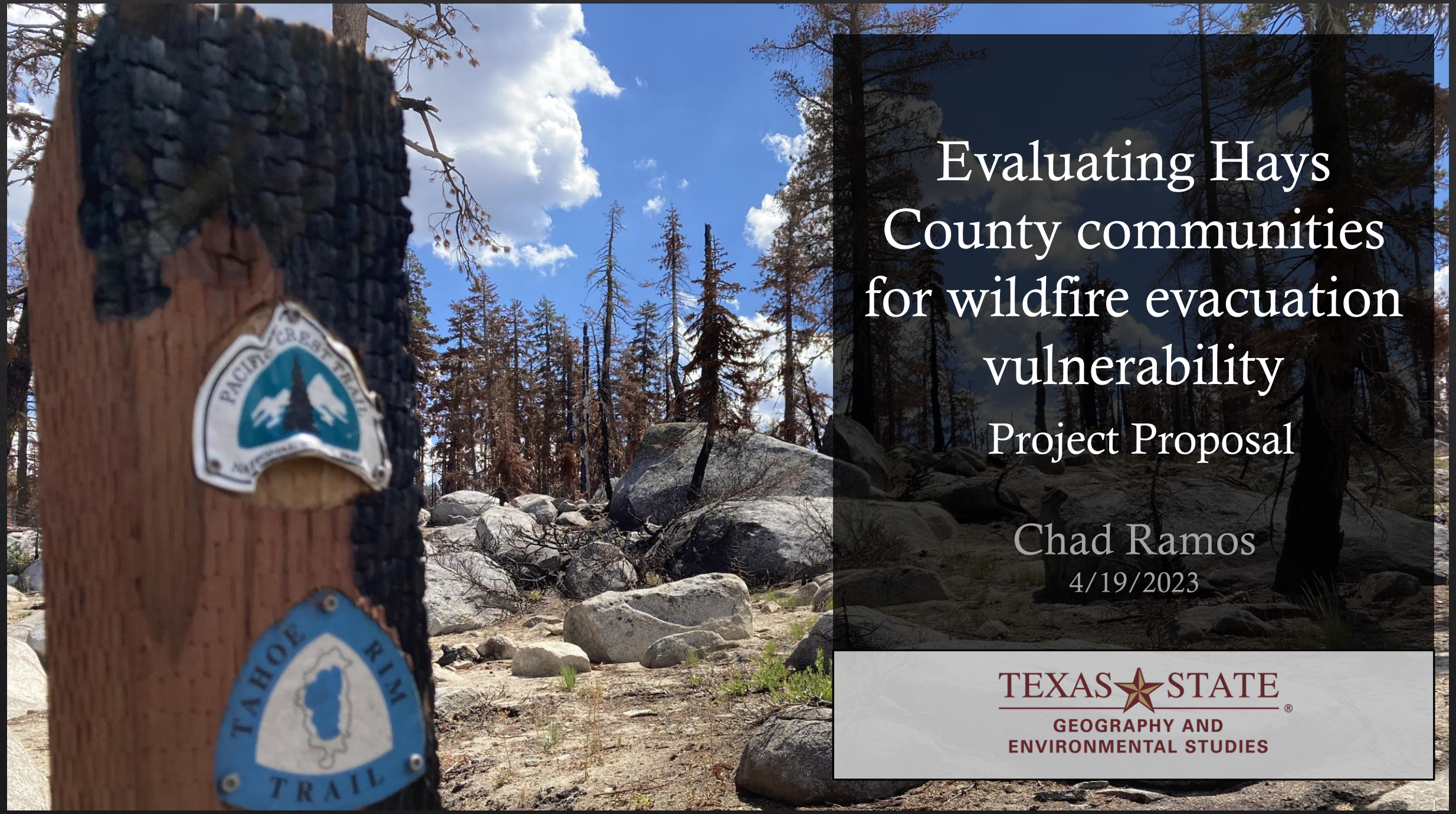

Evaluating Hays County communities for wildfire evacuation vulnerability

Project Proposal

Chad Ramos

4/19/2023

TEXAS STATE
GEOGRAPHY AND ENVIRONMENTAL STUDIES

Research Purpose and Goal

- Propose to search for neighborhoods at risk of a potentially disastrous wildfire evacuation
- The purpose is to develop a method for and then to locate neighborhoods within the Hays County Wildland Urban Interface (WUI) that are at risk of difficult evacuations.
- The goal is to quantify the compound risk of wildfire and constrained evacuation potential, for each neighborhood in the Hays County WUI, and to then identify which communities are at the highest risk of potential disaster.

Introduction

Understanding the Problem

Understanding the problem as a whole requires an understanding of:

- Definition of the Wildland-Urban Interface (WUI)
- Fire risk associated with the WUI
- Inadequate road infrastructure prevalent in WUI neighborhoods

Background

The Wildland Urban Interface

"The area where houses meet or intermingle with undeveloped wildland vegetation"

- Radeloff et al. 2005

- The fastest growing land use type in the US is the Wildland-Urban Interface
  (Radeloff et al. 2005, Radeloff et al. 2018).
- Expansion attributed to amenity-driven growth outside of metropolitan areas
  (Radeloff et al. 2005, Radeloff et al. 2018).
- Primarily new housing
  (Hammer, Stewart, and Radeloff 2009).
- 79.6% of Hays County residents live within the WUI
  (Texas A&M Forest Service 2022).

Figure 1. A neighborhood in the WUI, Texas A&M Forest Service 2022

Background

Fire Risk in the Wildland Urban Interface

"…that geographical area where structures and other human development meets or intermingles with wildland or vegetative fuels" - International Code Council 2014

- Risk of wildfire due to the adjacency of human development and flammable vegetation
  (Radeloff et al. 2005, Radeloff et al. 2018)
- Humans cause the majority of wildfire ignitions
  (Radeloff et al. 2018)
- 80% of Texas wildfires occur within 2 miles of a community
  (Texas A&M Forest Service 2022).

Figure 2. A WUI fire threatening a neighborhood, Texas A&M Forest Service

Background

Factors Compounding the Fire Risk in the Study Area

Climatic Factors

- Central Texas is prone to periodic drought to the extent that it is considered a normal condition. Drought severity is expected to increase in Texas due to climate change, further exacerbating the wildfire risk (Sansom, Armitano, and Wassenich 2008; Nielsen-Gammon et al. 2020)

Topographic Factors

- The Edwards Plateau physiographic province is comprised of rolling hills and canyons which can funnel air allowing fire to spread rapidly up-hill and up-valley, adding to the risk (Hyndman and Hyndman 2017)

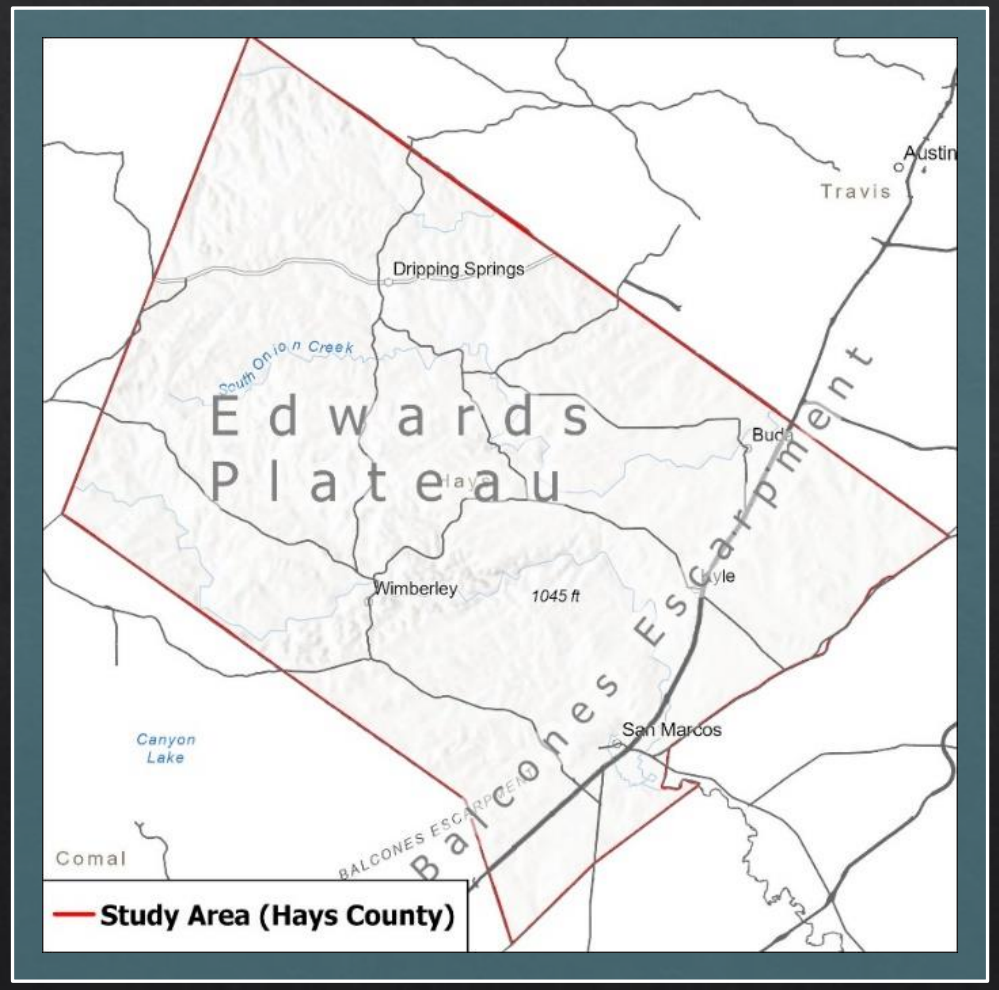

Figure 3. Study Area Overview Author: Chad Ramos | Map Sources: TPWD, CONANP, Esri, HERE, Garmin, SafeGraphy, Meti/NASA, EPA, NPS, CAPCOG

Background

Compounding Factors in the Study Area

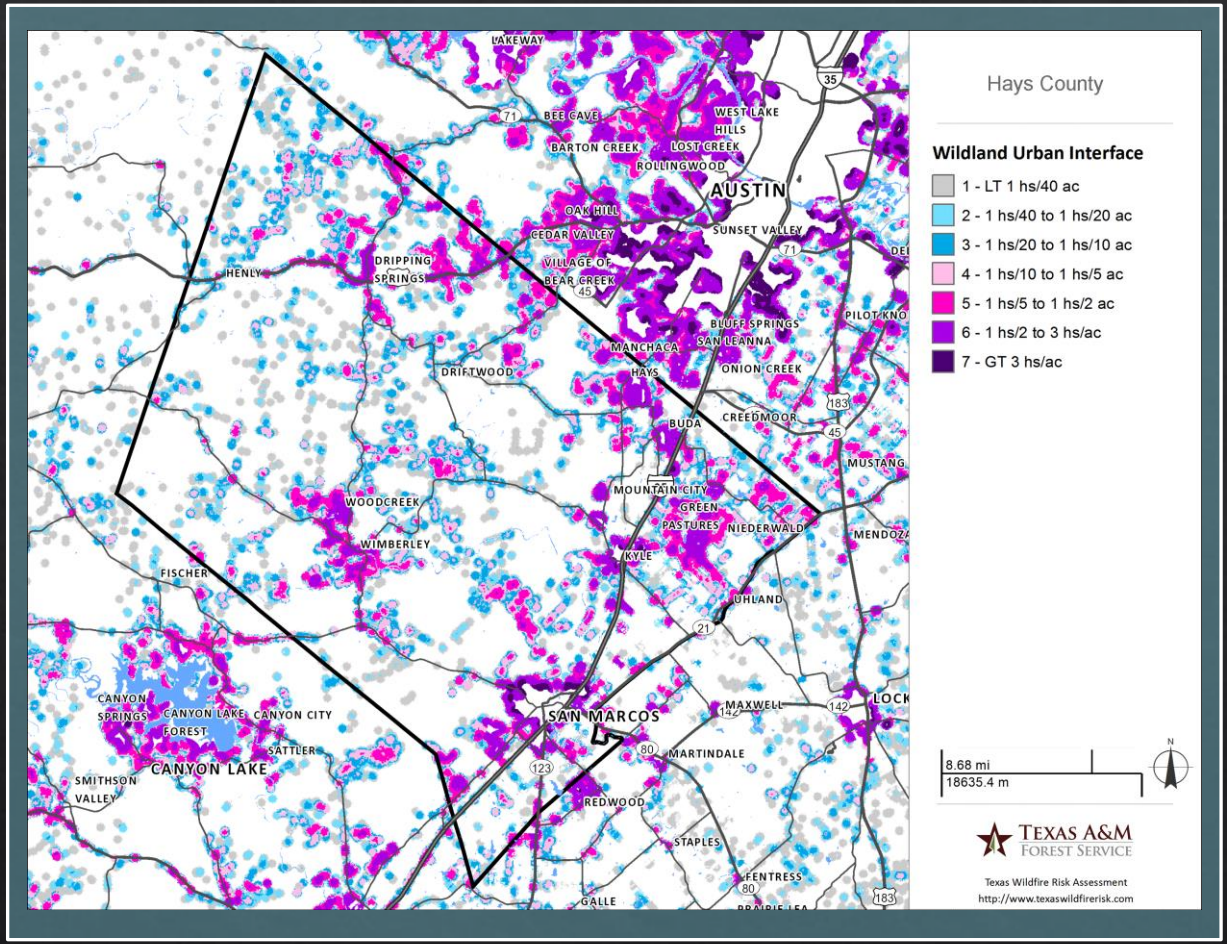

Figure 4. Hays County WUI. 79.6% of Hays County residents live within the fire-prone WUI. Texas A&M Forest Service 2022

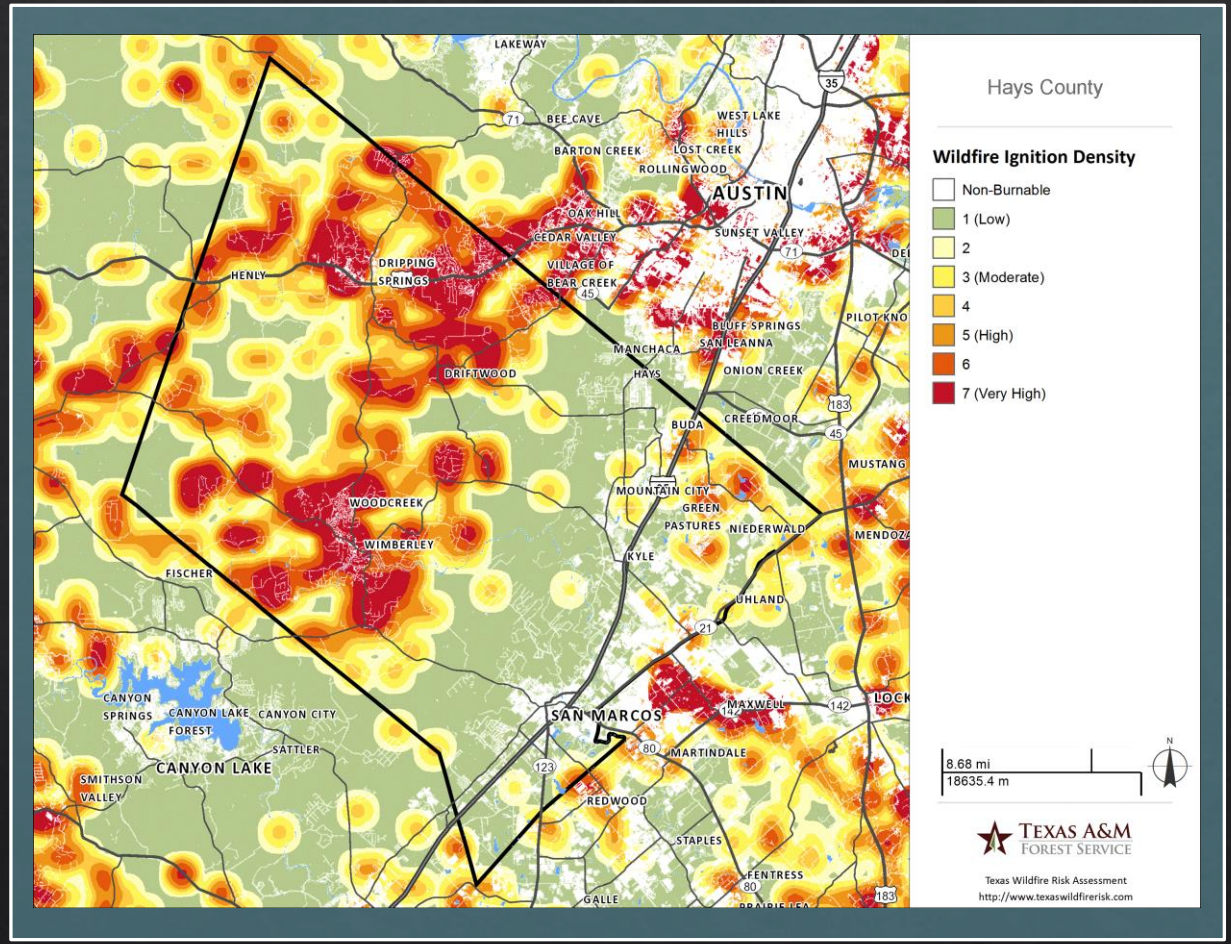

Figure 5. Hays County wildfire ignition density, based on historic fire ignition. Texas A&M Forest Service 2022

Inadequate Road Infrastructure

Oakland Hills Firestorm of 1991

- 337 homes in this neighborhood with four exits. The fire blocked the two primary exits in its first 30 minutes leaving the remaining residents two 13ft wide, uphill exits opposite the primary exits
  (Cova 2005).
- Many of the fatalities were residents caught in or near their cars at the end of a traffic line when the fire passed
  (Cova 2005).
- "It is extremely difficult to evacuate a heavily populated interface zone"
  -US Fire administration after action report
  (Routley 1991)

"The road network is a maze of narrow streets" (Cova 2005)

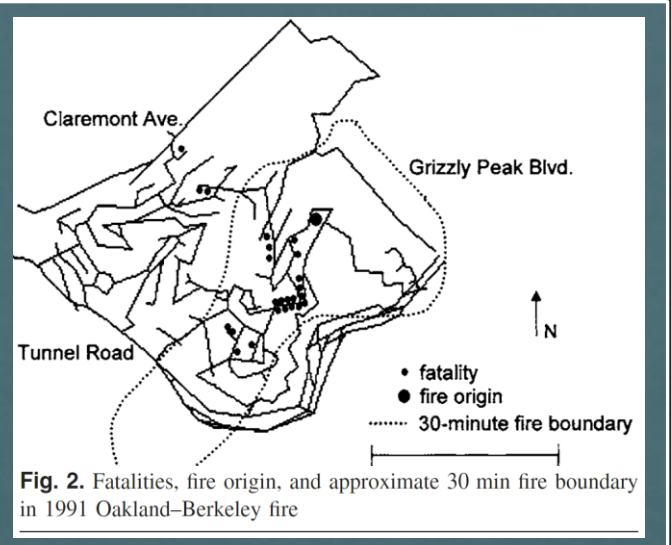

Fig. 2. Fatalities, fire origin, and approximate 30 min fire boundary in 1991 Oakland–Berkeley fire

Figure 6. Depiction of fire spread and fatalities, and Google Street View of East Bay Hills Neighborhood as it is today.

Inadequate Road Infrastructure

Oakland Hills Firestorm of 1991

10:40 A.M. “Confident that they could handle the situation”

-Radio Communication from responding units

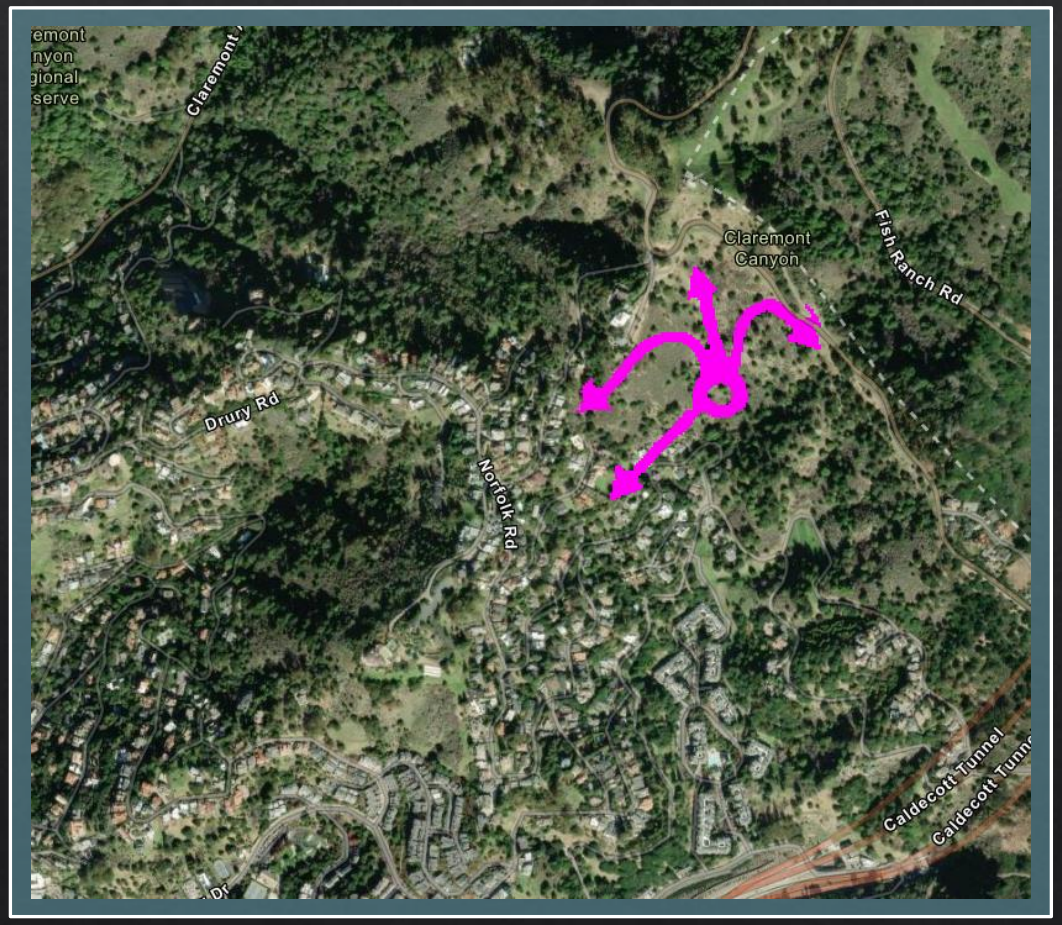

Figure 7. East Bay Hills Fire Origin and initial spread over 25 minutes Map created by author with information sourced from Routley 1991

Situation at 1130 “Totally out of control”

-Radio Communication from responding units

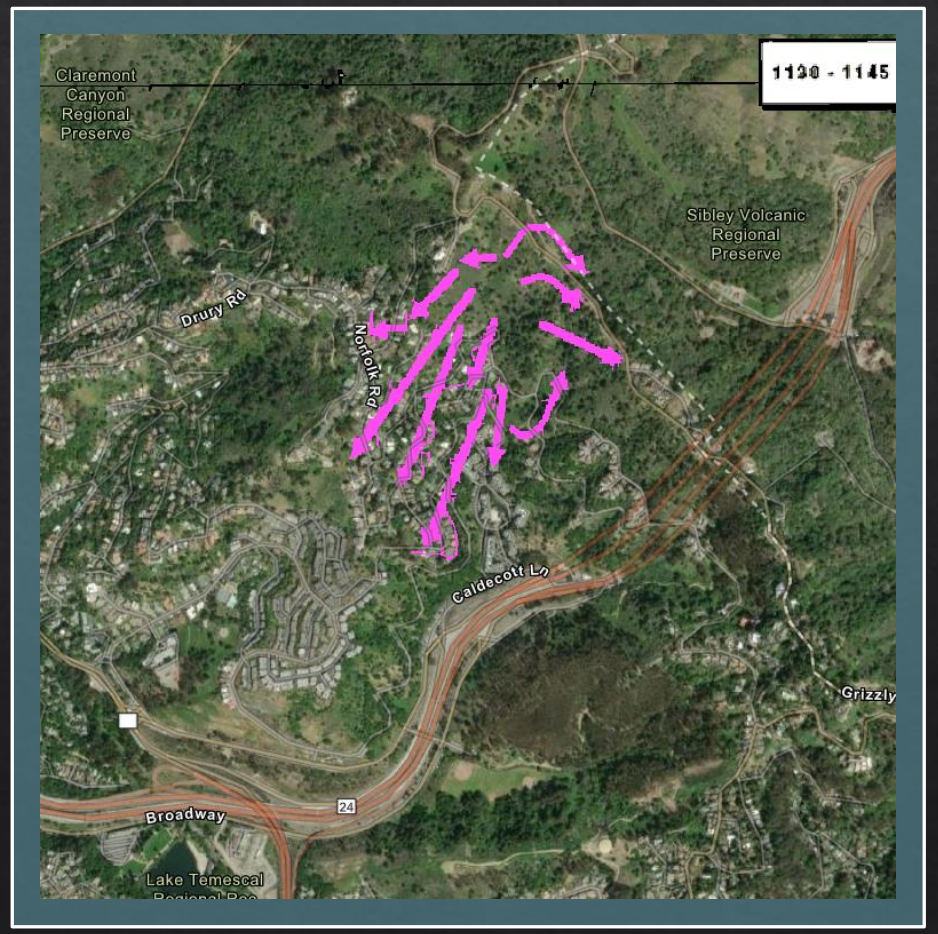

Figure 8. East Bay Hills Fire spread after 50 minutes. Map created by author with information sourced from Routley 1991

Inadequate Road Infrastructure

Examples from Cova et al. 2013

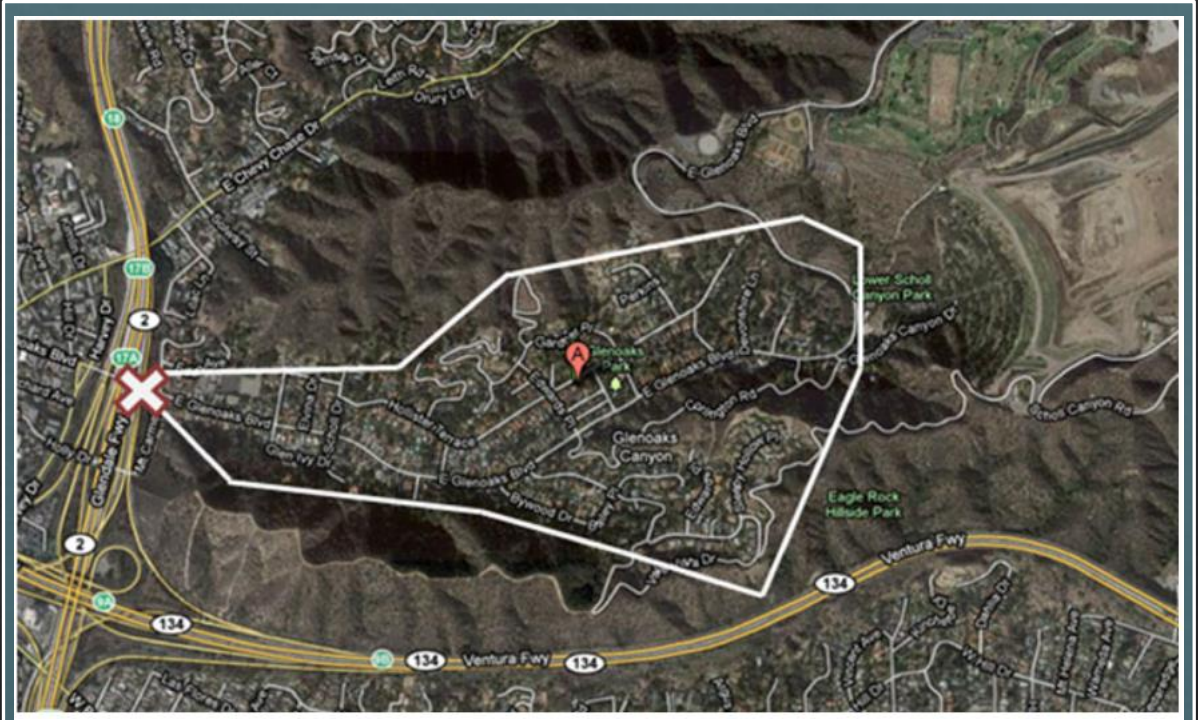

Fig. 2 The Glen Oaks Canyon subdivision in Glendale, CA has an estimated 776 homes and 1 exit (*Image source*: Google Maps)

Figure 9. Illustration of an at-risk neighborhood from Cova et al. 2013

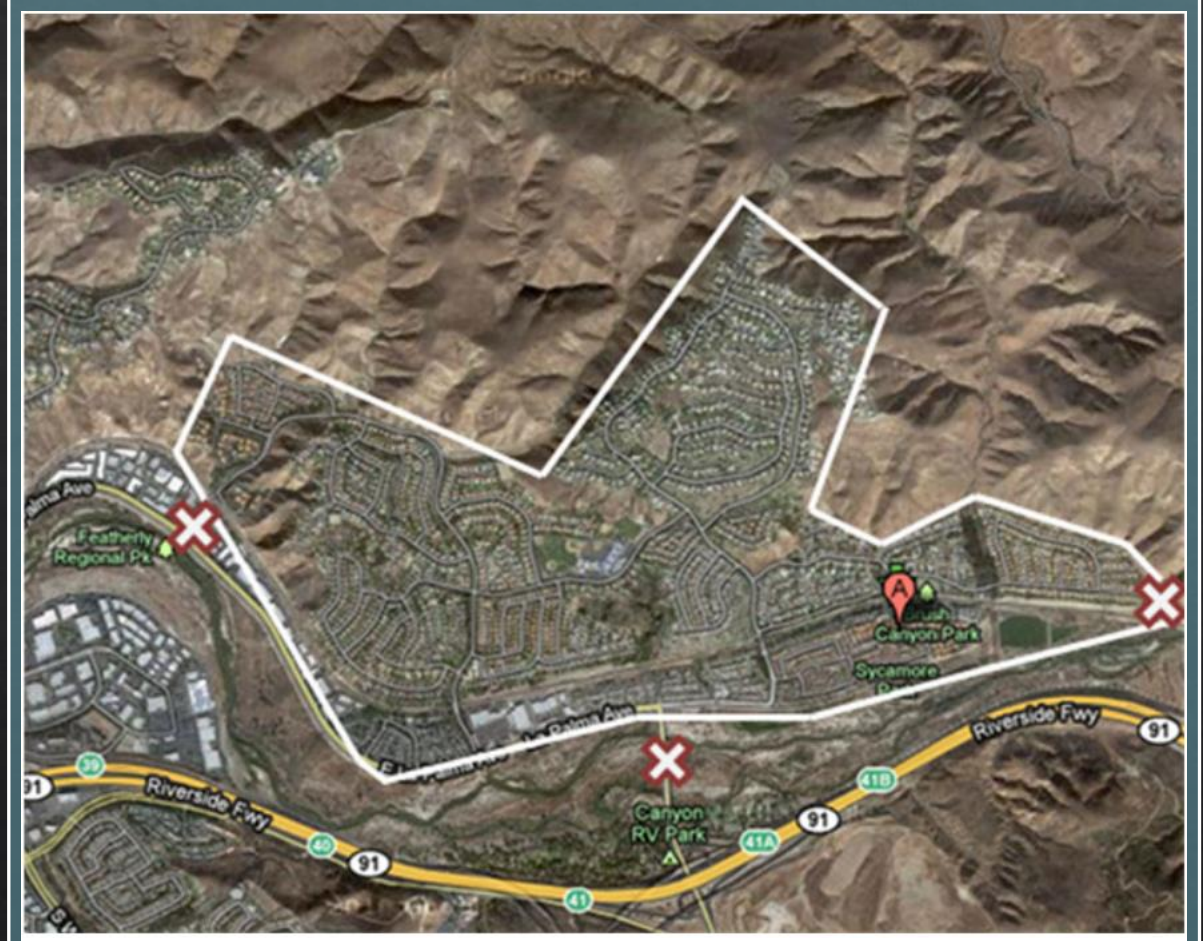

Fig. 4 Bryant Ranch in Yorba Linda, CA has an estimated 1,222 homes and 3 exits (*Image source*: Google Maps)

Figure 10. Illustration of an at-risk neighborhood from Cova et al. 2013

Methods

Finding at-risk Neighborhoods, adapted from Cova et al. 2013

Cova et al. 2013

- Searching for WUI neighborhoods with greater than 200 households per community exit
- Developed the Critical Cluster Model
- Uses complex road networks with impedance values such as travel time or number of lanes
- Uses potential bottleneck intersections to define neighborhoods from a road network
- Integer programming inside optimization software

Proposed Research

- Searching for WUI neighborhoods with greater than 200 households per community exit
- Quantifying combined risk of wildfire and constrained evacuation.
- GIS Spatial Analysis and Spatial Overlay on publicly available datasets set to NENA NG9-1-1 standard
- Uses the NG9-1-1 Neighborhood Attribute to define neighborhoods
- Performed within traditional GIS

Data

Roads and Address Points set to NENA NG9-1-1 GIS Data Standard

- Supports the exchange of address and road information required for emergency 9-1-1 calls across government agencies (NENA Data Structures Committee 2020)

- The GIS data structure includes the attribute, Neighborhood Community:

  "The name of an unincorporated neighborhood, subdivision, or area, either within an incorporated municipality or in an unincorporated portion of a county or both, where the address is located" (NENA Data Structures Committee 2020)

- The NG9-1-1 data model was widely adopted in 2014 (URISA 2021)
- Obtained from Capital Area Council of Governments Open Data Portal

Data

Texas wildfire risk assessment data | Texas A&M Forest Service

- A set of GIS layers that can identify wildfire prone areas based on estimated fuel load, likelihood of ignition, potential impact to life and property, etc. (Texas A&M Forest Service 2022)
- The Wildfire Threat Index layer: describes the “likelihood of a wildfire occurring or burning into an area” and is derived by from a combination of physical landscape characteristics such as surface and canopy fuel loads, historical fire occurrence, historical weather observations, and terrain characteristics (Texas A&M Forest Service 2022)
- Obtained from Texas Wildfire Risk Assessment Portal

Methodology

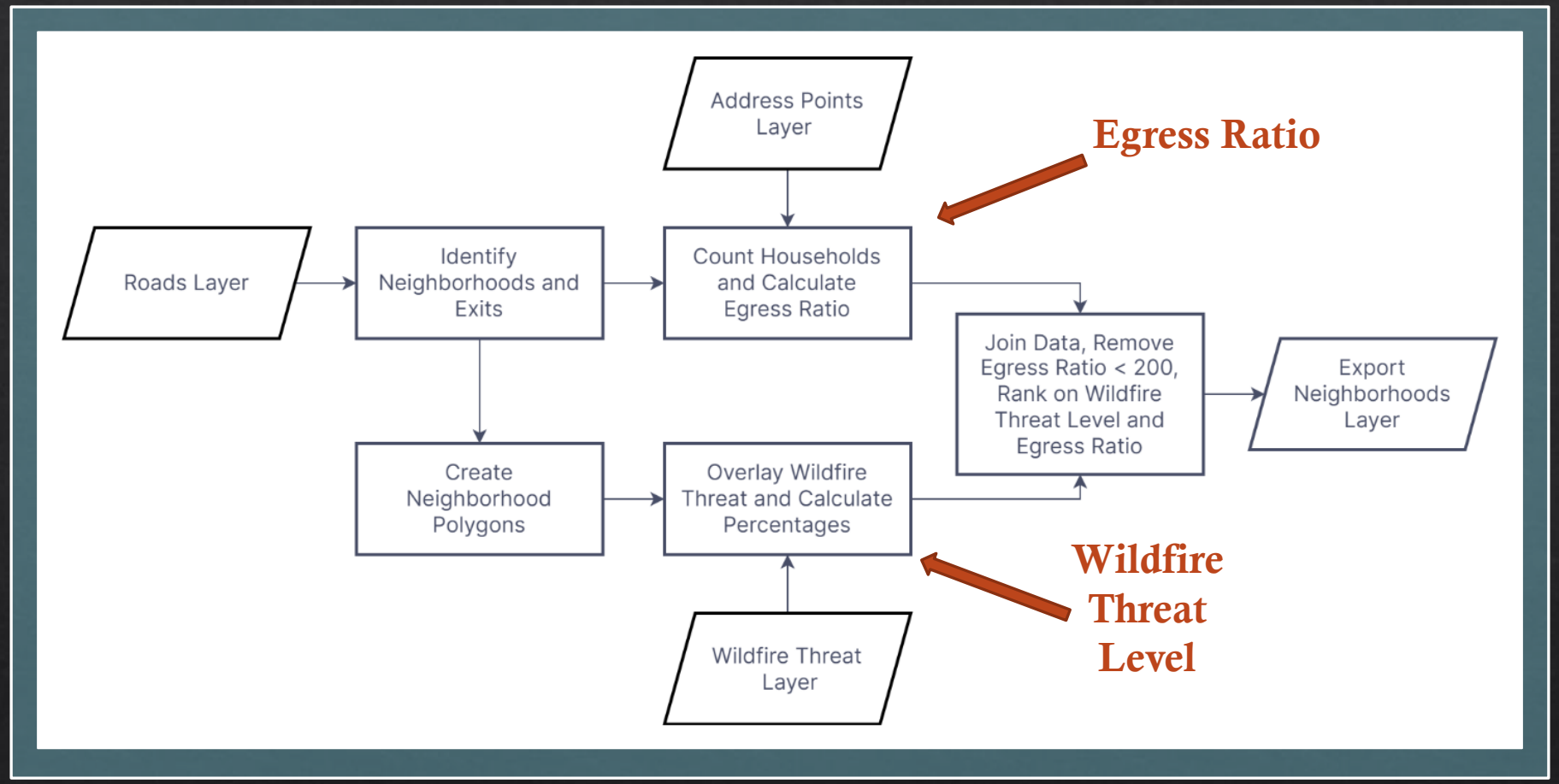

Figure 11. Conceptual flowchart of proposed research. Created by author.

Methods

Figure 12. Input CAPCOG Roads Layer, map created by author.

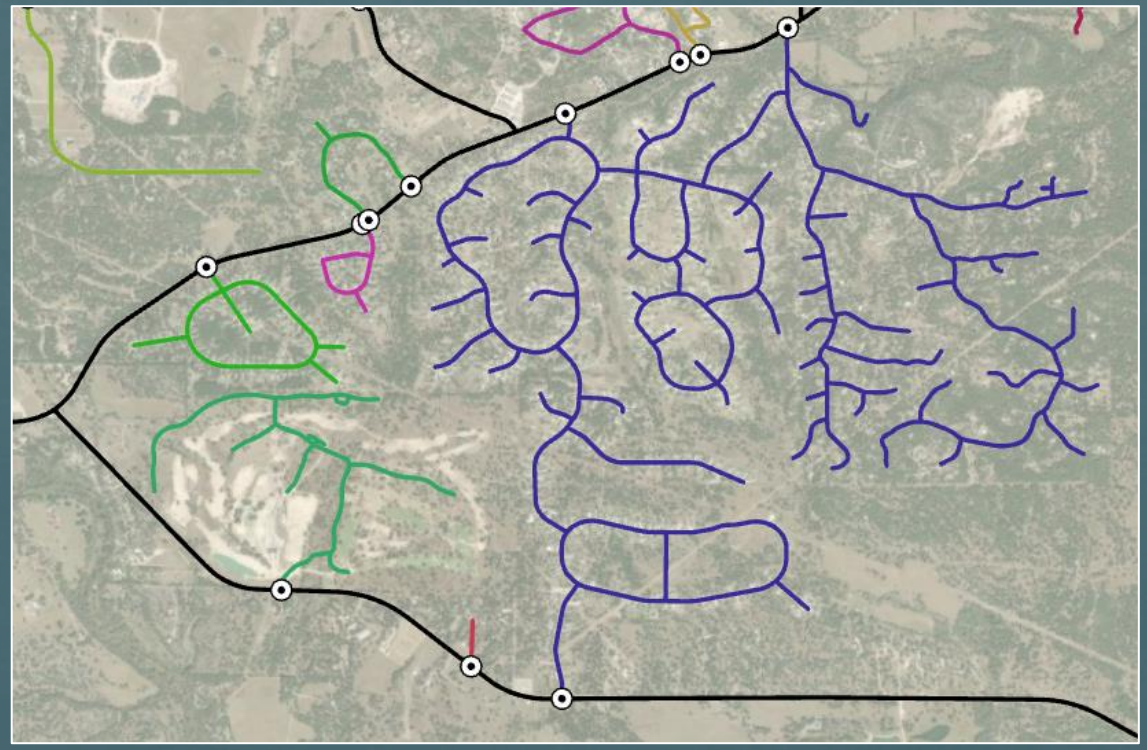

Figure 13. Roads Layer categorized by Neighborhoods attribute, with exits indicated as the intersection of neighborhood and non-neighborhood roads. May created by author.

Methods

- From the Same NG9-1-1 Dataset, add the address points
- Use proximity analysis buffer technique to estimate the number of address points per neighborhood
- Calculate Household to Exit Ratio
- Rim Rock (purple) neighborhood has 995 households and 3 exits for a Household to Exit Ratio of 331.

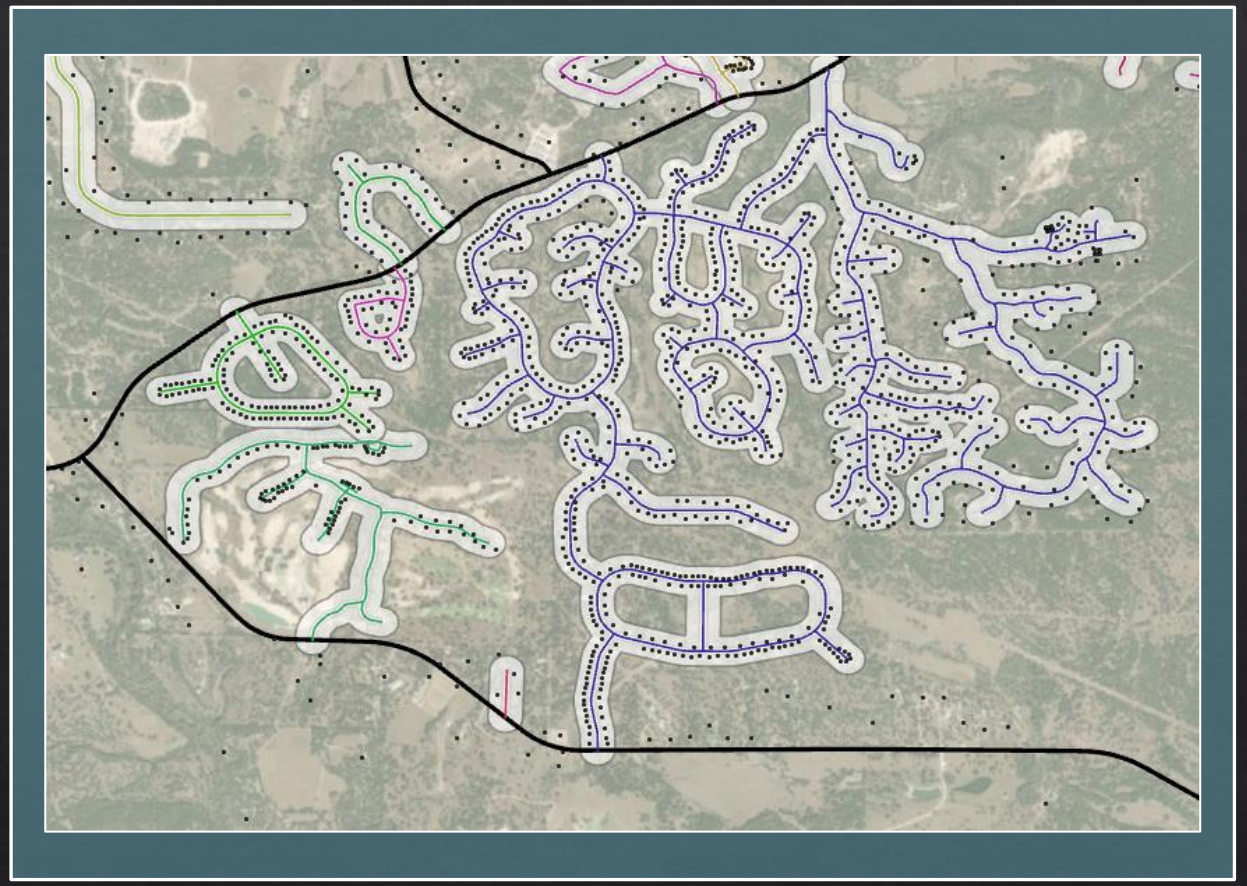

Figure 14. 100 ft Neighborhood-Road Buffer to count Address points. Map created by author.

Methods

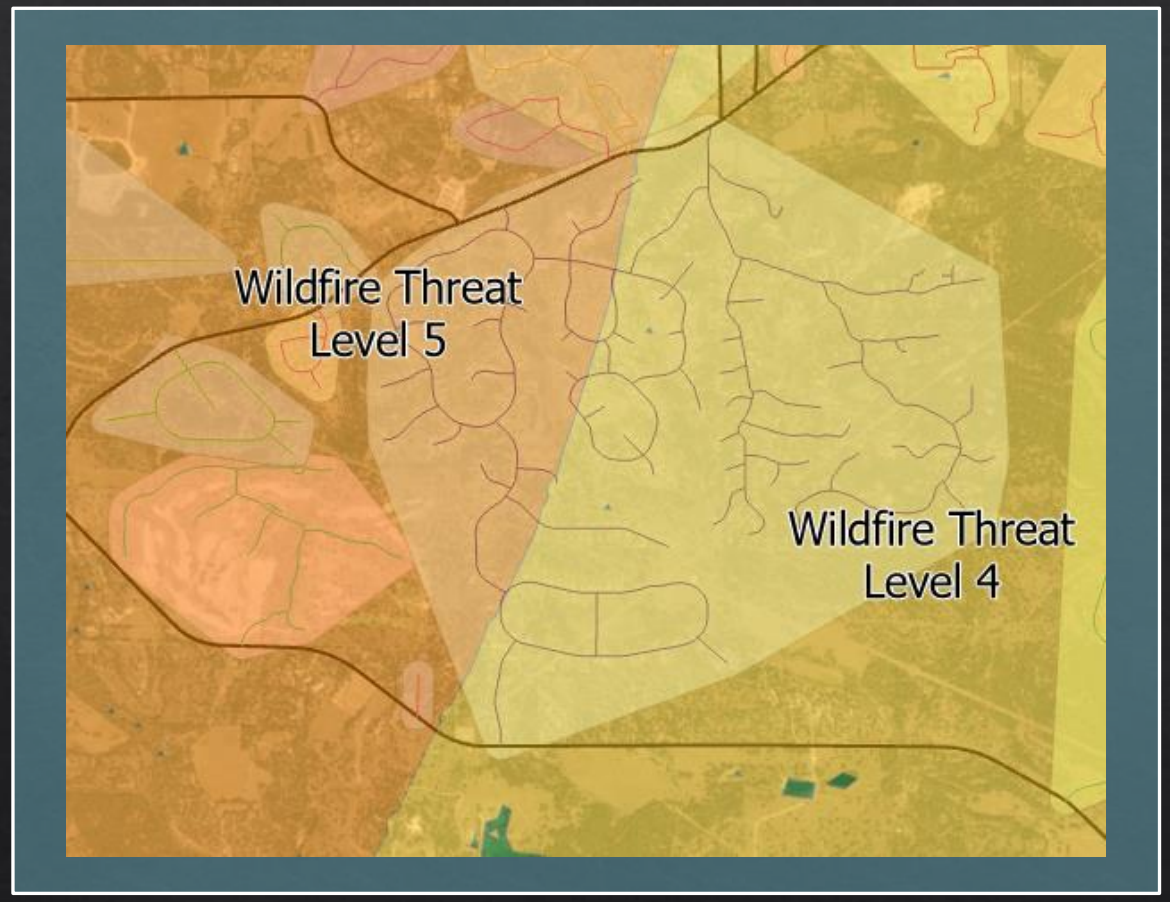

Figure 15. Neighborhood areas defined by Minimum bounding geometry, overlaid by TWRA Wildfire Threat Index Layer. Map created by author

Figure 16. Percent of TWRA Wildfire Threat Index apportioned to each neighborhood area. Map created by author.

Ranking Risk Level

1. Group neighborhoods according to their primary level of wildfire threat as calculated by the overlay of the TWRA Wildfire Threat Index layer-from class 7 “Very High” threat to class 1 “Low” threat (Texas A&M Forest Service 2022).

2. Within each group, Ranked in descending order by their egress ratio of households per community exit. Finally, all neighborhoods that do not meet the 200 households-to-exit threshold set by Cova et al. will be removed (Cova et al. 2013).

Ranking Risk Level

Highest risk neighborhoods will be those that:

1. Represent the highest risk of a wildfire occurring within the neighborhood based on landscape characteristics such as fuel load, historical fire and weather patterns, and terrain conditions

2. Meet the threshold for, and have the highest value of being at-risk of constrained evacuation (based on household to exit ratio)

Limitations

1. The methods presented here can only identify neighborhoods that have been pre-defined, and that have been named such that the *Neighborhood* attribute required by the NG9-1-1 standard can be populated. In contrast, the Critical Cluster Model developed by Church and Cova does not rely on a set of pre-defined neighborhoods, the model *defines* neighborhoods by searching a road network while.

2. Relies on Cities and Counties to provide the Neighborhood attribute

3. Does not take into account the arrangement of neighborhood exits, only the number of exits. All exits might be on the same side of a given neighborhood rather than spread around the perimeter like building fire exits would be.

Expected Results

- The proposed research will address the compound risk of wildfire and constrained neighborhood evacuation. Identifying these at-risk neighborhoods would allow Hays County Emergency Managers, Planners, and the residents themselves, to open discussions about awareness and mitigation.

- There would be two final deliverables for this project: The research paper indicating the underlying risk, identifying the neighborhoods, and detailing the precise steps taken in the GIS. Second would be an executive summary which would be distributed to local Planners and Emergency Managers through personal connections.

Work Cited

Routley, J. G. 1991. *The East Bay Hills Fire*. U.S. Fire Administration. https://www.usfa.fema.gov/downloads/pdf/publications/tr-060.pdf (last accessed 27 August 2022).