# Tracking Santa Barbara County Wildfires: A Web Mapping Application

by

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To my extraordinary family and friends, and to my employer, County of Santa Barbara, for allowing me the time to work towards finishing this thesis.

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# List of Abbreviations

| | |
|---|---|
| AGOL | ArcGIS Online |
| CALFIRE | California Fire Department of Fire and Forestry Protections |
| EPA | Environmental Protection Agency |
| GeoMAC | The Geospatial Multi-Agency Coordination Group |
| GIS | Geographic information system |
| GISci | Geographic information science |
| InciWeb | Incident Information System |
| SSI | Spatial Sciences Institute |
| USC | University of Southern California |
| UI | User Interface |
| UX | User Experience |

# Abstract

Wildfires have always been a source of devastation throughout California. With the persistent drought, wildfires in Santa Barbara County pose an extreme threat. Currently, residents of Santa Barbara County do not have one specific location to view available live information and data regarding both current and past wildfires. Instead, residents must find and view this information in a number of different locations, whether it be via social media, local news stations, or intermittently produced maps by the fire department. The purpose of this applied thesis is to create a well-designed web map mashup by which residents of Santa Barbara County can view spatial data and emergency information published by different emergency response agencies in one area.

By using geographic information systems, a web map mashup created based on weather conditions, current fire burn areas, evacuation warnings, fire suppression facilities, and local fire department social media feeds inform residents of Santa Barbara County on what is happening as wildfires burn throughout the County. Creating a web map using available data from resources such as Santa Barbara County Fire, CAL FIRE, Waze, and GeoMAC allows residents to monitor evacuation potential, fire size, and emergency updates throughout the county during the event of a wildfire. Developing hypothetical user profiles to ensure efficient user experience design, using ArcGIS Online, a web mapping application was produced to bridge the gap between emergency response institutions and the general public, creating a resource for the public to consult during wildfires. By surveying twenty-five people, all with different professional backgrounds and levels of GIS experience, it was determined the overall webpage, and mapping application provided users with a positive experience that could be beneficial during the event of a wildfire.

# Chapter 1 Introduction

In the event of a wildfire, residents look to a number of different media outlets to gather information to plan for and ensure the safety of their homes and themselves. This thesis uses data from various national, state, and local government agencies, to create a web map that combines available spatial and multimedia data regarding Santa Barbara County Wildfires to inform the public before, during, and after wildfires ignite. Santa Barbara County Fire currently disseminates information using Twitter to provide live updates during the event of fires in the county. Nationwide agencies, such as GeoMAC and the Environmental Protection Agency, provide professionals with updates of fire size and locations and air quality, respectively, and the statewide agency CAL FIRE, provides the public with locations of fire suppression facilities, past fires burn area and wildfire statistics. The availability of live information is sparse, so in the event of a wildfire, residents of Santa Barbara County rely on information from social media, fire department produced maps, and local news broadcasts and publications. This thesis provides a visual, interactive alternative by combining layers of information from these agencies to create a singular map mashup. The goal of this thesis is to provide residents of Santa Barbara County, without a background in GIScience or fire management, a reliable resource of information that they need to remain safe and informed in the event of a wildfire.

## 1.1. Study Area

Santa Barbara County is located along the California Central Coast and is home to some of the most beautiful views in the state. Consisting of nearly 450,000 residents, Santa Barbara County occupies 2,774 square miles of land. The area of Santa Barbara is unique in that it consists of a variety of different climates—dryer in the valleys and cooler, more humid along the

coastline. The unique culture and over 100 miles of beaches in the county also attract millions of tourists per year (Santa Barbara County Fire, 2016).

While Santa Barbara County is a community of eight cities, each unique in their own way, it is also home to devastating fires that have taken homes, lives, and more. Within the 2,774 square miles, 16 fire stations and 2 battalions employ over 240 full-time employees. In 2016, over 50,000 acres burned, destroying 76 structures and 77 vehicles, with an estimated $1.7 million in fire loss dollars (Santa Barbara County Fire, 2016). As development and population throughout the county continue to grow, fire-sensitive zones are beginning to be filled with homes and commercial properties.

## 1.2. Motivation

In 2017, Santa Barbara County was the site of the largest wildfire in California history. The Thomas Fire burned nearly 282,000 acres, and destruction resulted in 1,063 destroyed structures and two fatalities, (CAL FIRE, 2018). Wildfire history shows vast, uncontrollable fires as part of the ecosystem in Santa Barbara County. Santa Barbara County consists chaparral vegetation, with the average slope in wildland areas nearing 40% (Santa Barbara County Fire Department, 2011). These factors, coupled with the current drought, limited rainy season and fierce Santa Ana winds, pose an extreme wildfire threat to the county and its community.

As residential and commercial development increases throughout the county, the threat to members of the community continues to grow. Creating a user-friendly web mapping application allows for the flow of real-time information from emergency response agencies and Santa Barbara County residents.  Air quality, fire perimeters, text, traffic conditions, and Twitter updates, and locations of fire suppression facilities and evacuation centers are all types of information available over six, or more, current websites. The real-time information is important

to the public when planning for a potential evacuation or determining the likelihood of a wildfire nearing homes and neighborhoods. This thesis produced a web mapping application to function as an interface for available information in the event of a wildfire.

# Chapter 2 Related Literature

Currently, several different publicly-available maps have been created regarding wildfires in California. There is still no consolidation of one simple map or mapping application that the public can access in the event of a crisis. Per review of different scholarly articles, the gap between authoritative emergency sources and the general public has been addressed in several different ways, but as research has shown, a consolidated mapping application produced by governmental agencies during disasters seems to be missing in Santa Barbara County. Though, several of the reviewed articles provide insight into different means of data acquisition, production of maps, and the necessity for these types of maps. The following review of related literature gives examples of crowdsourced crisis maps, describes currently produced wildfire tracking applications, and explores the realm of user-experience design. The goal of this literature review is to explore ways disaster and crisis events have been mapped in the past and to examine current wildfire mapping applications, thereby assisting in the design of a Santa Barbara County wildfire web mapping application and webpage.

## 2.1. California Wildfires

Over the last four decades, wildfires have become larger and more frequent across the western United States (Calkin *et al.,* 2005) and as the drought in California persists, the threat increases. California is home to some of the most devastating fires during the fire season due to the topography, climate, and vegetation throughout the state. Fire ignition relies on three variables: fuel, oxygen, and heat (National Park Service, 2016). As average temperatures remain higher throughout the state of California and the current drought increases areas of dry brush, fire potential throughout drylands remains increasingly high (National Weather Service, 2017).

In 2014, roughly 160,000 acres were burned throughout California due to wildfires of a variety of different causes (CAL FIRE, 2015). Currently, just under 480,000 acres have burned in California since January 1st, 2017 (CAL FIRE, 2017). With the current state of drought in California, counties throughout the state are increasingly threatened by the loss of homes, lives, and infrastructure.

## 2.2. Crowdsourced Crisis Maps

Zook *et al.* (2010) authored a paper that discusses how crowdsourcing was an effective tool in response to a natural disaster—the Haitian earthquake. The paper gives an in-depth look at how the efforts of a remote team helped to create a map that assisted in the relief efforts post-earthquake. "Post-earthquake, the demand for spatial information and online maps increased tremendously and, given the urgency of relief operations, the ability to crowdsource the data collection process became particularly important," (Zook, 2010). As with any disaster, the catastrophic event is oftentimes unpredictable, and after the disaster strikes, there is suddenly a need for tools that may have been a non-priority before—in the case of this article, a crisis mapping application. A handful of different articles have also been written indicating the impact of OpenStreetMap on the Haitian earthquake recovery. All of these articles seem to arrive at a similar conclusion—the crowdsourcing efforts were a vital part of the relief efforts, especially when agencies involved did not have direct access to the site of the quake.

While not an exact correspondence of the type of web mashup map proposed, Zook *et al.* (2010) indeed addresses the idea of combining information from government agencies to assist in crisis mapping and mitigation. Perhaps a wildfire web mapping application for the public is not necessarily produced by one agency, like the fire department, but is actually a group effort of a group of agencies producing one map for the public. Though the creation of crowdsourced

maps explained in Zook *et al.* (2010) solved a problem that needed to be addressed immediately, a crowdsourced map might pose security threats unless it functions through a correctly secured connection. The idea of crowdsourcing information to create a singular map is appropriate in many situations, namely the Haitian earthquake.

In another article by Sutton *et al.* (2014), the authors discussed the role of social media during California wildfires. This article gives some validity to the need for a publicly available web mapping application. As stated in the study conducted by Sutton *et al.* (2014), "though several official information sources were cited as helpful some official information sources were described as consistently slow to update information to at-risk and evacuated communities or simply overwhelmed and stymied by on-line traffic," (Sutton, 2014). These findings reiterate the public frustration with finding up-to-date information on wildfires as they occur, hence the role of social media. The authors found that, while emergency responders may have disagreed, social media was a way for members of the public to get current information regarding evacuation warnings or other important information—many participants in the study were using social media to bridge the communication gap.

Social media undoubtedly plays a role in disaster situations, and as it becomes more prevalent, government agencies and fire departments take to social media to provide the public with information. Social media, though may not be the only way to quickly get information across, can surely play an important non-spatial role in a web mapping application.

## 2.3. Web Mashup Cartographic Studies

Liu *et al.*(2010) addressed the rise of nonprofessional online maps during the event of crises. Throughout the article, Liu *et al.* (2010) analyzed crisis mashups to illustrate different approaches to mapping disasters. "Next-generation GIS should be more interactive and

accessible to citizens to foster public participation and collaboration in the development and management of geographic databases and any decisions made based on such data," (Liu, 2010). The review provided by Liu *et al.* (2010) refers to what geo-professionals of the past hoped GIS would eventually be capable of—providing public participation and exploration of data for decision making for crisis events.

In the paper, *Liu et al.* (2010) reviewed a Los Angeles Fire Tweets mashup, mentioning the creator "decided to share the mashup online for formal new dissemination only after he had discovered how quickly it expedited reporting and appealed to viewers," (Liu, 2010). The public demand for a map with georeferenced tweets regarding Los Angeles Fires grew, and a mashup made for personal use soon became a relevant source of information for the community.

As Liu *et al.* (2010) stated, "crisis situations create additional imperatives for visualizing information rapidly, and because natural hazards are geographic in their extent, mapping is a natural—and increasingly at-hand—information visualization solution for the interested person's use," (Liu, 2010). As the Geospatial Web and Web Mapping 2.0 grows, there likely will continue to be an increase in geo-browsing activity, like Google Maps.

In a paper by Field *et al.* (2010), the authors discussed the lack of design in online map mashups. The authors state "the purpose of design is to clarify and to simplify and the power of design lies in its nuance which must be planned and skillfully achieved (Baer and Vacarra, 2008) yet we are surrounded by a world of poor web maps brought about largely by the democratisation of cartography and the massive increase in consumer grade tools for the creation and consumption of maps by non-experts," (Fields, 2010). This idea lends itself to a handful of different web mapping mashups found on the internet, and this issue is touched on in the next section. Throughout researching different designs of social media web mashups, different styles

are analyzed, and design flaws are explained—one being the use of a Google basemap, which the authors believe provides unnecessary clutter. Again, the authors find issues with more Twitter and social media mashups; oftentimes, areas with no markers on maps are not areas on no activity (rainfall, snow, etc.), yet are areas of no georeferenced tweets.

Fields *et al.* (2010) explained, "simple ineffective push-pin style mashups need to be replaced by more complex maps that reveal far more information through the processing of data and the representation, cartographically, of characteristics of the data." Many wildfire maps produced by the public online are, in face, simple pushpin maps. These maps show the center or ignition locations of fires, but do not give the user much more than that simple information.

University of Southern California alumni, Ryan Mock (2017), created a web mashup that addressed the lack of accessibility of wildfire data in San Diego County. The end result of the web mashup provided residents with information regarding past wildfire burn areas, wildfire hazard areas, proximity to emergency response resources, and real-time wildfire information. While the San Diego Wildfire Hazards Information Center Mashup provides users with important information regarding the real-time hazard severity of wildfires throughout San Diego County, it does not incorporate live layers displaying perimeters of active fires or live traffic data. The webpage created in this thesis aims to give users access to relevant real-time data to allow users to remain both aware and prepared in the event of a wildfire.

## 2.4. Fire Web Maps

The Geospatial Multi-Agency Coordination Group (GeoMAC) is an internet-based mapping application designed for fire professionals to access online maps of current fire locations and perimeters. While GeoMAC produces a map with live data, the map only displays this information—there are no layers displaying facilities, weather conditions, or non-spatial

data. While the GeoMAC viewer (Figure 1) is catered to professionals, it can also be accessed by the general public. The wildfire viewer gives users an in-depth experience, having to turn layers on to begin viewing, switching controls to click for information, pan, or zoom. The overall wildfire viewer provided by GeoMAC provides a useful tool for GIS and fire professionals, and even provides important information to the public, but does not include any other information besides fire perimeters and locations.

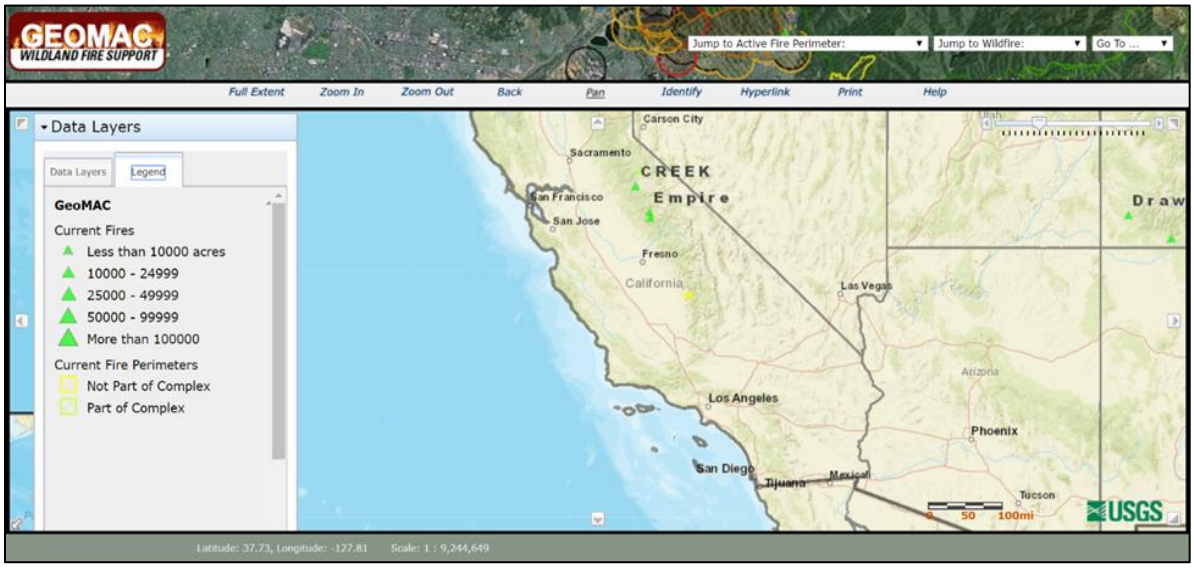


Figure 1: Geospatial Multi-Agency Coordination Wildfire Viewer Screenshot

Incident Dashboard is a real-time web and mobile mapping application for active wildfires. The application uses crowdsourced data from both firefighters and the public to provide a newsfeed of active and contained fires throughout the United States. Unlike the GeoMAC produced web application, Incident Dashboard, while free to firefighters, is a paid service for the general public and commercial users. Members of the Incident Dashboard have access to produced web maps of current fires, fire department blotter, and a Twitter feed displaying hashtags related to the selected fire (Figure 2). Incident Dashboard gives users quick facts on the top banner, such as current weather conditions, percentage contained, and total

current burn acreage (Figure 2). The Incident Dashboard uses crowdsourced data to create a tool that provides both paid users and firefighters alike with information on current wildfires.

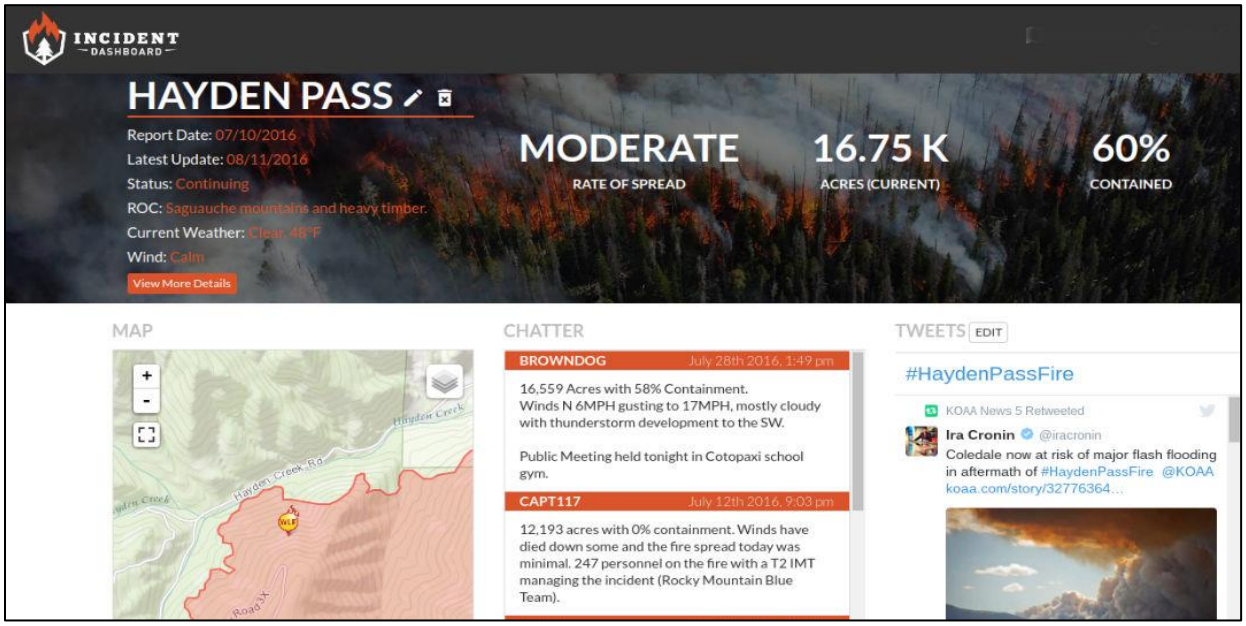


Figure 2: Incident Dashboard Landing Page Screenshot

San Luis Obispo County Fire Department recently launched a new incident dashboard that gives community members a look at pinpoint fire incidents, daily fire danger levels, and the locations of the last 50 incident calls, both fire-related and not. This incident dashboard is currently being designed, but the early stages of the webpage provide the user with geolocated information straight from emergency dispatchers. While the dispatch reports give little information on the incidents, the other features of the dashboard give the public information, like fire potential, that can assist in decision making in the event of a fire.

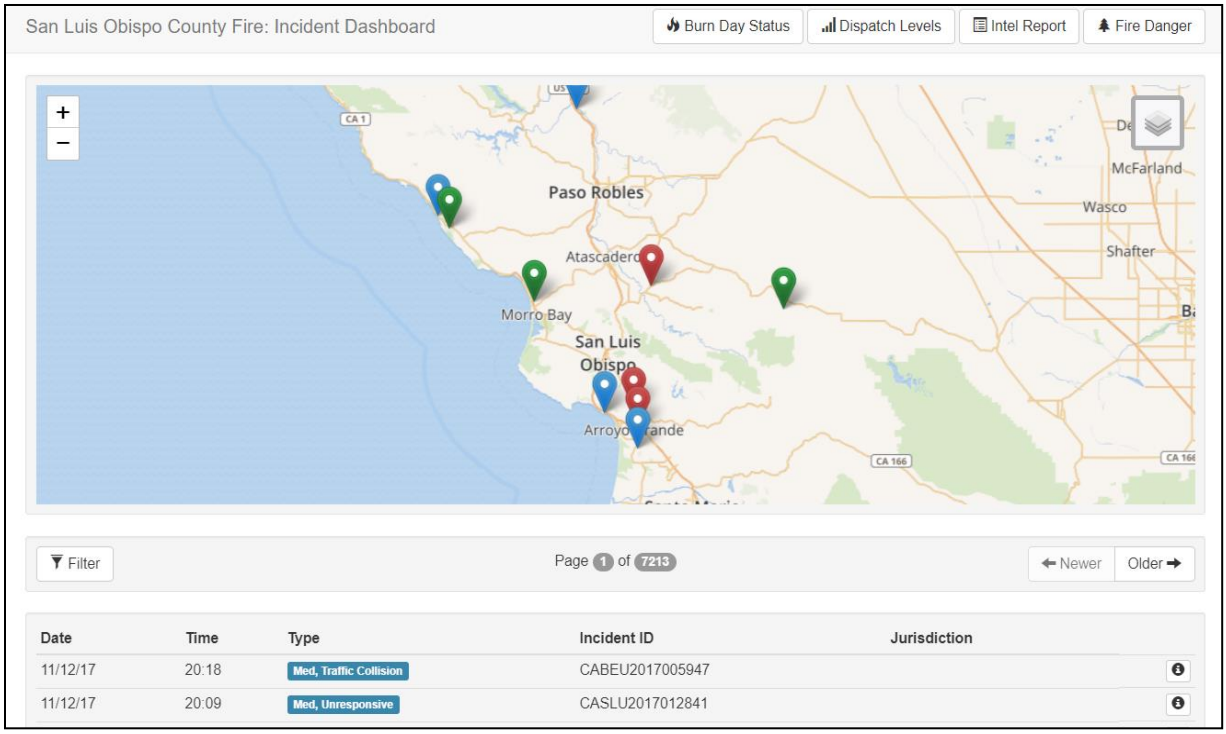


Figure 3: San Luis Obispo County Fire Incident Dashboard Screenshot

# Chapter 3 Methodology

With current technology continually advancing, information is easily available at any given time. The availability of information regarding wildfires is important to the public in decision making and empowerment. The importance of a streamlined user-experience design is recognized in creating a successful web mashup. The following chapter explains the intended users, user needs, design requirements, and goals of the web mashup.

## 3.1. Intended Users

The intended users are the general public of Santa Barbara County. Users will most likely and often access the web map during the event of a wildfire. The web mapping mashup sets out to provide publicly produced information regarding current wildfire in one place, and a place that the community can assess information and plan during the event of a wildfire. The web mashup is used to gather all relevant information regarding current wildfires in Santa Barbara County and displays current burning wildfires, past fire burn areas, traffic conditions, and locations of fire departments and evacuation centers. The mashup is intended to be an information hub for members of the public trying to understand the facts, size, geographic context of a wildfire.

### *3.1.1. User Requirements*

The application is accessible via computer, tablet, or mobile device by an internet connection. The webpage and mapping application are geared towards Santa Barbara County residents of all computer literacies; thus, a simplistic design and features are used. The web mapping application is intuitive in its features, for example clicking on a fire burn area for info or zooming and panning using commonly used commands. Most importantly, the application can be accessed by anyone, with no necessary login credentials or cost. The goal was to create a

user-friendly mashup by which users can gather information quickly in the event of a wildfire and provide the general public with information that is quick and easy to decipher during the event of a wildfire. The application provides a one-stop-shop for users to gather information about current burning wildfires, in order to make proper decisions based on evacuation orders, burn areas and emergency information. Creating a mashup that is simplified yet still informative helps to provide users of all technological literacies necessary information regarding wildfires in Santa Barbara County.

## 3.2. Application Functionality

Currently, members of the public rely on information from news websites, Santa Barbara County tweets, and maps intermittently produced by County Fire—all formatted differently and available. The application retrieves real-time data from GeoMAC, Waze, and tweets from Santa Barbara County Fire's Twitter profile. The CAL FIRE Facilities dataset and local evacuation centers are also embedded in the application itself.

## 3.3. User Experience Design

Nielsen (2000) promotes that web users want to find what they're after quickly, and if the users don't know what they are looking for, they still want to quickly browse and access information in a logical manner. The importance of unambiguous icons and features on a webpage leads to a successful user interface and experience design. Williams (2000) explains that in its simplest sense, the design of the user interface is an attempt to convey visually the logical, functional, or natural relationships that exist among the elements in an information display. Thus, removing distracting backgrounds or unnecessary GIS functions or tools is important in successfully creating an aesthetically appealing webpage and mashup. In web mapping, only relevant information should be displayed initially, including symbols in the

legend (Gaigg, 2017). Using commonly known and regularly seen icons assists in creating a simplified user experience, giving way to an informative mapping application to provide both GIS and non-GIS users with tools to visualize and understand the events of wildfires.

## 3.4. User Scenarios

Developing user scenarios was the first step in the application design. By creating personas, scenarios for each persona were developed. Using this technique helps to predict how a user may interact with the interface and help eliminate major rework of the design. Several personas led to a group of scenarios—some scenarios for GIS users and some scenarios for non-GIS users—all of which assist in ensuring the simplicity of the design and functions still prescribe valuable and useable information for all.

### *3.4.1. User Cases*

With a public platform, a web mashup tracking current wildfires can attract a variety of different users, all at different computer literacy levels. Developing personas can help ensure the design of the web mashup is appropriate to all potential users— a non-GIS user, a GIS professional, and a firefighter.

The first user persona considered was a non-GIS professional, with computer literacy—this user was anticipated to be the most common user of the application. The non-GIS user looks for common icons, such as those seen in Google Maps or other applications, and is familiar with scroll to zoom, click to pan, and can easily determine how to change layers by spending time on the webpage. All of these familiarities—the icons, the gestures, and the navigation—become requirements for the non-GIS user.

The next user persona considered was a GIS professional. This user is familiar with the capabilities of mapping applications and does not require a map with simplified features. Since

this type of user was assumed to be only a fraction of the total user base, the needs a GIS professional might request in a web mashup were taken lightly.

Another professional user persona considered was a firefighter. The firefighter user respects and appreciates the validity of information published by government agencies, like CAL FIRE, as well as information provided by local fire departments. The firefighter user requirements dictate the information included in the web mashup—reputable data layers and information from government agencies are included, not crowdsourced information from public users.

Each of these different user cases or personas play an important role in the design of the web mashup. Every user requires different features, but creating and considering personas allows for less rework of the design and ensures the web mapping application is a useful and informative tool for all.

# Chapter 4 Web Application Development

The importance of information during a wildfire can be extremely important for planning for safety. The lack of an interface for Santa Barbara County residents to easily access information to plan for safety in the event of a wildfire became the driving force for creating a web mapping application and webpage. The web mapping application and webpage were then created by utilizing data and service layers from different local, state, and private entities. This chapter explains the steps taking to create the web mapping application and the webpage that facilitates the mapping application.

## 4.1. Establishing a User Need and Scenario

Santa Barbara County was home to the largest wildfire in California state history in 2017, yet a single webpage to gather information during the event of wildfire is missing. Consolidating information that is already being produced creates a solution to the problem—establishing one, single webpage residents can look to in the event of a wildfire. Devastating wildfires remain significant in Santa Barbara County, thus confirming the need of a single webpage with an interactive map and updates from local agencies for the general public use case. The webpage creates a space for non-GIS and GIS professionals alike to view and interact with live data regarding wildfires in the county—this could be as simple as viewing the extent of an active fire or searching for and getting directions to the nearest evacuation center in the event a user needs to evacuate.

## 4.2. Data

The web map includes several different layers, all intended to provide users with an informative and current mapping application. Table 1 categorizes the data acquired from a

number of different state, local, and national agencies. Once downloaded, the symbology and attribute tables were edited in ArcMap and ArcGIS Online to create a simple map which was then publish via ArcGIS Online.

Table 1: Acquired Data

| Source | Contents | Data Type | Implementation |
|---|---|---|---|
| CALFIRE | A statewide geodatabase of wildfire history | Vector | The burn areas were clipped to Santa Barbara County, then layers were created dependent on fire burn acreage. |
| CALFIRE | Statewide fire stations | Vector | A layer was created consisting of only Santa Barbara County fire stations. |
| County of Santa Barbara | Santa Barbara County Border | Vector | This perimeter of Santa Barbara County was used to clip the statewide data acquired from CALFIRE. |
| Created | Locations of evacuation centers | Point | An Excel spreadsheet with names and locations of common evacuation centers was imported via AGOL. |
| GeoMAC | Active fires, recent fires, MODIS thermal hotspots | Feature Service Layer | The service layer was added to the web map via ArcGIS Online. |
| Waze | Traffic alerts | Feature Service Layer | The service layer was added to the web map via ArcGIS Online. |
| County of Santa Barbara | Declared disaster zone | Vector | The layer was added to the web map via ArcGIS Online. |

## 4.3. Preparing the Data

The data acquired from CALFIRE is statewide. For the use in a web application specific to Santa Barbara County, the historical fire perimeter and fire suppression facilities data needed to be clipped to only include data within Santa Barbara County borders. This processing was accomplished in ArcMap, using a Santa Barbara County perimeter shapefile acquired from Santa Barbara County, and the clip tool.

Once the data was clipped to be specific to Santa Barbara, further processing was done in ArcMap from the single fire perimeter layer to create five different layers, dependent of fire burn acreage—0-10,000 acres, 10,001-50,000 acres, 50,001-100,000 acres, 100,001-150,000 acres, 150,001-300,000 acres, and 300,001-500,000 acres. When editing the attribute tables for the CALFIRE layers, it was important to consider User Experience Design (UX), as a common

principle is to only include useful information in map applications (Gaigg, 2017). Thus, within ArcMap, the attribute table for each layer was edited to clean up the appearance of text of attributes and remove information that was not necessary to include in the web mapping application. From ArcMap, the edits CALFIRE layers were shared to ArcGIS Server for further development of the web mapping application.

## 4.4. Creating a Web Map

ArcGIS Online (AGOL) was utilized to import the CALFIRE layers to a web map. Within the web map, the additional layers and feature service layers were added to the map. To create the Evacuation Centers layer, Microsoft Excel was used to create a spreadsheet with evacuation center name and situs address. The Excel spreadsheet was imported directly to the web map and points were created based on evacuation center location, then appropriate symbols were selected. All of the layers attributes can be edited within AGOL, ensuring only appropriate information is displayed in popups when features are selected. Editing the attributes proved to be important for this project—using layers and data acquired from a number of different sources, it was vital to stay consistent.

Waze traffic updates were added to the web map via a feature service layer. Waze traffic updates are submitted by users, which oftentimes provides users with updates regarding road closures or traffic jams before some government agencies have this data to publish. For this reason, the Waze layer was a vital component of the web map.

Perhaps the most important component of the web map is the GeoMAC service layer, which includes up-to-date fire perimeters. Utilizing this layer was important in executing the intentions of the web mapping application—providing Santa Barbara County residents with real-time information during the event of a wildfire. All of the data collected and layers worked to

create an informative web map that could be used before, after, and during the event of a wildfire, and ensure appropriate results of a web mapping application, which was created from a web map in ArcGIS Online.

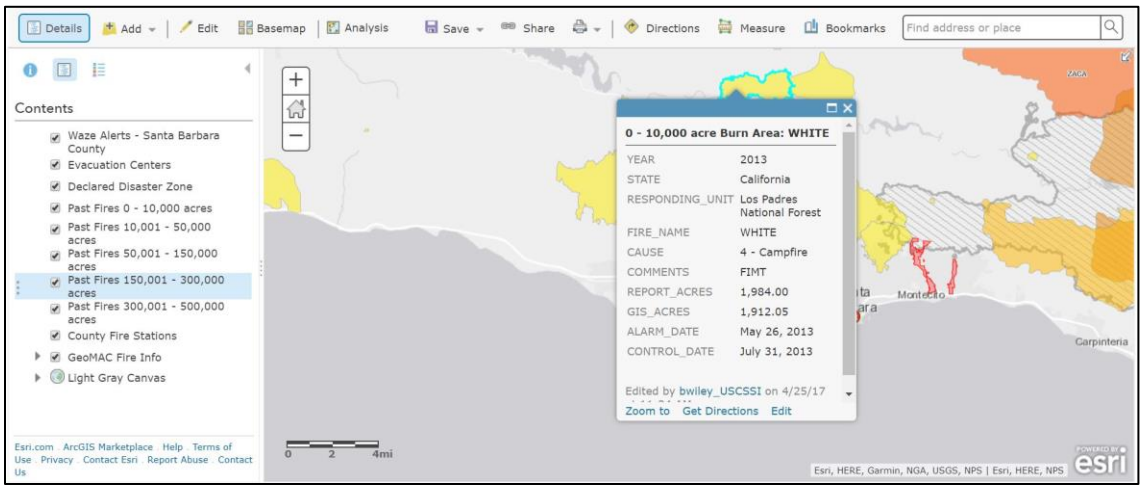


Figure 4: Building the Web Map

## 4.5. Creating a Web Mapping Application

Web AppBuilder produces a web mapping application from any web map available in one's AGOL content library (Esri, 2018). Thus the web map created with all of the data acquired for a fire tracking application was easily converted into a web mapping application. Using Esri ArcGIS Online Web AppBuilder, the Billboard theme was chosen to create the web mapping application.

The Billboard theme creates a simple web mapping application that allows for several widgets, all to be selected by the app creator. Given the anticipated use of the Santa Barbara County Fire Tracker, it was important to include widgets that would most likely be utilized in the event of a wildfire; these include a directions widget, a near me widget, basemap selector widget, layers widget, and the legend. Using the Directions widget (Figure 5), the user is able to from directions to and from multiple points, determine the drive time and distance, as well as the walking time and distance.

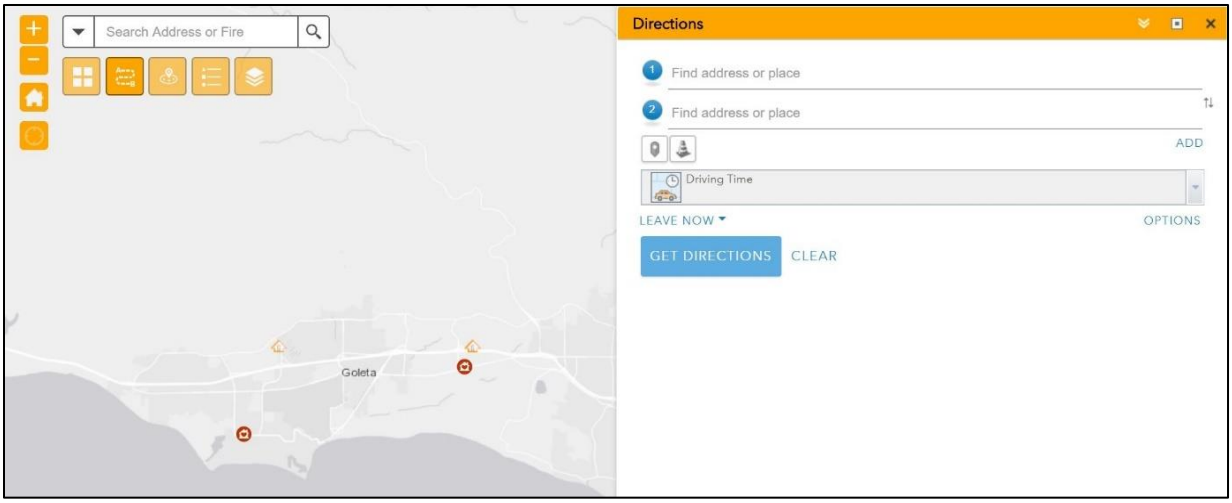


Figure 5: Directions Widget

Using the Near Me widget, users can locate the nearest evacuation center to a specific address. Determining the nearest evacuation center allows users to locate evacuation center up to fifteen miles away, select from an evacuation center within the fifteen-mile radius, and get directions to the selected evacuation center, as seen in Figure 6. The remaining widgets within the web mapping application allow the user to select from three different basemaps—imagery with labels, terrain with labels, topographic, and the default light grey canvas basemap—and view the legend and select the from the available layers.

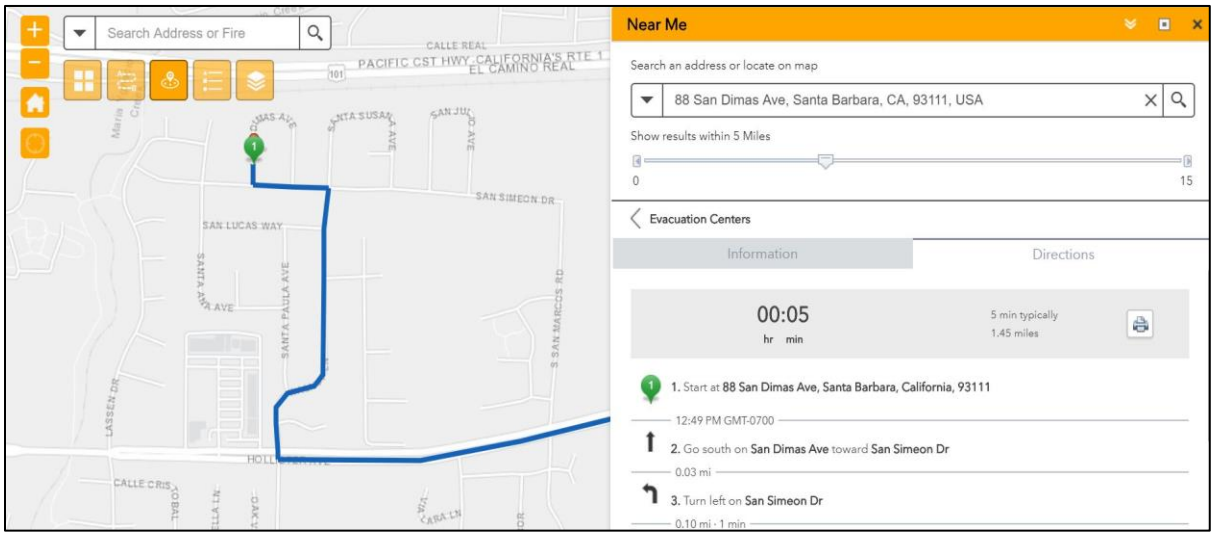


Figure 6: Near Me Widget

## 4.6. Webpage Design

The final webpage can be explored at http://gis-web.usc.edu/bwiley/FireTracker.html (see Landing Page in Figure 7). All coding for the webpage was done using Notepad++ for Windows, using HTML and CSS for typography, buttons, navigation, and other interface components. Utilizing Bootstrap, a free and open-source front-end library for designing websites and web applications, a simple webpage design was created to incorporate the web mapping application creating using ArcGIS Online, links to other relevant webpages, and twitter from local government agencies.

The header of the webpage includes links to the County of Santa Barbara, the National Weather Service, and Ready Santa Barbara County (Aware & Prepare). With these links, users are directed straight to other websites with useful information in the event of emergency situations. The main focus of the webpage is the web mapping application, as it is a visual and interactive reference to utilize in the event of a wildfire. Thus, most of the overall webpage design is dedicated to the mapping application, which can be seen just below the webpage header.

Located below the mapping application, is a brief description of the map and its data, and a Twitter feed. The Twitter feed was created from a Twitter list that includes tweets from County of Santa Barbara, a Santa Barbara County Fire chief, the Santa Barbara County Sheriff's Office, and the County of Santa Barbara Office of Emergency Management. Each of these Twitter accounts provide the public with updates regarding emergencies and any other important information for Santa Barbara County residents. Social media has been recognized as a way to effectively communicate information during emergency situations, thus the Twitter feed was thought to be a significant portion of the website.

Based on the literature review and review of similar published websites, the overall website focuses on features that prove to be important during disaster. The overall design of the webpage reflects the type of information that is important for users in the event of a wildfire. The simplicity of the design is to eliminate distractions and crowding of information and tools that are not detrimental to the intended use of the webpage.

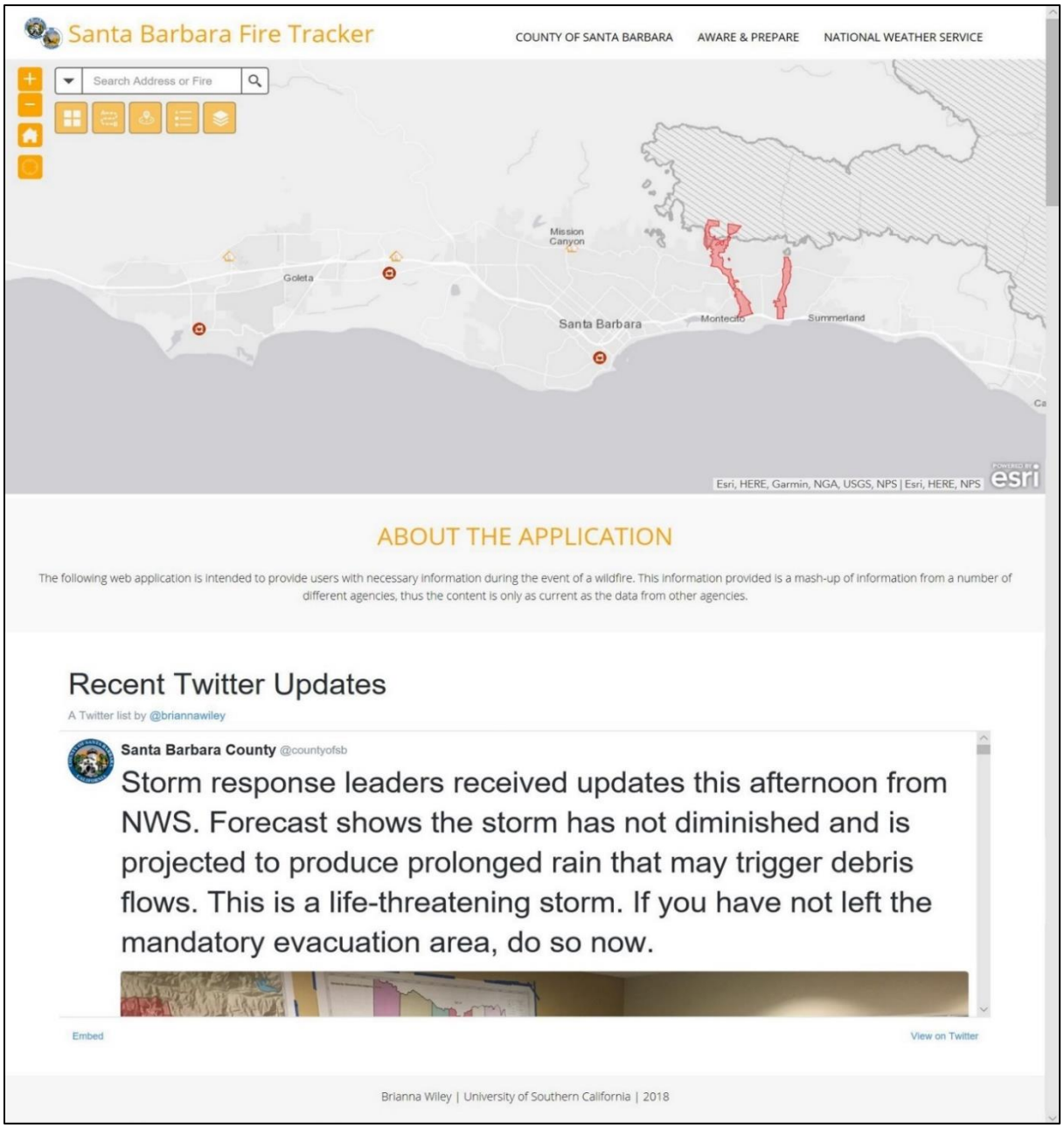


Figure 7: Full Webpage

# Chapter 5 Results

Based on the information gathered, the anticipated users, and the results of user reviews, a successful webpage supporting the web mapping application was created. The overall success of the web mapping application and webpage was determined by a survey of twenty-five participants. While most feedback was positive, the survey results indicated potential for further development.

## 5.1. Survey Sample

SurveyMonkey was used for twenty-five participants to critique the final webpage. Forty different participants—ages seventeen to sixty-five, and all with different levels of computer literacy—were provided a link to the survey via email. The survey remained live for two weeks, which resulted in twenty-five survey responses. Amongst the twenty-five participants were emergency response professionals, such as firefighters and paramedics; GIS professionals, such as cartographers and GIS analysts for environmental agencies and local government agencies; college students and teachers; Santa Barbara County residents with non-GIS or emergency response careers; and, non-GIS professionals from other counties that have been affected by a wildfire. The diversity amongst the surveyed group was intended to test the well-roundedness of the overall webpage.

## 5.2. Survey Results

The survey consists of eight multiple choice questions and one short answer question, ranging from the location of users to the profession of users. Figures 8-1 through 8-9 graphically represent the results of the survey. Based on the data, nearly half of the survey population resides in Santa Barbara County (Figure 8-2), and 75% of the users were neither in a GIS profession nor

an emergency response profession (Figure 8-1) (Survey Monkey, 2018). Roughly 70% of the survey population had some experience with GIS, indicating that they had familiarity with Google Maps, but no real professional or technical GIS experience (Figure 8-3). The results from question 7, seen in Figure 8-7, explain that the design and functionality of the webpage is successfully executed.

The short answer survey question was only answered by five of the twenty-five surveyed (Figure 8-9). Three of those five responses indicate that nothing else could be added or changed to make the webpage more successful. The two suggestions that were received offer the addition of more social media feeds and a mobile-friendly version. While these suggestions were considered for further development of the webpage, ultimately, the webpage was considered to be successful and did not warrant any changes.

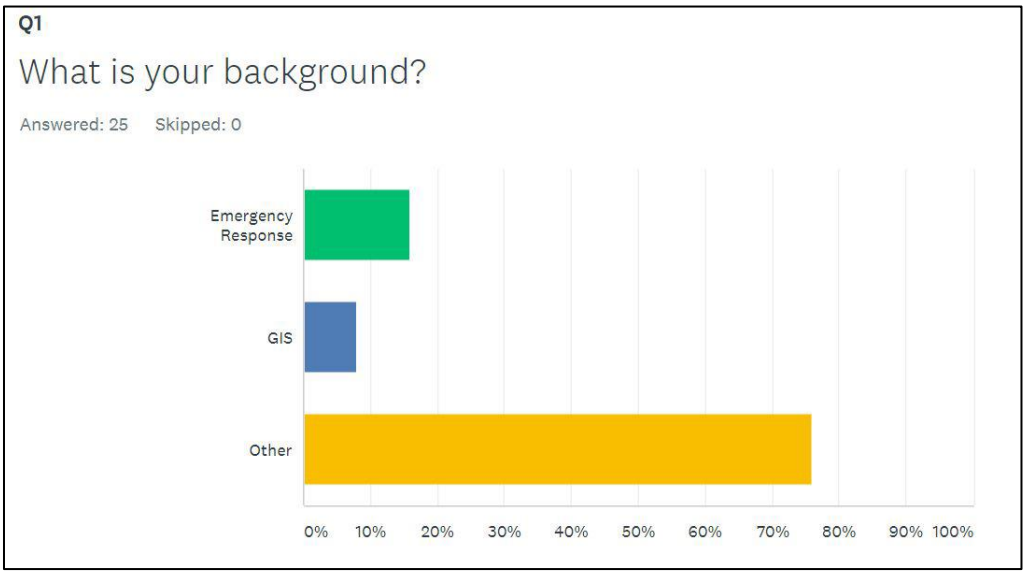


Figure 8-1: Question 1 Results

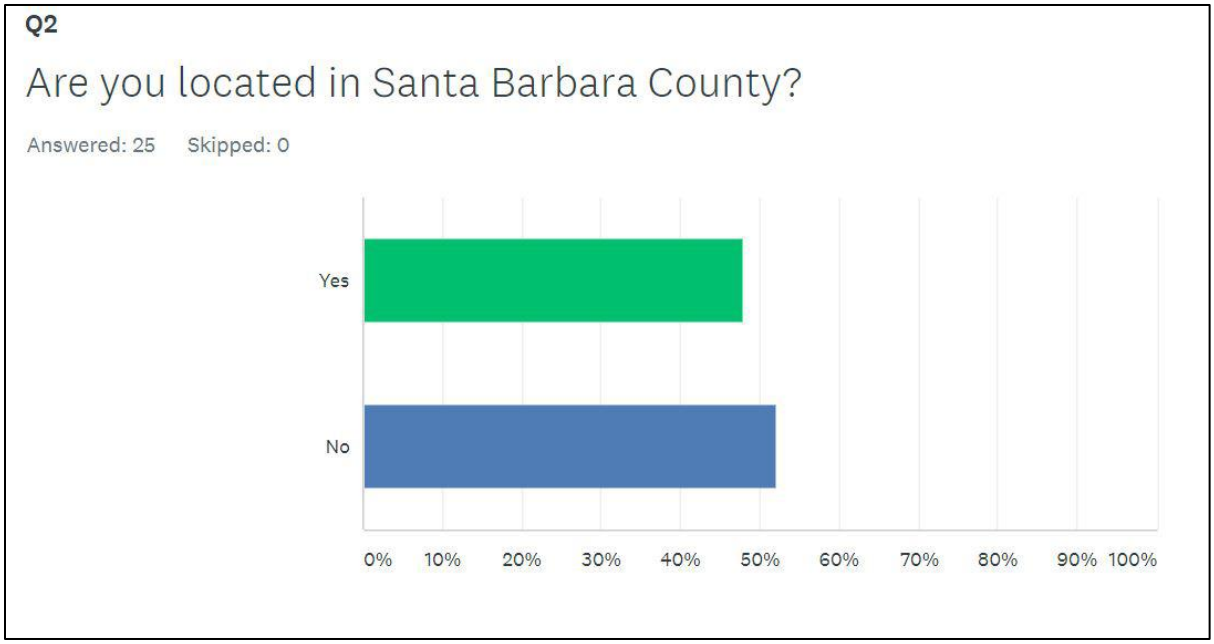


Figure 8-2: Question 2 Results

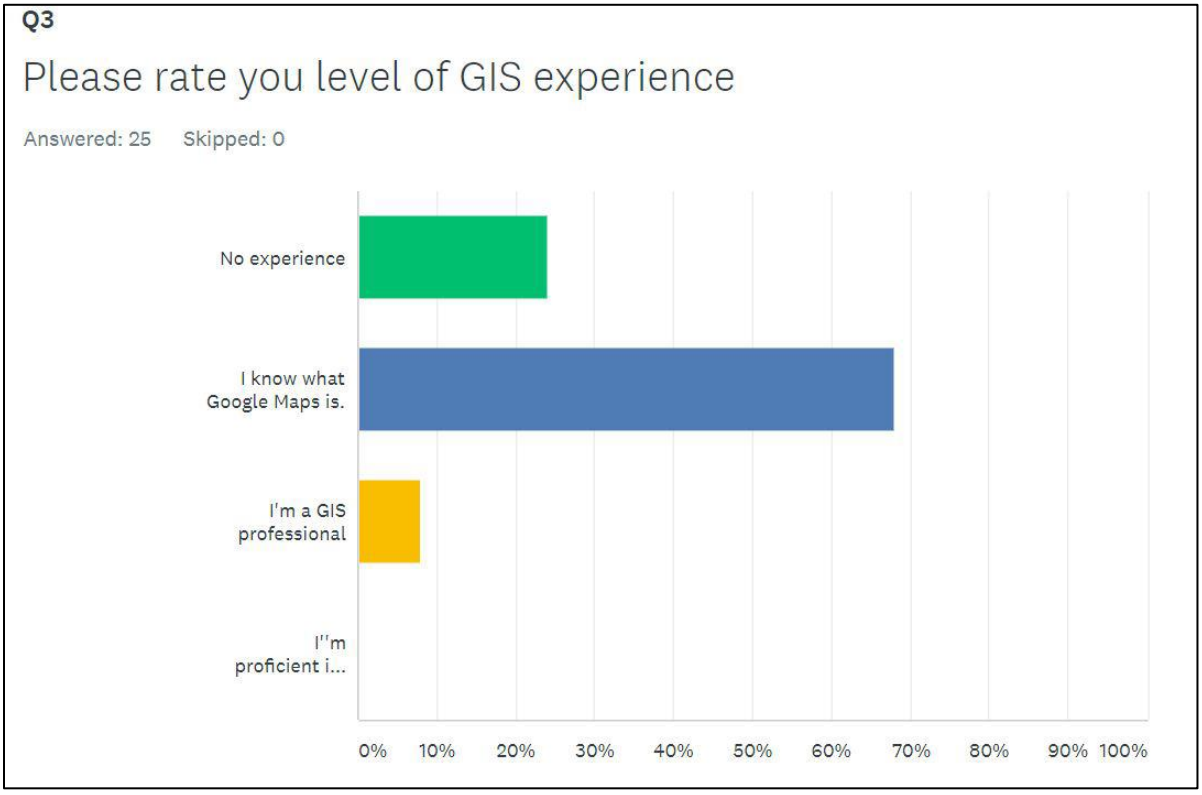


Figure 8-3: Question 3 Results

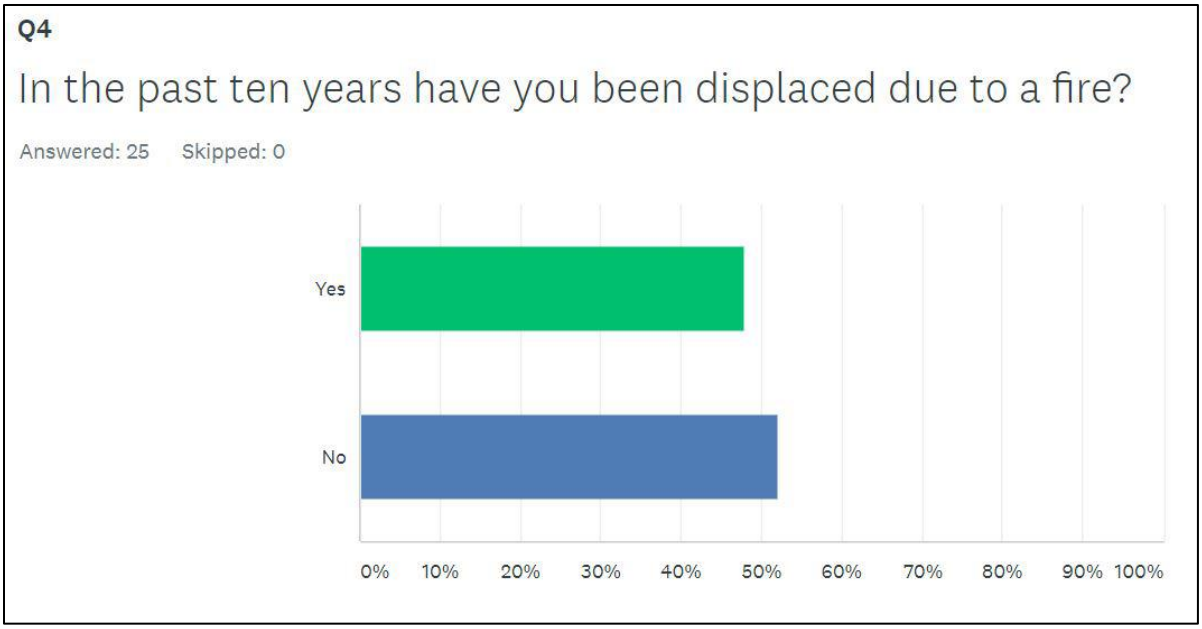


Figure 8-4: Question 4 Results

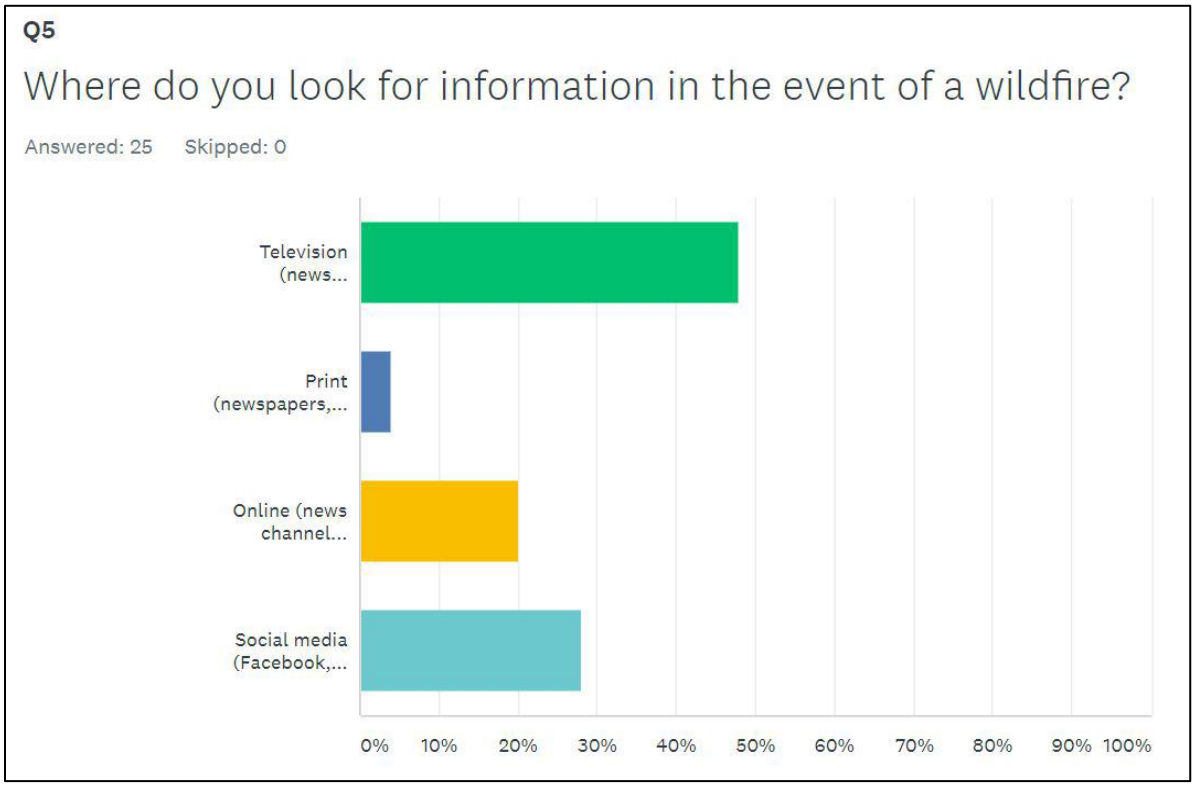


Figure 8-5: Question 5 Results

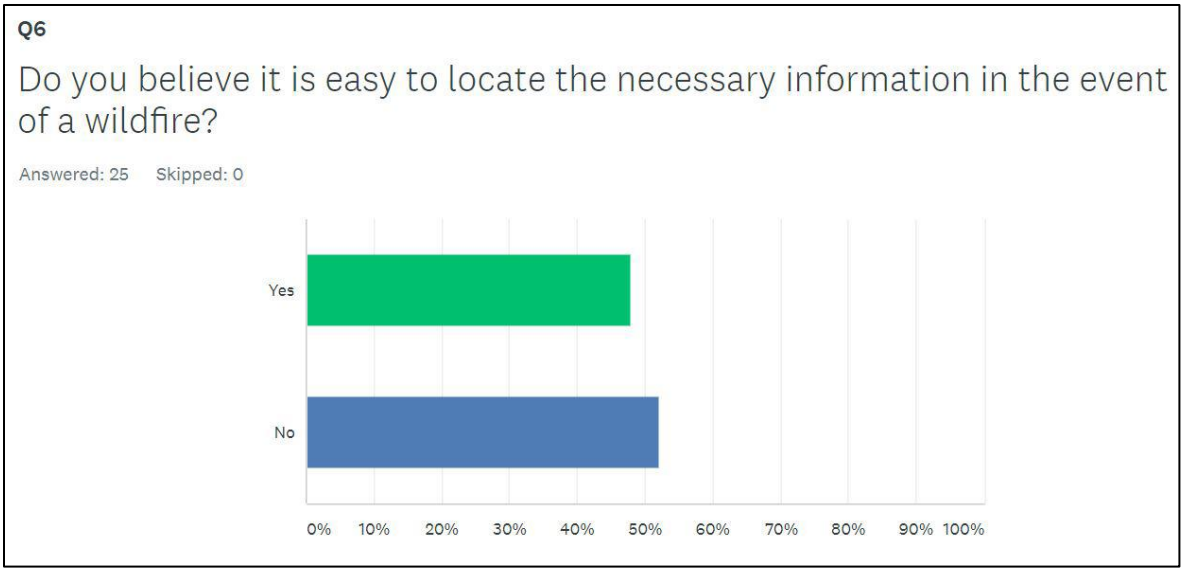


Figure 8-6: Question 6 Results

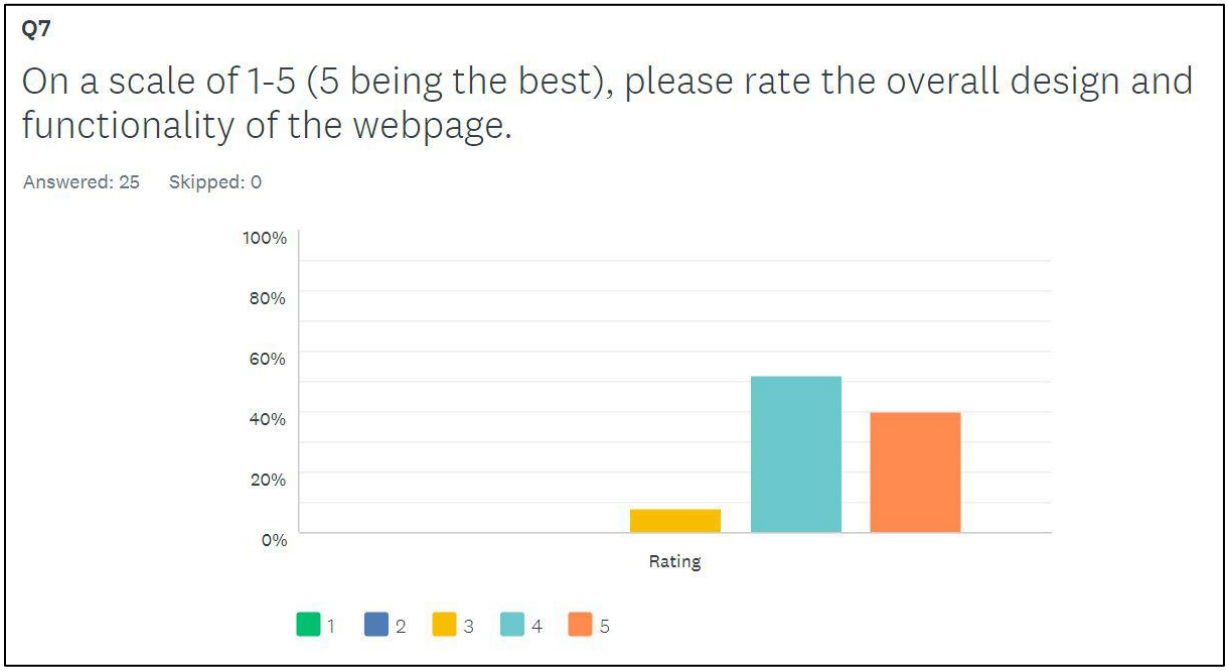


Figure 8-7: Question 7 Results

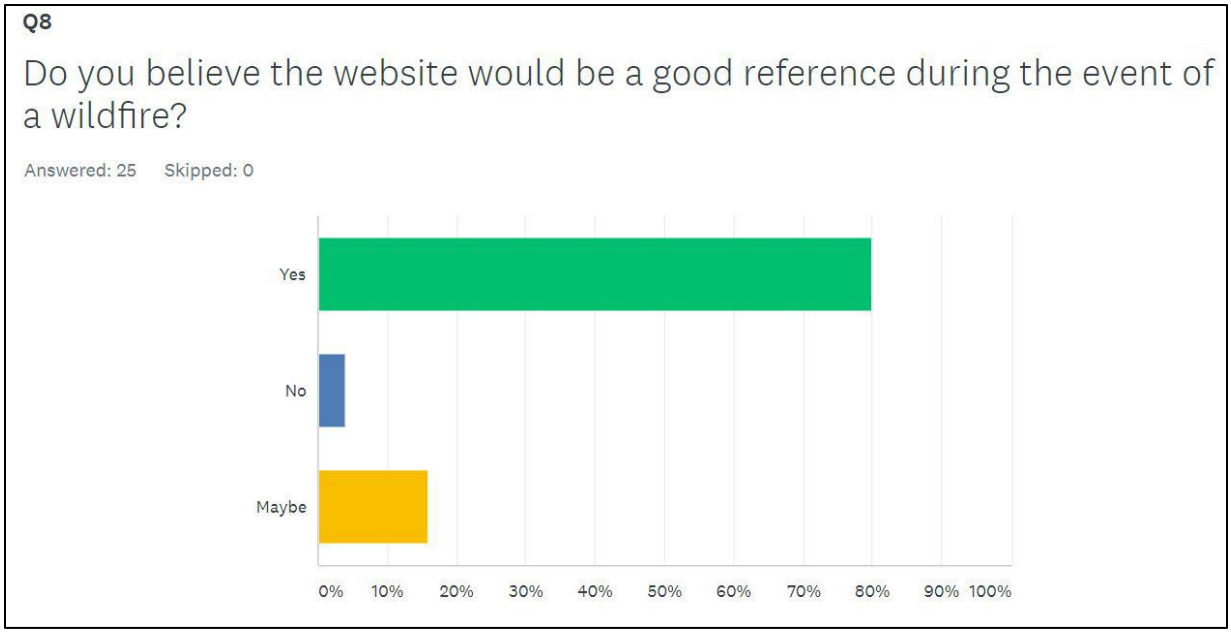


Figure 8-8: Question 8 Results

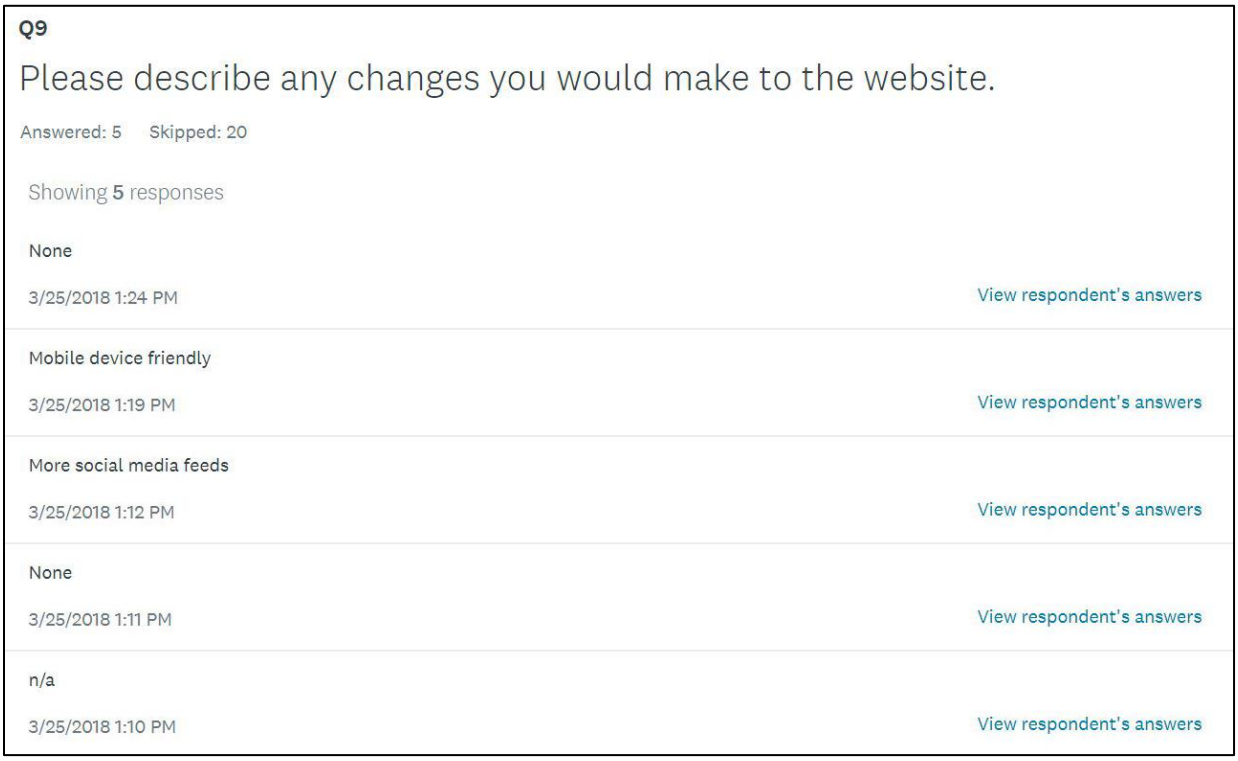


Figure 8-9: Question 9 Results

# Chapter 6 Conclusion & Recommendations

The overall webpage facilitates a web mapping application intend to be used by Santa Barbara County residents during the event of a wildfire. This chapter explains the issues, successes, and describes future development planned for the web mapping application and webpage.

## 6.1. Issues

Lack of experience with coding caused some thesis challenges. The ability to use ArcGIS Online templates for the web mapping application and the goal of a simplistic webpage design assisted in the development of the end product. The Twitter feed embed also proved to be a problem. The parameters of the feed can be set on the Twitter website, but do not allow for customizing the text or styles, thus using the ArcGIS template results in the feed provided in the final application being displayed in a large font, different from the font found on the rest of the webpage.

Web AppBuilder also has limitations regarding widgets and design and limit the user abilities of the web mapping application. Though the directions and near me widget showed to be appropriate for the web mapping application, the ability to incorporate other features could have allowed for a more successful end result. Customization of widgets was not considered as part of this thesis work, thteration of the application (Esri, 2018; Fili, 2017).

## 6.2. Future Work

For this thesis, the survey responses resulted in very little critical feedback. Although some of the survey population requested additional social media feeds and a mobile-friendly version, the goal of this project was to create a webpage. Further work would incorporate crowd-sourcing tools, such as a comments thread for users to post comments pertaining to the wildfire

or disaster event within the webpage. The incorporation of a comments thread could allow for additional updates, whether it be road closures or other important information. In addition to a comments section, a weather widget could be incorporated in the webpage design, rather than a link to the National Weather Service. Including a weather widget within the webpage itself would allow users to anticipate the path and the future of the wildfire growth based on the local weather provided on the webpage. The Federal Emergency Management Agency (FEMA) provides REST service layers with information regarding emergency shelters. The REST service layers are automatically updated by FEMA during a declared disaster. Rather than relying on the developer to update evacuation center information, the FEMA REST service layer would continually update to provide users with the most current information (OpenFEMA, 2017).

To allow for volunteered geographic information, additional Web AppBuilder widgets could be included to allow users to add temporary graphics directly to a map, such as points, lines, polygons, and other shapes (Esri, 2018), or allow end users to add features to the map for a specified layer and provide data within a given feature layer attribute table (Esri, 2018). Maintenance, quality control and security planning for implementing the addition of volunteered geographic information data into application would also be required.

Further work would also include developing both iOS and Android mobile application using Android Studio or Esri AppStudio. A mobile application would be an important resource for residents to use in the event of a wildfire, because features of the web mapping application widgets, like the directions widget, could be used while remote positioning, e.g. in a car (Esri, 2018). The addition of a mobile application would ensure the functions of the webpage are available to most all residents of Santa Barbara County.

Ultimately, the webpage successfully provided users with a product they felt would be beneficial in the event of a wildfire. That said, there can always be further development to fine tune the web mapping application and the webpage design. Further development may include working with a professional whom is proficient in HTML and CSS to assist in developing a website that allows for ease of use and appealing aesthetics.

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# Appendix A Webpage Code

```
<!DOCTYPE html>
<html lang="en">
  <head>
    <meta charset="utf-8">
    <meta http-equiv="X-UA-Compatible" content="IE=edge">
    <meta name="viewport" content="width=device-width, initial-scale=1">
    <title>SBC Fire Tracker</title>

    <link href="css/bootstrap.min.css" rel="stylesheet">
    <link rel="stylesheet" href="css/animate.css">
    <link rel="stylesheet" href="css/font-awesome.min.css">
    <link href="css/style.css" rel="stylesheet">

  </head>
  <body>
    <header><span>
        <div class="container">
            <div class="row">
                <nav class="navbar navbar-default" role="navigation">
                    <div class="container-fluid">
                        <div class="navbar-header">
                            <div class="navbar-brand">
                            <a><h1>Santa Barbara Fire Tracker</h1></a>



                            </div>
                        </div>
                        <div class="menu">
                            <ul class="nav nav-tabs" role="tablist">
                                <li role="presentation"><a href="http://www.countyofsb.org"target="_blank">County of Santa
                                Barbara</a></li>
                                <li role="presentation"><a href="http://www.readysbc.org"target="_blank">Aware & Prepare
                                </a></li>
                                <li role="presentation"><a href="http://www.weather.gov"target="_blank">National Weather
                                Service</a></li>
                            </ul>
                        </div>
                    </div>
                </nav>
            </div>
        </div>
    </span></header>

    <div style="width: 100%"><iframe width="100%" height="600" src="
    http://uscssi.maps.arcgis.com/apps/webappviewer/index.html?id=0b2b25aa4a384e4890d783854ab64c1d" frameborder="0" scrolling=
    "no" marginheight="0" marginwidth="0"></iframe></div>

        <div class="content">
            <h2><span>About The Application</span></h2>
            <p>The following web application is intended to provide users with necessary information during the event of a
            wildfire. This information provided is a mash-up of information from a number of different agencies, thus the
            content is only as current as the data from other agencies.</p>
        </div>

    <footer>
        <center><div class="container">
            <div class="row">
                    <div class="widget">
                        <a class="twitter-timeline" data-width="100%" data-height="500" data-link-color="#ffa500" href="
                        https://twitter.com/briannawiley/lists/recent-twitter-updates?ref_src=twsrc%5Etfw">A Twitter List by
                        briannawiley</a> <script async src="https://platform.twitter.com/widgets.js" charset="utf-8"></script>

                    </div>
                </div>
            </div></center>


        <div class="sub-footer">
            <div class="container">
                <div class="row">
                    <div class="col-lg-12">
                        <div class="copyright">
                            <p>
                                <span>Brianna Wiley  |  University of Southern California  |  2018</a>
                            </p>


                        </div>
                    </div>

                </div>
            </div>
        </div>
    </footer>
```