MAPPING THE VULNERABILITY OF WILDFIRES IN SANTA BARBARA COUNTY

Photo Credit: National Geographic (2018) Cranston Fire

PPD 631 GIS Project

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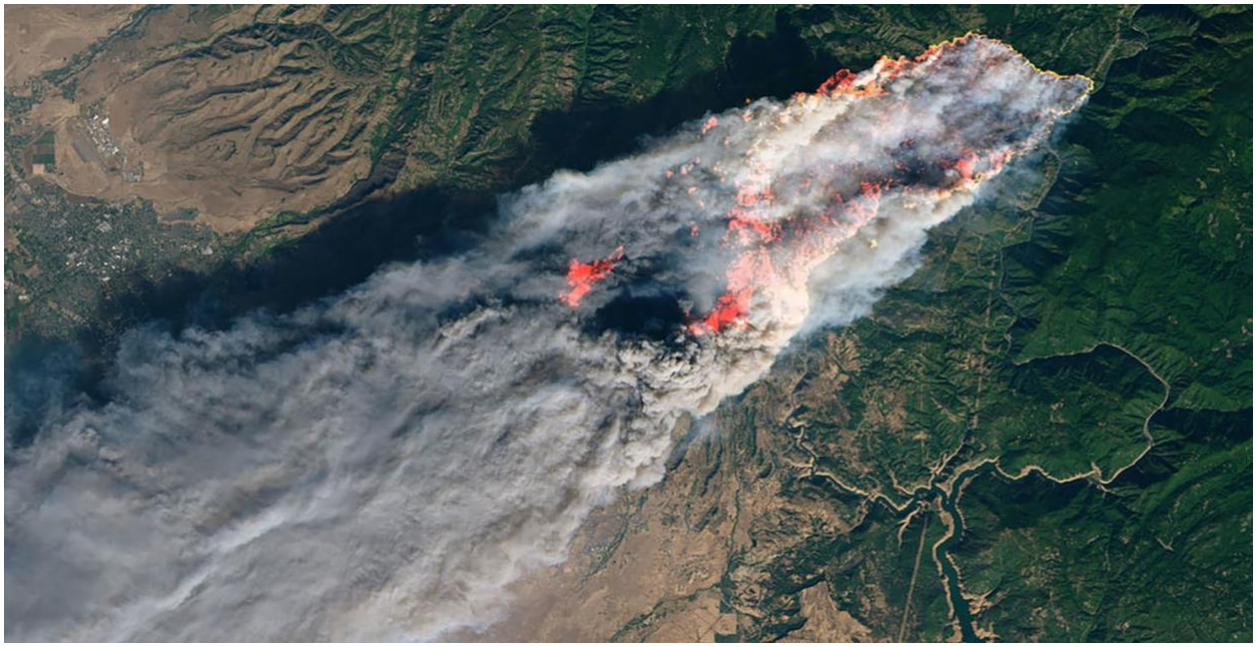
Introduction

The dry, windy and often hot weather conditions from spring through autumn have always made Southern California a target place suffer from wildfires. Started on November 8, 2018, the Camp Fire has become the most destructive and deadliest wildfire in California's history since the Cloquet fire in 1918, torching thousands of homes and obliterating the historic town of Paradise.[1] According to BBC news reports, the fire has caused at least 63 civilian fatalities, more than 600 people missing, razed an area of about 14,500 acres, and destroyed 17,148 structures. As of November 19, the latest estimated insured losses from the Camp and Woolsey wildfires in California will be between $9 billion and $13 billion.[2]

The plague of the wildfires in California is often the result of the combination of winds, dry combustible vegetation and growing wildland-urban interface areas.



Source: Esri & NASA, 2018

[1] Martinez, Gina (2018). "The California Fire That Killed 48 People Is the Deadliest U.S. Wildfire in a Century". *Time*. Retrieved November 18 from http://time.com/5453710/california-camp-fire-deadliest-wildfires-us-history/

[2] James, Emmanuel (2018). "Insured losses from Camp and Woolsey wildfires estimated at $9-13 billion: RMS" *Reuters*. Retrieved Nov. 18 from: https://www.reuters.com/article/us-california-wildfires-insurance/insured-losses-from-camp-and-woolsey-wildfires-estimated-at-9-13-billion-rms-idUSKCN1NO18Y

Project Objective

There are more than 20 major wildfires on record in Santa Barbara County from 1955 to 2018. The Thomas Fire that started in Ventura County, spread rapidly into southern Santa Barbara County in December 2017, destroying at least 1,063 structures and causing over $2.2 billion in damage.[3] The dry and hot summer in Santa Barbara County makes it more likely to be in high wildfire danger in late fall. Winter rains will further worsen the situation by causing massive mudslides and debris flows. The County occupies 2,774 square miles of land, one third of which is the Los Padres National Forest, making it more vulnerable to the spread of wildfires.

This project aims to identify the relationship between zones/areas that are most vulnerable to wildfires in Santa Barbara County and the following elements using Geographic Information System (GIS):

- Degree of development (using population density as measurement)
- Fuel loading (coverage of grassland)
- Proximity to fire stations

Assumptions are made that areas with relatively high population density, high fuel coverage and distant proximity to fire stations would experience more severe damage during wildfires.

Rationale of Using GIS

GIS tools can help us understand the big picture of the relationship between these elements and the region's vulnerability to wildfires. Geo-mapping allows the analysis to combine geographic distribution with regards to population density into the maps. The maps will picture the fire hazard severity zones in state responsibility area (SRA) using graduate colors to notice the differences.

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[3] Annette, Ding (2018). "Charting the Financial Damage of the Thomas Fire". *The Bottom Line*. Retrieved Nov. 2018 from https://thebottomline.as.ucsb.edu/2018/04/charting-the-financial-damage-of-the-thomas-fire

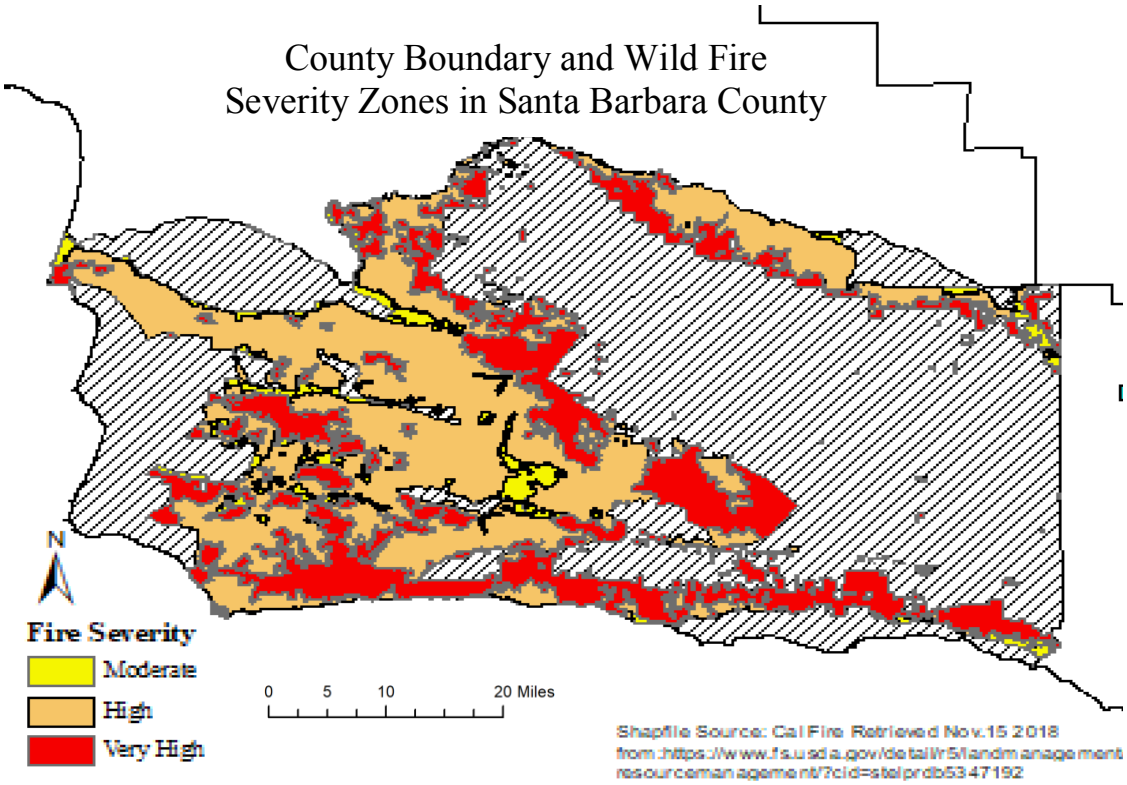
Data Collection and Methodology

- *Base Map and County Boundaries*

Source: California Department of Forestry and Fire Protection (CAL FIRE)

Both the State of California and Santa Barbara County boundaries shapefiles were retrieved from California Department of Forestry and Fire Protection (CAL FIRE). The County boundaries exclude four Northern Channel Islands: Santa Barbara Island, San Miguel Island, Santa Rosa Island, and the large Santa Cruz Island. The project will use the fire hazard severity zones in SRA in Santa Barbara County as the base map. It maps areas that designates zones (based on factors such as fuel, slope, and fire weather) with varying degrees of fire hazard (moderate, high, and very high) in graduated colors, demonstrating variations in three-level vulnerable zones/areas to wildfires.[4]

Figure 1



[4] Cal Fire (2018) "Wildland Hazard and Building Code" Retrieved Nov. 2018 from http://www.fire.ca.gov/fire_prevention/fire_prevention_wildland_faqs#fhsz01

- *Population Density*

Source: U.S Census Bureau: 2010 Census Tract, American Fact Finder: GCT-PH1

Research shows that there is a positive relationship between population density and an increase in burned area during a wildfire.[5] The project will examine the relationship between the severity of a wildfire and population density. I decided to use population density data by census tracts in Santa Barbara County to map the relationship. Census tracts shapefiles were retrieved from U.S. Census Bureau. The population data can be downloaded in Excel format from America Fact Finder website, which was classified into 6 quartiles in the ArcGIS Map. Two files were then joined together to create a new population density shapefile.

- *Fuel loading (coverage of vegetation)*

Source: United States Department of Agriculture Forest Services, Cal Fire

Fire spread is primarily through the fine herbaceous fuels, either curing or dead.[6] Wildfires can be intensified and exaggerated by the herbaceous material, in addition to the litter, stem and branch wood from the open shrub.[7] The project uses forest meadow data collected by Cal Fire and USDA Forest Service programs that is available in geodatabase format. The data was originally classified into 4 categories, indicating different forest vegetation.

- *Fire stations*

Source: California Department of Forestry and Fire Protection (CAL FIRE), Santa Barbara County Fire Department

[5] Ioannis Bistinas, Duarte Oom, Ana C. L. Sá, Sandy P. Harrison, I. Colin Prentice (2013) "Relationships between Human Population Density and Burned Area at Continental and Global Scales". *Plos One.* https://doi.org/10.1371/journal.pone.0081188

[6] Rocky Mountain Area Coordination Center. (n.d.) "Fire Behavior Fuel Model Descriptions" Retrieved Nov. 2018 from: https://gacc.nifc.gov/rmcc/predictive/Fire%20Behavior%20Fuel%20Model%20Descriptions.pdf

[7] Ibid.

Updated in 2018, 17 fire stations in total are located across Santa Barbara County. The data downloaded from Cal Fire includes all fire stations operated by local, state and Schedule A contract in California.

- *Proximity to fire stations (Travel Time)*

Travel time is defined as the time interval that begins when a unit is en route to the emergency incident and ends when the unit arrives at the scene.[8] NFPA Standard 1710 establishes an 80 second "turnout time" and 240 second "travel time" benchmark time goal for not less than 90% of dispatched incidents.[9] In the 2016 edition of NFPA 1710, the following was added: "… all units must arrive within 8 minutes travel time."[10] Since Santa Barbara County only has 17 fire stations compared to 106 fire stations in the City of Los Angeles, it's reasonable to give the County 5-minute travel time as mapping parameter. Given the traffic condition and other considerations, 5-minute travel time for fire engines in Santa Barbara City is estimated to be 2.5 miles. Buffer tool was used to visualize areas around fire station locations that can be reached within 5 minutes. As seen in Figure, the overlapped areas were dissolved so that the maps show the areas that can be reached in 5 minutes in Santa Barbara County.

Map Analysis

Figure 2 shows that population is concentrated in the southern, northwestern part of Santa Barbara County with a small part living in the middle of the county. The populous areas include Santa Barbara City, Santa Maria, Los Alamos, Lompoc, City of Goleta etc. Generally speaking, Santa Barbara County is not populous comparing to the neighbor counties like Los Angeles

[8] National Fire Protection Association (2016). "Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments" Retrieved Nov. 2018 from: https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=1710

[9] Fire and EMS Department. (n.d.) "Fire Response Time" Retrieved from https://fems.dc.gov/page/fire-response-time

[10] Ibid 8.

County. In the map, the areas with relatively large population density are shown in deep blue compared to the other regions. From this figure we could learn that the populous Santa Barbara City are surrounded by wildfires labeled very high severity by Cal Fire. High severe wildfires usually take place in the middle of the County, with occasional very high severe wildfires.

Figure 3 shows relationship of the coverage of vegetation and wildfire hazard severity. High and very high-level fire severity tend to happen in places covered with chaparral sine it provides the most widespread wildland fuel threat in Santa Barbara County.[11] The County's state responsibility area is covered with fire prone vegetation, referred to as "fuel beds". The map shows that the fires take place in all types of vegetations and most likely in the middle part of the County.

Figure 4 displays the layer of 5-minutes driving distance from fire stations. The fire stations in Santa Barbara County are concentrated in the City of Santa Barbara and other populous cities. Within the county limit, we notice that there are large areas in the middle, southwestern and northern part that are not covered by the 5-minute proximity. To cross-reference Figure 2 and Figure 4, we notice that the populous northern part of the County, where population ranges from 4,233 to 41,260, do not fall within the 5-minute response zones. Most areas that have potential to experience high or very high level of wildfire severity are out of the 5-minute response areas. The City of Santa Barbara that is more likely to be affected by wildfires is fully covered by emergency services. Judging from the map, the County is recommended to provide more fire services in areas that have high potential to be severely damaged by wildfires.

[11] Santa Barbara County Communities (n.d.) "Wildfire Protection Plan" Retrieved Nov.2018 from: http://cdfdata.fire.ca.gov/pub/fireplan/fpupload/fpppdf258.pdf

Conclusion

Overall, majority of the populous areas in Santa Barbara county have high capacity in responding to wildfires as seen in **Figure 5**, except for the upper northern part (Santa Maria) and middle western part (Lompoc) of the county. Even though most of the city area are covered by the 5-minute radius, the City of Santa Barbara is the most vulnerable municipality that faces the fire threat as it's surrounded by the very-high level fire severity zones whereas the only areas that has no fire threat face the ocean. Middle parts of the county share most of the wildfire zones, which few has been covered by the 5-minute radius. Even though these areas do not have large residency compared to other places, it greatly reduces the county's capacity to prepare for and respond to wildfires.

One way of ensuring that Santa Barbara county has the ability to prepare for, respond to and recover from wildfires would be to maintain an up-to-date GIS database used for operations, planning, and analysis. It's also important for the County to collaborate with local governmental agencies in the creation and adoption of land use plans, building codes, fire codes, and development standards in High Fire Hazard Areas.[12] Since one third of the county is covered by Los Padres National Forest, it's necessary to conduct vegetation management projects to reduce fuel loading especially in high level fire severity zones. Last, the county should consider increase emergency response forces like the number of fire engines, helicopters used to suppress fires etc.

Limitation

Temperature, relative humidity, growing wildland urban interface areas and climate change etc., are known factors drive fire behaviors. This project fails to identify other factors that affect wildfires' severity other than the three discussed in this paper.

[12] Santa Barbara County Fire Department (2018). "Unit Strategic Fire Plan Santa Barbara County" Retrieved from: https://cosantabarbara.app.box.com/s/yohuuij6ve8p1depioyjcl21nebvz1by

As the climate warms, wet areas are becoming wetter and dry areas drier, which might bring more wildfire threats. The project fails to take climate change into consideration due to the complexity of estimating changes in precipitation levels and the effects of its consequences. The project also doesn't include wildland urban interface areas as one potential factor that increases the severity and damages in a wildfire due to limited researches. Growing population and limited residential land spaces are driving people to place their property in WUI areas in California. In the very recent Camp Fire, many luxury mansions located in WUI have been destroyed. The need to better understand and characterize risks of living in WUI has been an ongoing problem for researchers and policy makers.

I also came across several limitations while working on organizing data into ArcGIS Map. The Santa Barbara County boundaries shapefile retrieved from Census Bureau are different from the one in geodatabase format. The former includes the four channel islands whose fire severity information is not provided by Cal Fire. Therefore, this project uses the geodatabase data to map the County and California State boundaries. Additionally, the vegetation data retrieved from Cal Fire was originally categorized into four classes, where no indication of the types of the forest meadow was made. Only one type of vegetations, chaparral, was identified by looking into literatures. It leaves unclear about the reference of the variation in colors. Therefore, no specific types of vegetation were identified in this project to demonstrate the causal relationship between wildfire severity and specific type of vegetation but general description. Furthermore, there's no exact numeric standards or formula for calculating travel time into distances. It's assumed in this project that the fire engines drive at the speed of 35-40m/h with few stops along the way to the emergency location. But this calculation lacks evidence support and will change when it comes to traffic, road condition etc.

Appendix

Figure 2

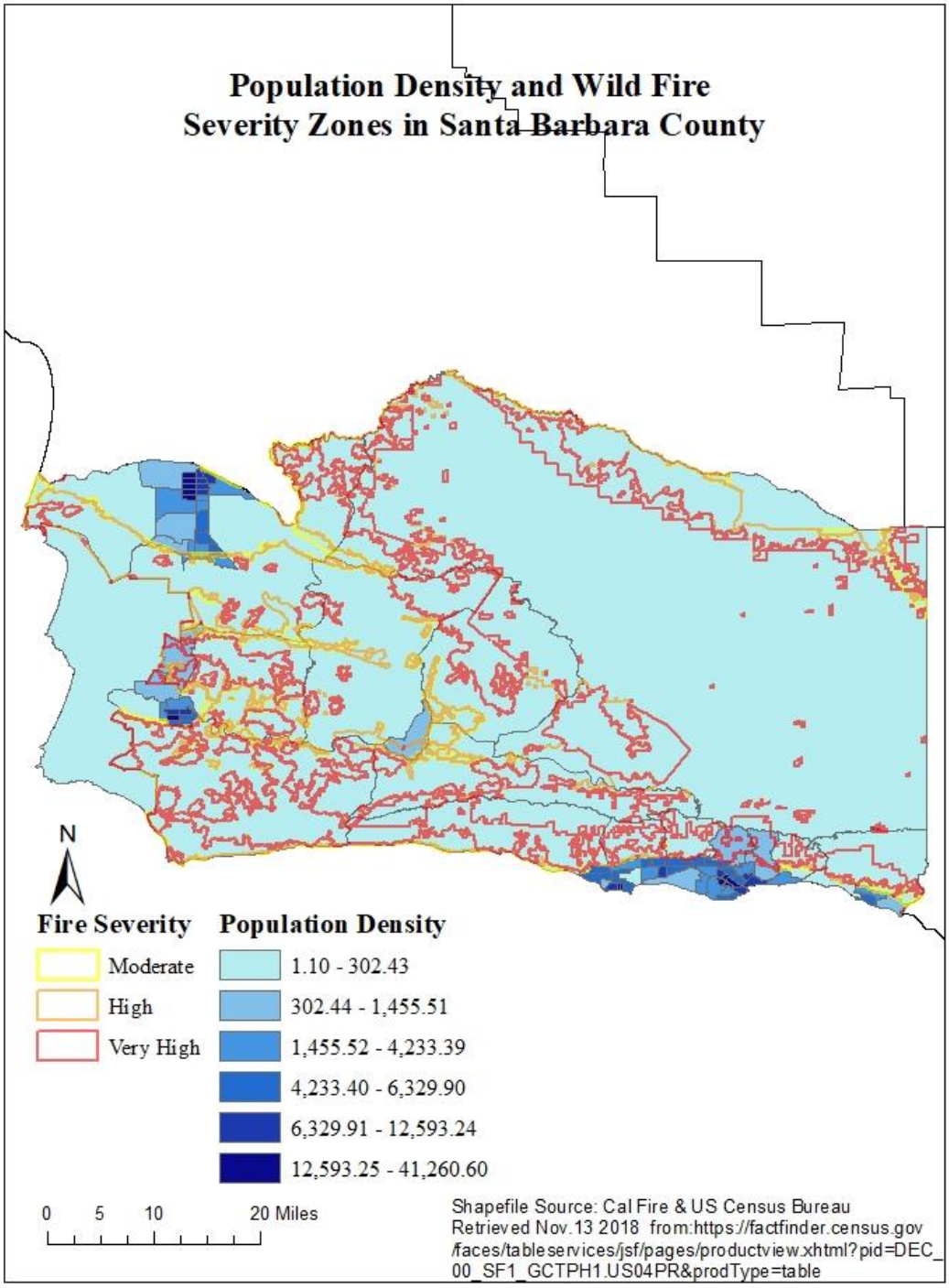


Figure 3

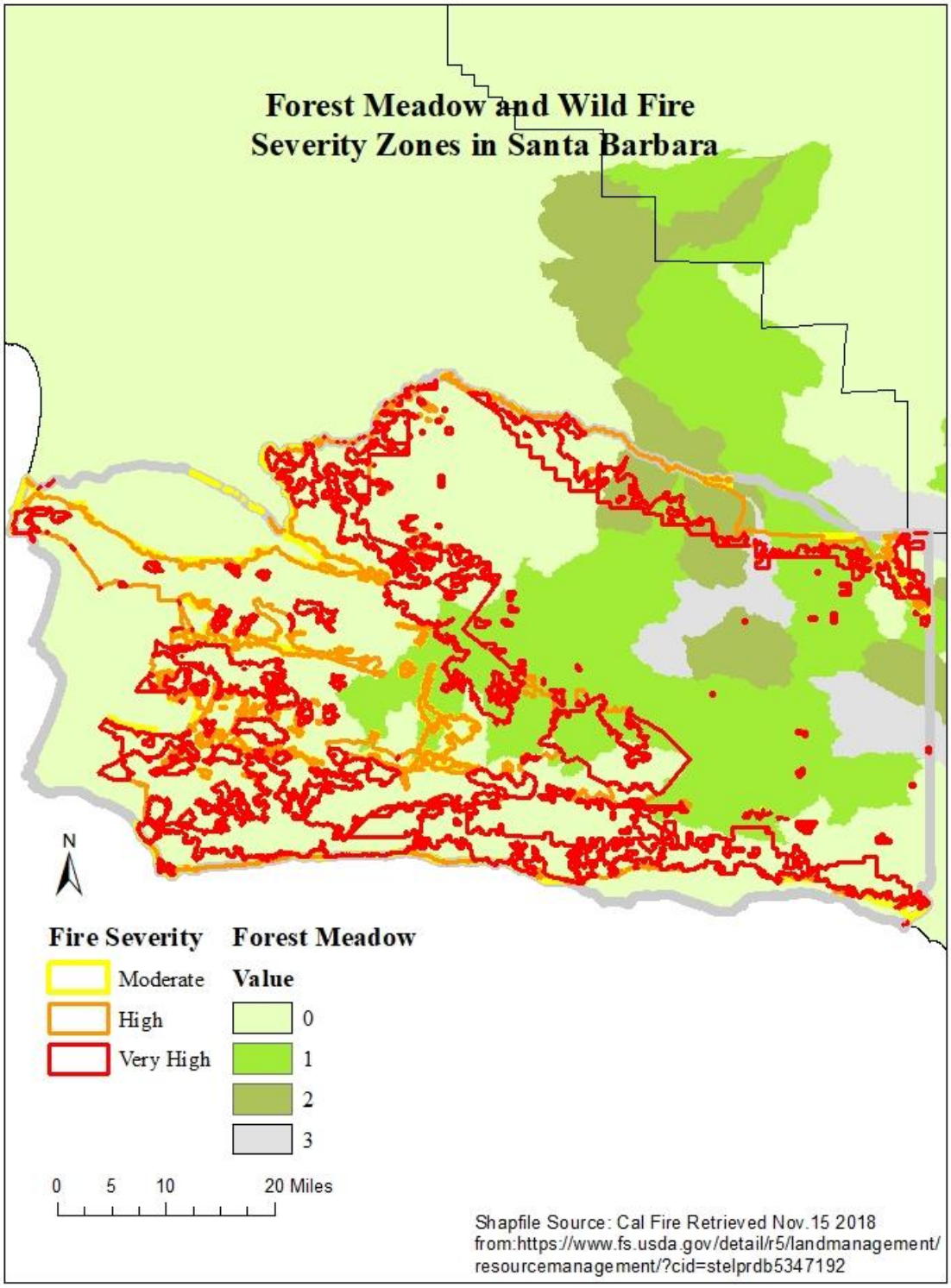

Forest Meadow and Wild Fire
Severity Zones in Santa Barbara
N
Fire Severity
Moderate
High
Very High
Forest Meadow
Value
0
1
2
3
0 5 10 20 Miles
Shapfile Source: Cal Fire Retrieved Nov.15 2018
from:https://www.fs.usda.gov/detail/r5/landmanagement/
resourcemanagement/?cid=stelprdb5347192

Figure 4

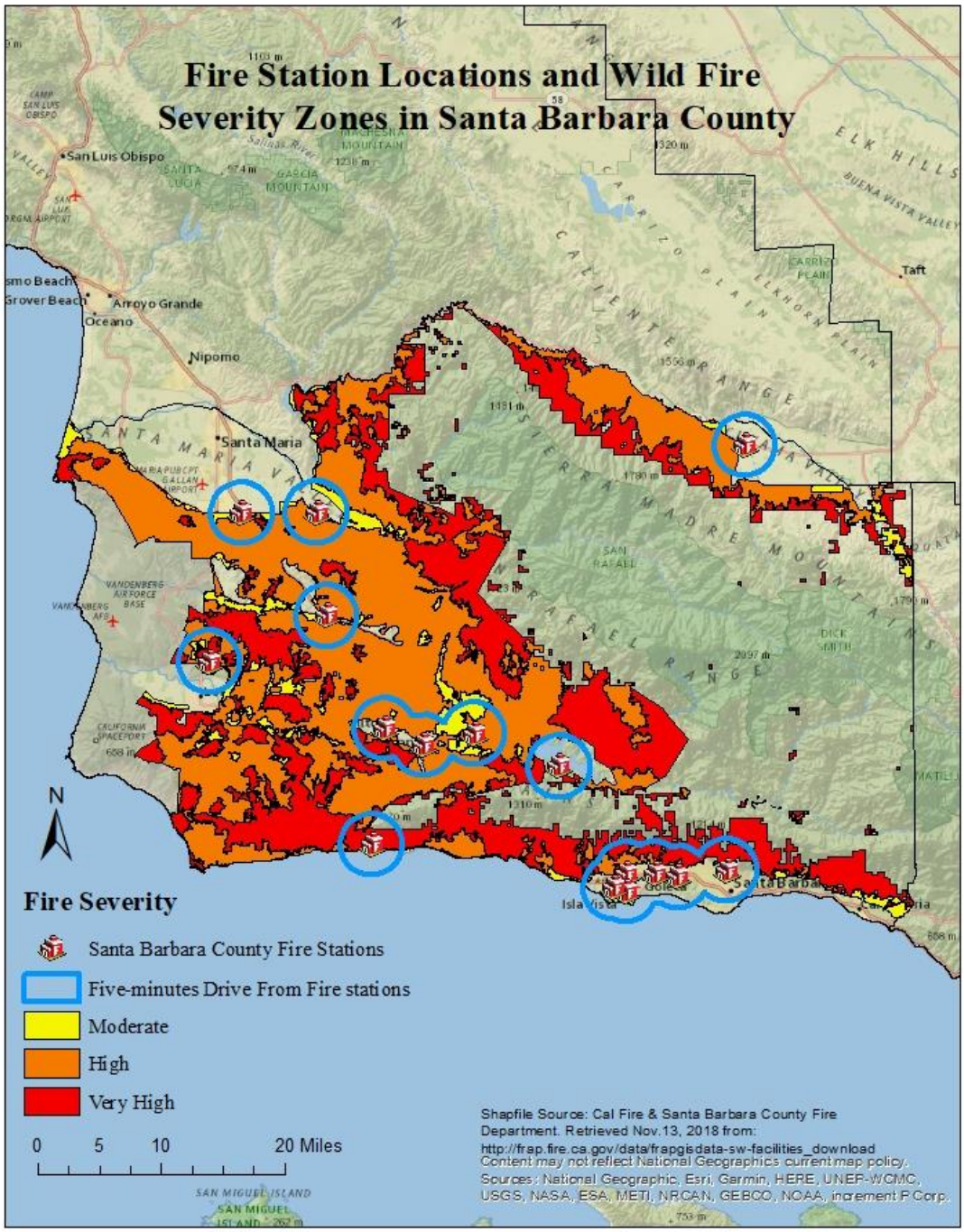
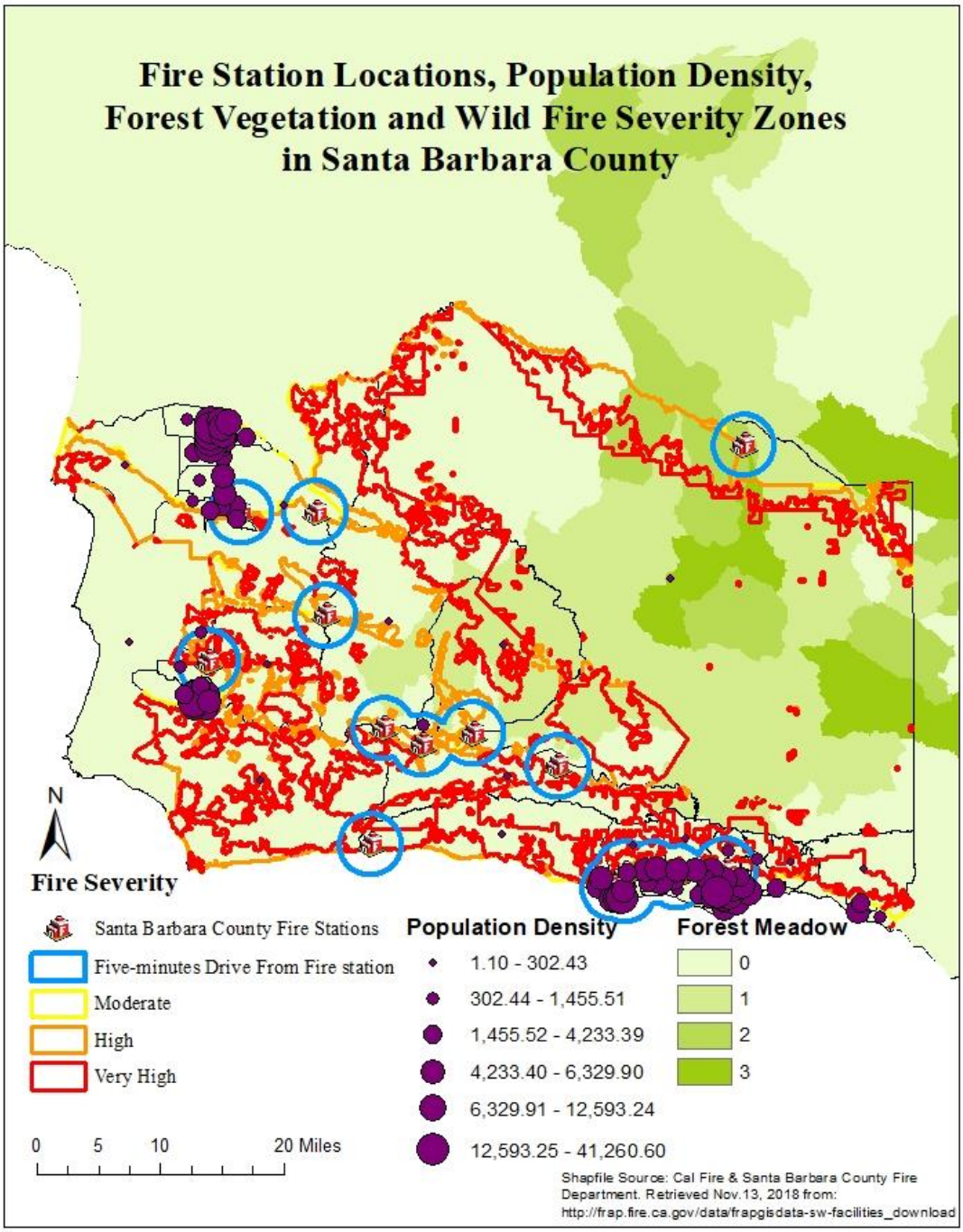

Fire Station Locations and Wild Fire Severity Zones in Santa Barbara County
San Luis Obispo
Arroyo Grande
Oceano
Nipomo
Santa Maria
Taft
Fire Severity
Santa Barbara County Fire Stations
Five-minutes Drive From Fire stations
Moderate
High
Very High
0 5 10 20 Miles
N
Shapfile Source: Cal Fire & Santa Barbara County Fire Department. Retrieved Nov.13, 2018 from:
http://frap.fire.ca.gov/data/frapgisdata-sw-facilities_download
Content may not reflect National Geographics current map policy.
Sources: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

Figure 5


Fire Station Locations, Population Density,
Forest Vegetation and Wild Fire Severity Zones
in Santa Barbara County
N
Fire Severity
Santa Barbara County Fire Stations
Five-minutes Drive From Fire station
Moderate
High
Very High
0 5 10 20 Miles
Population Density
1.10 - 302.43
302.44 - 1,455.51
1,455.52 - 4,233.39
4,233.40 - 6,329.90
6,329.91 - 12,593.24
12,593.25 - 41,260.60
Forest Meadow
0
1
2
3
Shapfile Source: Cal Fire & Santa Barbara County Fire Department. Retrieved Nov.13, 2018 from:
http://frap.fire.ca.gov/data/frapgisdata-sw-facilities_download

Works Cited

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