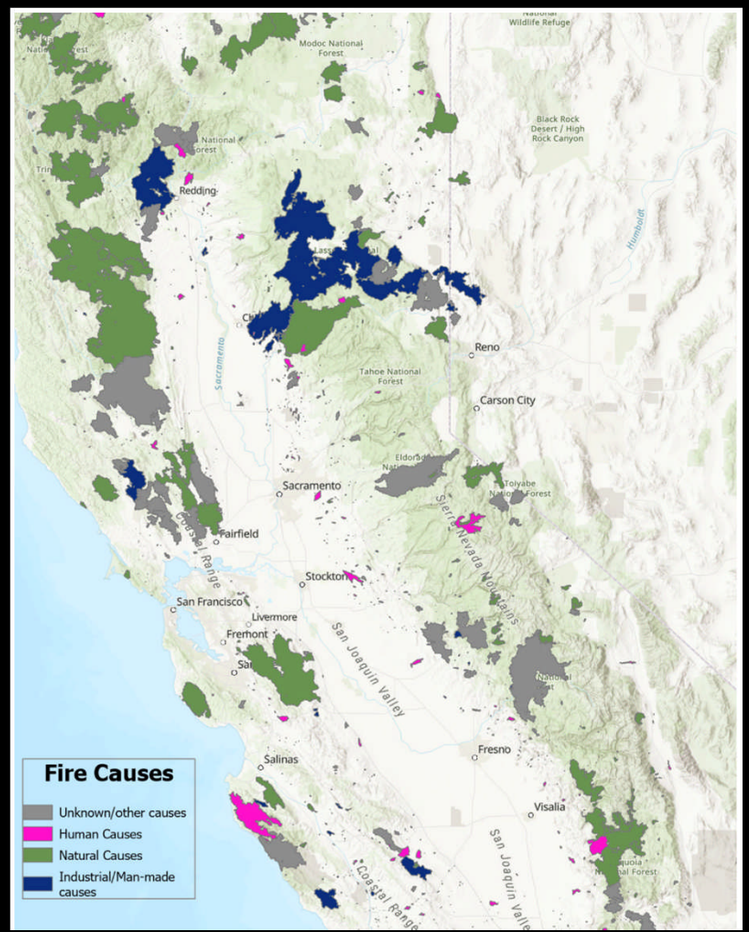
Additional analysis was conducted to further investigate the proposed correlation: Only larger fire data were included - those that burned at least 5,000 acres

Huge Fire Locations/Huge Fires with the Population





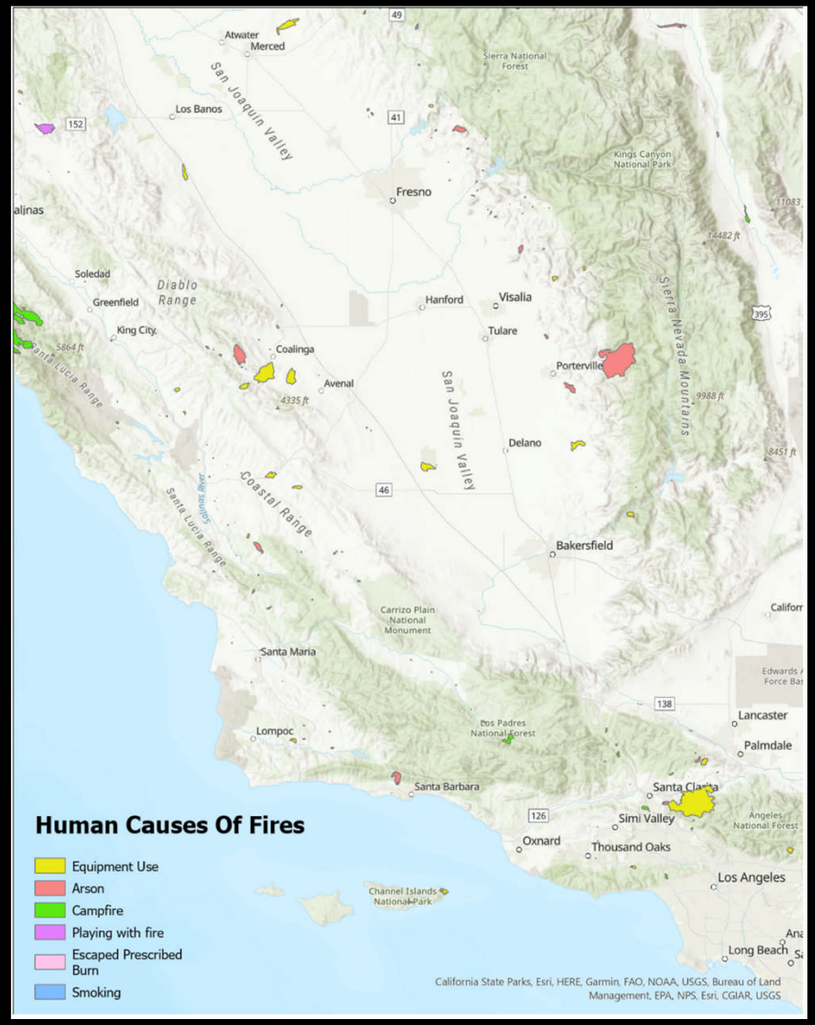
Causes and Acres Burned



To get a deeper understanding, the summary-statistics tool used to return the frequency of the fires per cause, the sum of all the acres burned, and the mean acres burned for a given cause

Cause	Frequency	Sum of acres	Mean of acres
Unknown/other	1,189	3,023,862.61	2,543.20
Human	525	464,800.54	885.33
Natural	495	2,845,918.36	5,749.33
Industrial	355	1,609,638.03	4,534.19

Human Causes



Equipment use is a more frequent cause of fire with 298, but its mean acres is just 481.3095. Campfires burned the most acres (180,044.4) and the highest mean (3,830.73). The least cause is smoking where the frequency is 14 and the mean of acres is 78.8814

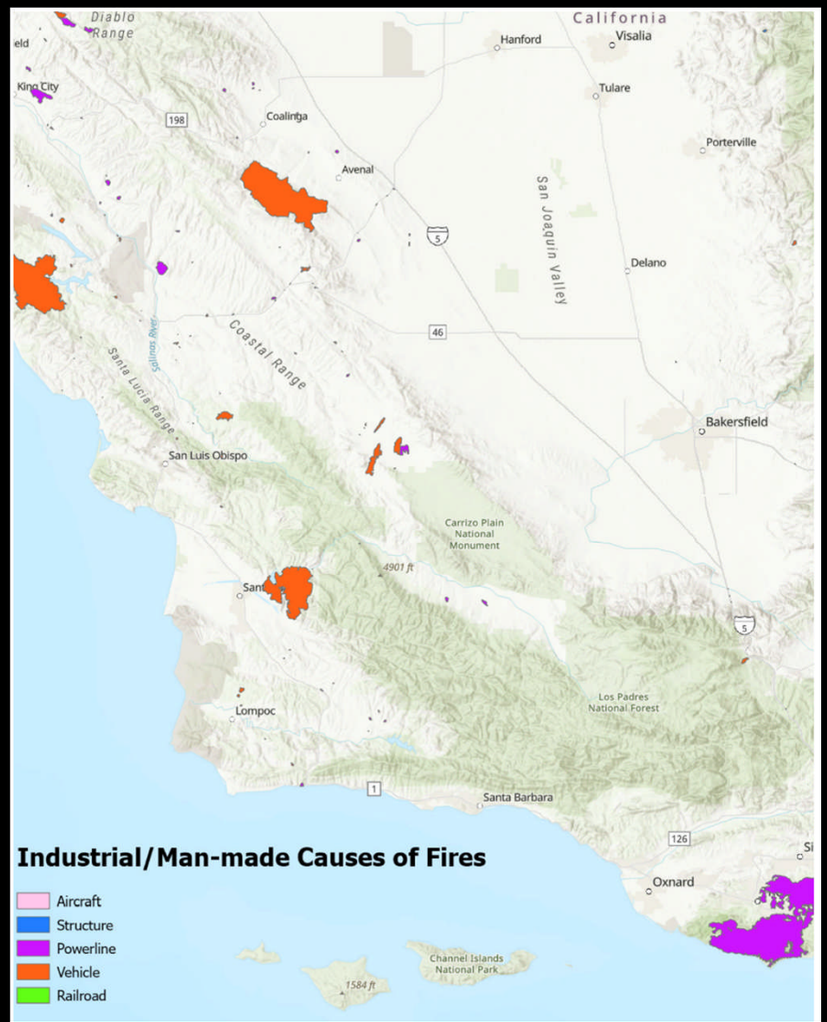
Cause	Frequency	Sum of acres	Mean of acres
Equipment Use	298	143,430.20	481.31
Smoking	14	1,104.34	78.88
Campfire	47	180,044.40	3,830.73
Arson	125	135,449.90	1,083.60
Playing with fire	26	2,325.25	89.43
Escaped prescribed burn	15	2,446.46	163.10

Natural Causes and Types

Two sub causes of the natural causes were debris and lighting. The separate layers help visualize fires based on their specific causes. Lighting is the most common natural cause with also a higher mean of acres burned compared to debris

Cause	Frequency	Sum of acres	Mean of acres
Lightning	393	4,620,219.4	11,756.28
Debris	102	62,338	611.157

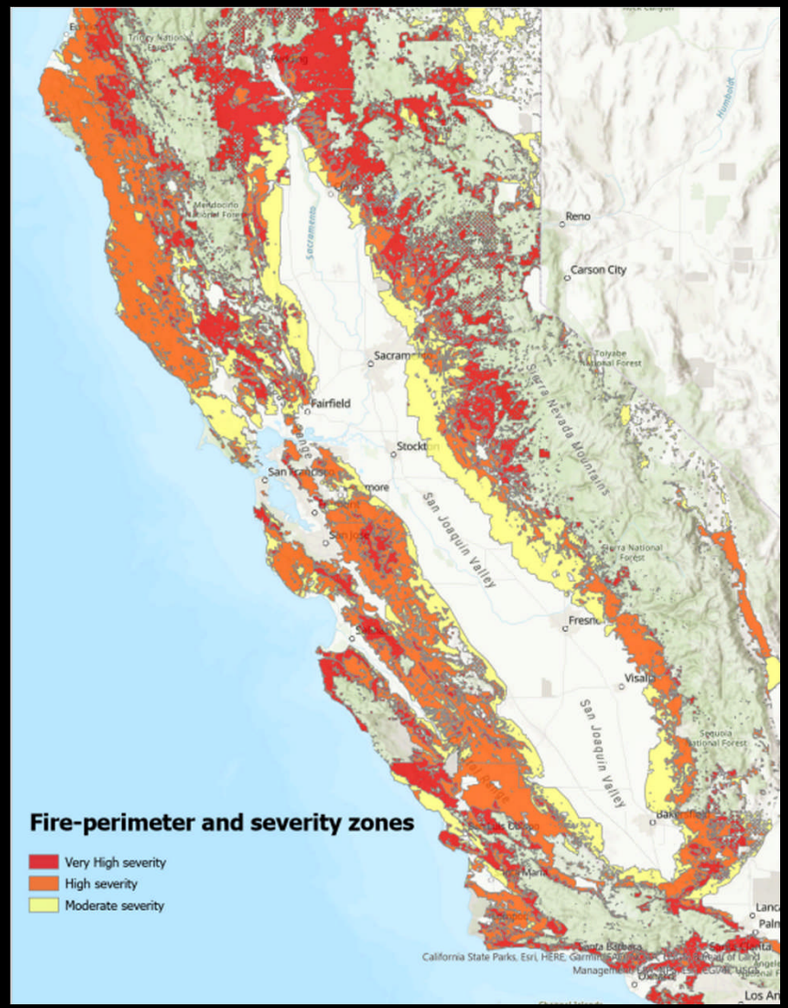
Industrial Causes and Types



The most frequent cause is vehicle while the higher mean of acres is powerlines. The least frequent are both railroad and aircraft causes while the mean of acres for the railroad cause is higher than for the aircraft cause

Cause	Frequency	Sum of acres	Mean of acres
Railroad	3	427.00	142.33
Vehicle	198	368,135.40	1,859.27
Powerline	144	1,240,273.50	8,613.01
Structure	7	502.15	71.74
Aircraft	3	300.00	100.00

Fire-Perimeter and Severity Zones



Another investigation joined the fire-perimeter and severity zones. After the joining, the summary-statistics tool was used to learn how frequently the fires occurred in the area, the sum of acres burned in the severity zone, and the average acres burned per zone

Severity	Frequency	Sum of acres	Mean of acres
Moderate	633	149,997.29	236.96
High	608	207,325.72	340.99
Very High	1,323	7,586,896.53	5,734.62

Main Findings

- There is no correlation between population density and acres burned (R^2 = 0.000009) where more wildfires are caused by humans than by nature
- Population density does not affect fire severity
- More awareness campaigns must be conducted at the state level and might help reduce the number of acres burned

Future Directions, Research Limitations, and Techniques in Analyzing Wildfire Causes

One of the research limitations is the data used for the analysis - some causes were classified as unknown/other. If the causes were known, the results may change

- As a future direction, interviews may be conducted to classify those causes, or other data may be used
- Another future direction is to change the analysis techniques by, for example, using the Kernel density estimation (KDE) Spatial Analyst tool or other techniques to create a map of statistically significant hot spots for wildfires


Joining Forces…Building an Approach
to Wildfire Prevention