**GIS Analysis of AFD’s Wildfire Incident Data**

**From January 2012 to March 2018**

BOBCAT WILDFIRE CONSULTANTS

Consulting Team Members:

David Olguin: Manager

Thanh Nguyen: Schedule Coordinator/Analyst

Jorge Perdomo: Budget Coordinator/Analyst

Samuel Becker: Literature Reviewer/Analyst

Rhodes Smartt: Data Coordinator/Analyst



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**Introduction**

Summary

The city of Austin, Texas has a population of over one million people and is growing every day. With around 450,000 living within the ‘Wildland Urban Interference’, or WUI, it is important to look at what potential hazards could arise for the citizens living within these areas. Due to extensive droughts and high levels of vegetation density, one of the largest threats we have here in Central Texas is wildfires. Cases of these wildfires can be seen all over Central Texas with the Bastrop fire of 2011 being a prime example, which destroyed 1,673 homes and inflicted $325 million in property damages. Observing and understanding these wildfires and their causes is key to trying and preventing future damage that could be brought with wildfires in the area. In order to accomplish this, the Austin Fire Department’s Wildfire division will work with the Bobcat Wildfire Consultants to conduct a temporal and spatial analysis of wildfire trends, as well as analyze potential threats of ignitions. By following the correct steps in our GIS analysis, we hope to identify and mitigate wildfires within the area while also informing the public about the potential threats and damages that these hazards can cause.

Purpose

This study aims to observe the trends and causes of wildfires from 2012 to the present within the Austin community, as well as develop predictive locations for possible future fires based on fuel type and population based on data provided by the City of Austin as well as data that the Bobcat Wildfire Consultants have gathered. In this study we will look at a temporal analysis of ignitions, which includes the time of day, week, season, and also what the weather conditions were during the fire occurrence. We will also perform a spatial analysis of ignitions using methods such as a Getis-Ord Hotspot analysis, and will also include political boundaries to show if certain tracts and/or districts are more prone to wildfires. By combining all of these different methods, we plan to develop an in-depth perspective on wildfires within Austin while furthermore remaining thorough, analytical, and creative.

Scope

The scope of our study will be limited to Austin’s city limits, and will focus specifically on the city’s WUI areas. The data collected is from 2012-2018, however, we will be doing analyses that attempt to look into future possibilities of potential wildfires.

**Literature Review**

In order to holistically discuss the work done on wildfire risk analysis, it is necessary to build a conceptual model of how the project’s components are crucially connected to each other, which can then be used to precisely describe why the study area is at risk based on the attributes involved.

*A. Attribute-Similar Studies*

Beginning with the ‘Wildland Urban Interface’ (WUI), which can be seen as the frame that all the other components will be built upon, a 2007 Journal of Forestry article aimed to further define the WUI, and included the Federal Register 2001 report that stated the Federal government’s official definition of it (Stewart et al. 2007). Split into two categories, their definition is as follows:

*1. If A) housing density is greater than 1 housing unit (hu) per 40 acres, and B) greater than 50% of the pixels within a given area’s digitized census block is wildland vegetation, then it is intermix WUI.*

*2. If A) housing density is greater than 1 hu per 40 acres, B) less than 50% of the pixels within a given area’s census block is wildland vegetation, and C) the given area is within 1.5 miles of a large area containing more than 75% wildland vegetation, then it is interface WUI.*

Continuing with the WUI, Society & Natural Resources published a journal on the demographics, history, and development of the WUI in the United States that described how the WUI came to be a regular feature of this country’s urban landscape (Hammer et al. 2009). Key stats from this journal are as follows:

*1. During the 1990s, the contiguous US’s WUI grew 115,000 km², a 19% increase in its total area; concurrently, ~8 million houses were added to the nation’s WUI, a 22% increase in its total amount, and for every 100 houses built during this decade, 53 were built in the WUI.*

*2. In 2000, the contiguous US’s WUI accounted for 38% of all housing units, totaling at 44.3 million homes, and 11% of the nation’s area, totaling at 715,000 km²; from this total WUI area, 18% was interface and 82% intermix, with 51% of WUI houses being in the interface and 49% being in the intermix.*

*3. In 2000, the contiguous US’s WUI accounted for 37% of the nation’s total population, or 104 million people.*

Addressing an alarming element of US wildfire history, it is essential to discuss the previous failures in federal policy that allowed for our current wildfire vulnerability status to be as high as it is, specifically the policy steps that were taken from 1905 to 1911 that paved the way for such a high wildfire vulnerability to even be possible. While there are numerous works done on this matter, the issue is most succinctly laid out by a 2004 Review of Policy Research article (Busenberg 2004) and a 2015 Science Magazine article (North et al. 2015). Both argue that the policy failures are, arguably, causal in their long-term consequences regarding the acceptance of dense wildfire fuel accumulation, history of dogmatically imbalanced mitigation strategies, and the federal expansion of national forests that led to a nationally-encompassing wildfire vulnerability. Furthermore, the exact nature of and processes concerning the spread of wildfires has not yet been determined, according to a 2015 Missoula Fire Sciences Laboratory report (Finney et al. 2015). Their report claims that theories of wildfire spread and their accompanying models both rely on a fair amount of assumptions rather than verifiable phenomena, and to mitigate this uncertainty, they have grouped key studies together that shed light into the nature of wildfire spread. The most relevant conclusion from this report is as follows: the wildfire ignition process is strongly tied to the amount of irregular (or, ‘non-continuous’) convection in its flame zone, buoyancy in its flame zone, and fine fuel particles present in the ignition area, with higher amounts of each being correlated to higher chances of wildfire ignition.

*Method-Similar Studies*

Shifting to studies that used methods that align well with the GIS-based methods we will be using, a 2011 paper included in the European Journal of Forest Research used two logistic regression models in GIS to perform risk estimations for wildfires caused by humans, rather than other factors (Vilar del Hoyo et al. 2011), and also included a WUI in their study area. While their first model focused on plotting fire ignition coordinates to be used as the main variable for observation, while their second model focused on mapping ignition density using Kernal density interpolation, a method that can be seen as much more useful for attempting to determine the variables involved with human-caused wildfires. Another GIS-based study published by the Journal of Environmental Planning and Management used both vector data and remote-sensing imagery to analyze subdivisions that have been burned by wildfires, and also utilized a regression model for risk estimation by comparing pre- and post-fire data with it (Bhandary et al. 2009). The vector data used contains large overlap with the data we will be using, including vegetation density, slope and aspect, distance from the closest fire station, etc., and their conclusions all support the land-use planning community’s prevailing fire prevention techniques, such as vegetation density regulation, topography-sensitive building site-planning, and equal access to fire stations throughout a given area.

*Localized Studies*

According to a report done by the Texas Comptroller of Public Accounts, the 2011 drought induced severe weather conditions that resulted in a total of 23,835 fires to level roughly 2,763 homes and burn roughly 3.8 million acres, during the period of November 15th, 2010 to September 29th, 2011 (Combs et al. 2012). Coupling these facts with a 2015 Texas State University dissertation that analyzed wildfire mitigation behaviors in the residential areas surrounding Balcones Canyonlands Preserve in Austin, Texas, there is considerable evidence to support the notion that many central Texas residents are actively taking measures to ensure that their homes are less vulnerable to wildfires (Nox 2015); using behaviors such as ‘cleaning vegetation out of the gutters and off of roofs’ and ‘trimming tree limbs to be at least ten feet away from the roof’, the study results indicated that a substantial amount of the residents in the study area participate in these mitigation behaviors to intentionally be less prone to wildfire damage rather than for another reason, however, it also concluded through the use of a hotspot analysis that there is no significant correlation between wildfire mitigation behaviors and adjacency to recent wildfire occurrences. Finalizing the review with a work that analyzed wildfire incidents in Travis County’s WUI using similar methods that account for many of the same attributes, a report included in the 2009 Geospatial Techniques in Urban Hazard and Disaster Analysis textbook sensibly revealed that the risk of wildfires within the county is greatest in areas with the densest WUI, and proposed that unused lands with considerable fuel density be used as fire buffer zones or stripped completely of their fuel (Lu et al. 2009).

The information above will be appropriately and effectively incorporated into our study, which will aid us in our analysis of relevant processes and phenomena, expansion on findings made from methodically-similar and geographically-similar studies, and synthesis of new material. Having this hefty load of information directly relevant to the concepts explored in this project will allow us to dive deeper into how they affect this local region and possibly contribute to the task of solving some of the problems discovered by previous studies’ findings.

**Data**

Seeing that we will be conducting a large amount of statistical analyses for this project, gathering the necessary data will be crucial for our success. In order to effectively complete these tasks, we have gathered data from various sources, including the City of Austin, Texas Wildfire Risk Assessment Portal, and ArcGIS’s website.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Entity** | **Attributes** | **Spatial Object** | **Status** | **Source** |
| Fire Risk | WUI, Vegetation Type, Fuel Type, Ignition, Fire Stations, Slope | Points, Lines, & Polygons | Available | Texas Wildfire Risk Assessment Portal |
| Flame Map Input Fuel | Vegetation, Fuel Inputs, Fire Locations, City of Austin Map | Points & Polygons | Available | Travis County: Wildfire Division |
| Wildland Urban Interface | WUI layer if needed | Polygon | Available | ArcGIS (Steven Casebeer) |
| Weather Conditions | Weather conditions of Austin according to date | No: Attribute | Available | Texas Weather Conditions |
| City of Austin Geodatabase | Transportation, Parks, Environmental, Administrative, Facilities | Points, Lines, & Polygons | Available | City of Austin |
| Austin Building Footprints | Footprints of Austin Buildings | Polygons | Available | City of Austin |
| Austin Land Use Data | Land use | Polygons | Available | City of Austin |

**Methodology**

We will combine client-provided point data with open source information we’ve gathered from various resources including:

1. City of Austin

2. ArcGIS Online

3. U.S. Department of Agriculture

4. U.S. Forest Service

5. Austin and Travis County Community Wildfire Protection Plan

6. Texas A&M University’s Texas Weather Connection

7. Texas Wildfire Risk Assessment Portal

We will be utilizing database operation tools in Microsoft Excel and various geoprocessing tools (listed below) to analyze our data in ESRI ArcMap. The following types of analyses will be studied for the project:

**Analysis**

Spatial Analysis

Nearest Neighbor—the question we want to answer is: “How are the reported wildfires spatially distributed?” Using a Euclidian distance, we’ll look at whether the points are dispersed or clustered. We’ll use the Austin city limits polygon as our study area and focus on the points that are clustered to help identify hot spots and assess risk potential.

Hot-Spot Analysis—we’ll converge our clusters into centroids using a one mile radius. We’ll also determine standard distances and the directional distribution for each cluster. These subsets will allow us to identify hot spots near the WUI.

Spatio-Temporal Analysis

We’ll take the dates of the wildfire points and create three new fields to separate the day, month, and year, then use a relational join to be able to look at various times of the year. Using definition queries, we’ll look at point data aggregated annually and quarterly to determine what years and seasons have been the most active and where. These definition queries will also help us identify where annual occurrences are growing or shrinking. We’ll also compare these temporal datasets to weather conditions to help identify any correlation with wildfire activity.

Regression Analysis

Using Texas A&M University’s Texas Weather Connection data we’ll add a weather conditions field for each wildfire point and analyze the correlation between cause of ignition and the corresponding day’s weather.

Ignition Potential Analysis

Looking at the timestamps from each wildfire data point we’ll also analyze the correlation between high traffic durations and the wildfire’s proximity to roadways. This will help us identify areas where ignition is likely during a given time of the day and day of the week.

Knowing that a big percentage of wildfire causes are human related, we’ll assess the human accessibility to areas where fuels (e.g. vegetation, or homes) are dense. We’ll use a vegetation model, park locations, and a road layer to locate those areas that have a high ignition potential. In relation to the WUI, we will analyze whether parks and access to forested areas are an ignition risk factor.

**Budget**

Data Collection

Total Hours (8 hrs/week\*2.5 weeks\*5 consultants)……………...100hrs

Hourly Pay…………………………………………………………………………….$31.92

Total….………………………………………………………………………………...$3,192

Data Analysis

Total Hours (8 hrs/week\*3 weeks\*5 consultants)………………..120 hrs

Hourly Pay……………………………………………………………………………..$31.92

Total…………………………………………………………………………………….$3,830.40

Map Implementation

Total hours (8 hrs/week\*3 weeks\*5 consultants)………………...120 hrs

Hourly Pay………….………………………………………………………………….$31.92

Total…………………………………………………………………………………….$3,830.40

Data interpretation

Total Hours (8 hrs/week\*2 weeks\*5 consultants)………………....80 hrs

Hourly Pay…………………………………………………………………………….$31.92

Total…………………………………………………………………………………….$2,553.60

**Grand Total....………………………………………………………………………...13,406.4**

**Timetable**

Phase 1: Data Collection and Processing

The first part will be 2.5 weeks for searching, collecting and processing the data. The clients gave us the fuel layers, the Austin and Travis shapefile with data of transportation, service, schools, etc. Other data are also being gathered. We currently have all the data, layers and features of the city of Austin and Travis County. Once completed we will start processing all the data.

Phase 2: Data Analysis

The second part of this project will be 3 weeks. In 3 weeks we will create and analyze all the data, shapefile, layers, base maps, imaginary surfaces in ArcGIS software. We use the guidance for wildland urban interface (WUI) fire evacuation and planning in Travis County to complete the project. Our project would include all the trends and hotspots for wildlife incidents, and how it concern to travel corridors, response areas, time of day and year, call type, NFIRS type, property use, ignition cause, ignition factor, structural and population densities, fuel connectivity, vegetation and land-use type.

Phase 3: Web and Map Development

The third part will take about 3 weeks to be completed. We use this time for making story map; identified, analyzed and visualized the data, layers, the spatio-temporal change of wildfire incidents using online map services, such as ESRI Story Maps. We might create a model builder for analyzing the project.

Phase 4: Data Interpretation

The final part allows about 2 weeks to conclude and interpret the results of our work. After creating the project with all the necessary data and information. We could tell how the wildfire affect the population, travel corridor, and the area around city of Austin. We would have what type of vegetation that sensible with fire and which area that they appear mostly in. In this project we might provide some location for new housing and neighborhood where they should be settled in order to avoid future wildfire.

**Timeline**

|  |  |  |
| --- | --- | --- |
| Date | Project Steps | Purpose |
| August 29th - September 17th | Data Collection | Searching and adding data to ArcMap |
| September 19th - October 10th | Data Analysis | Use different tool like Hotspot Analysis, Spatial Analysis, etc. |
| October 15th - November 5th | Web and Map Development | Model Builder |
| November 7th - November 21st | Data Interpretation | Finalize the Project |

**Final Deliverables**

* Simple maps showing wildfire points within Austin city limits, WUI polygon, and roads.
* Query and display maps showing temporal data, seasonal trends of wildfire incidents, and wildfire incidents by census tracts and council districts.
* Analysis maps showing hot spots of wildfire incidents. This will include a semivariogram between weather conditions and cause of ignition.
* Ignition potential model using vegetation, time of day and seasonal weather patterns.

**Conclusion**

Our team aims at analyzing wildfire incidents to help prevent future damages. We’ve incorporated previous studies that suggest theories, models and fire prevention techniques. Temporal, spatial and regression analysis of wildfires and their causes will be used to mitigate threats and inform the public.

Focus

Weather and geographic trends, along with human activities that promote suitable wildfire conditions.

Goal

Contribute to Austin’s Community Wildfire Protection Plan (CWPP) to promote healthy ecosystems and natural resources, while also protecting homes, businesses and emergency personnel.

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**Participation**

David Olguin: Methodology, Analysis

Thanh Nguyen: Timetable/Timeline, Analysis

Jorge Perdomo: Budget, Analysis

Samuel Becker: Literature Review, Data Retrieval, Master Data List, Analysis

Rhodes Smartt: Proposal Intro, Data Retrieval, Analysis