A Mixed-Methods Approach Case Study: The Dynamics of Differential Social Vulnerability in Communities Affected by the Thomas Fire and Subsequent Debris Flows in Southern California, United States

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Abstract

The burden of hazard prevention and of loss in communities on the wildland-urban interface (WUI) is often unequally shouldered along socioeconomic lines. The changing nature of social vulnerability in these communities, in light of the dynamic fire regime, is not well studied in the context of southern California. In this study we aim to characterize this shift by analyzing the 2017-2018 Thomas Fire and subsequent debris flow events using a mixed methodology approach. Maps of structural damage are created using Cal Fire parcel-level damage data in a geographical information system (GIS). Demographic data is reduced from Census block group information using principal component analysis (PCA) and re-represented it as a social vulnerability index (SoVI). To identify socially vulnerable groups that are not obvious from Census data, we utilized a content analysis of newspaper articles published by the Santa Barbara Independent to further inform our geospatial analysis. Preliminary results suggest that triangulating structural damage analysis, statistical analysis, and content analysis together can add new elements of vulnerability that each method cannot capture alone, and geospatial analysis observations can be enriched with observations found in content analysis and vice versa.

Background and Introduction

Triangulation

Methodological triangulation is a mixed-methods approach that was adopted in the social sciences to enrich the narrative of qualitative and quantitative analyses by unifying their results. In Howe's (2012) interpretivist perspective of mixed-methods research, qualitative analyses broaden the capacity of the researcher to widely identify factors that might influence the phenomenon under investigation while quantitative analyses offer the ability to identify a causative link between the targeted variables of study (Howe 2012). Interpretative insight gained from a qualitative analysis can then be used to iteratively rescope later quantitative analytical

efforts. In a sense, the implementation of a qualitative approach explores the space in which a quantitative analysis must happen, and it sets the conceptual framework in which that analysis must operate (Rebotier 2019; McKendrick 1999).

Despite the potential for interdisciplinary research, the application of mixed-methodologies in peer-reviewed disaster risk and resilience literature remains very limited (Gall 2015). Notably, Demeritt (2008) contextualized the qualitative-quantitative methodological divide as a natural symptom of a greater syndrome: an entrenched and far-reaching cultural division between the academic communities of human and physical geographers. That is, the nature of identifying answerable lines of academic inquiry in either human or physical geography necessarily involves setting aside the most peripheral aspects of one's study as an externality; in this case, contributions from the "opposite" field of geography are considered to be that externality. Demeritt argues that because even on thematically similar topics, the relevancy of (generally qualitative) human and (generally quantitative) physical geographical research questions are often not obviously congruent, geography as an academic discipline has grown increasingly dimorphic. For instance, Rebotier (2019) explored the impact of this division by evaluating crucial shortcomings in disaster risk management practices in Esmeraldas, Ecuador, as a result of a failure to use qualitative human geography methodologies to inform the true geography of disaster vulnerability in the municipality.

This study aims to simulate the mechanisms of the qualitative-quantitative divide in the context of wildfire hazard and disaster science by the means of a combined spatial analysis of building damage and a modified social vulnerability index in conjunction with a qualitative newspaper content analysis. The details of this combination are described in the Methods section. We also hope to observe the syncretistic outcome of the two in the context of recent southern California wildfire activity.

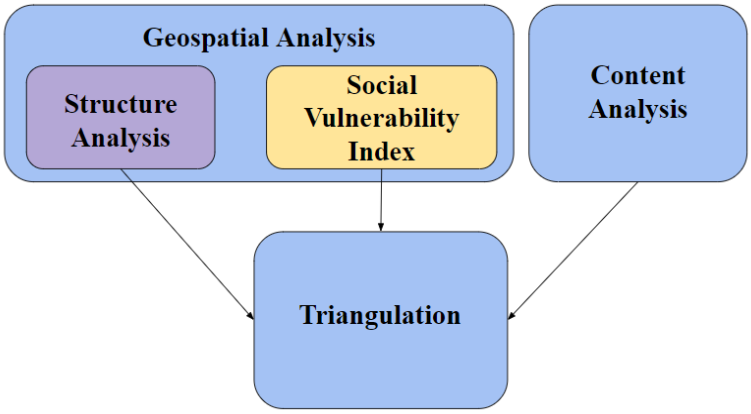

Figure 1: The mixed-methodology approach employed in this study. The individual methods contributing to the triangulation are discussed in detail in the Methods section.

Relationship Between Wildfire Hazards and Social Vulnerability

Recent authors have identified dramatically uptrending losses attributed to wildfires in the United States in recent years (Gall 2011). In the state of California in particular, the propagation of losses has been attributed to the increasing density of individuals moving into the wildland-urban interface (WUI) (USDA 2015), the increasing severity of the fires associated with the emergent effects of climate change (Westerling 2016) and the compounding effect of historically aggressive fire management policies in the state (Davis 2006), which preserved more herbaceous fuels over the past century for recent fires to consume (Westerling 2016). The increase in wildfires has also lead to an increase in government costs to mitigate these events. In 2017, The National Institute of Standards Technology found that federal suppression costs for U.S wildfires exceeded $2 billion for the first time, with annual U.S economic burden of wildfires cost around $71 and $348 billion when including local, state, and federal suppression costs. Communities experiencing the disasters may also encounter indirect losses from areas such as tourism, housing value, supply chains, and health impacts (Thomas 2017).

The resilience of communities facing the onset of a wildfire - and the capacity for those communities to recover in each disaster's aftermath - differentially depends on the socioeconomic situations of its residents (Cutter 2003). Residents of these communities are more vulnerable to harm and to property loss when they are dependent on others for their welfare (the young and old, those with physical or intellectual disabilities), when they are excluded from accessing emergency information due to a language or literacy barrier, or when they are financially confined to substandard housing (eg. mobile home owners) and/or lack the agency to take preventive measures to fireproof their residences (eg. renters) (Poudyal 2011). Under the threat of daily stressors, more disadvantaged communities often lack the agency to implement fire protection programs that would mitigate wildfire risk threatening their respective communities (Ojerio 2011). These vulnerabilities are often also intersectionally aggravated along the lines of race (Sharkey 2007; Davies 2018) and of gender (Enarson 2012) and against other metrics such as economic place dependence (on extractive (Mekbeb 2009) or touristic (Collins 2009; Solangaarachchi 2012) resources), for instance.

Disaster Context and Chronology

The Thomas Fire began on the evening of December 4th, 2017 in Ventura County, California. The fire progressed for several weeks, and expanded to 281,893 acres by the time it was fully contained on January 12th, 2018 (National Wildfire Coordinating Group 2018) (Figure 2). On January 9th, 2018, heavy rainfall resulted in rapid erosion, mud flow, and debris flow of soil and

stream channels, causing catastrophic damage in Montecito Creek and San Ysidro Creek. As of January 21, 2018, there were 21 fatalities, 2 missing persons, 129 destroyed residences and 307 damaged residences attributed to debris flows reported by the inter-agency, storm-response team in Santa Barbara County, (Santa Barbara Fire 2018). By its containment, the Thomas Fire had become the costliest and deadliest event in the 2017 California fire season, which - at the time - had become the costliest fire season yet recorded in the United States. Some $2.9 billion USD was expended on the management of the U.S. fire season in 2017 with the Thomas Fire responsible for nearly $2.2 billion USD of that sum alone (Nauslar 2018).

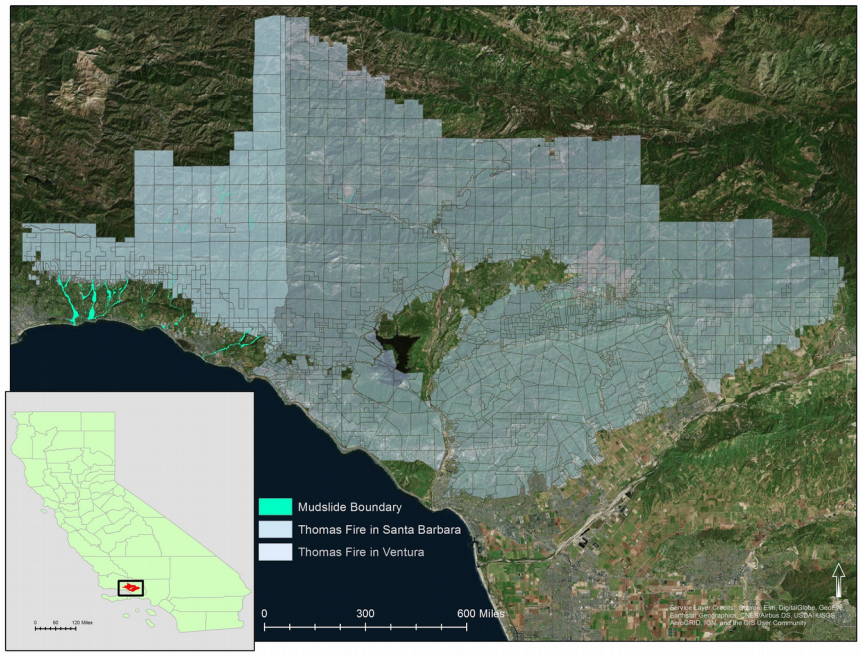

Figure 2: Study area featuring the extent of Thomas Fire respectively in Santa Barbara and Ventura Counties, the extent of the debris flows all in relation with both counties Census Block Groups boundary (ArcGIS Online).

Methods

Geospatial Analysis

In ArcMap, a parcel-resolution vector point feature class that classifies structures by damage criteria set forth by California's Office of the State Fire Marshal (OSFM) is aggregated according to Census block group acquired from the Tiger/LINE shapefile interface of the US Census

Bureau. OSFM criteria are applied as a percentage to damage inspection teams (DINs), trained to use such standards according to the Firefighting Resources of California Organized for Potential Emergencies (FIRESCOPE) training curriculum. By this metric, DINs canvass all areas where damaged structures are reasonably expected to be found, and are applied to any structure that inspected by a given DIN. Cal Fire offers this data with the caveat that their record may not necessarily encompass all damaged structures, as the degree of destruction in a fire - combined with poor access to certain areas - sometimes made it impossible to accurately survey certain sectors affected by the Thomas Fire. (Cal Fire, personal communication, 25 March 2019) This nevertheless remains the most comprehensive germane dataset available for this study. Note that a comparable geospatial analysis is not conducted for the 1/9 debris flows affecting Santa Barbara County; because the damaged properties of the debris flows are overwhelmingly concentrated in the communities of Montecito and Carpinteria, our chosen spatial resolution may be insufficient to meaningfully analyze this dynamic.

Adhering to Cal Fire's OSFM FIRESCOPE DINS damage classification levels, the properties were rated as "no damaged" (0%), "superficially damaged" (1-9%), "minor damage" (10-25%), "moderate damage" (26-50%), "major damage" (51-75%), or "destroyed". To capture the Census block groups that received more property damage from the Thomas fire, we created a choropleth map of the properties that were classified as "major damage" or "destroyed," utilizing the Sum functionality in the Join tool in ArcMap. (see Figure 3). We also created a choropleth map that depicts the Census block groups that were less impacted by the Thomas Fire, in term of the ratio of buildings that received a "superficially damaged" to "no damage" rating (1-9%) by Cal Fire inspectors (see figure 5).

Content Analysis

Recognizing that census data might not completely depict some of the differential social ramifications on the communities affected by the Thomas Fire and the subsequent debris flows and flooding, we explored the role that a qualitative analysis could have in exploring the phenomena at play in our study area in the form of a newspaper content analysis. Considering that hyperlocal media outlets are natural forums for the reporting and debating of local interest issues and tend to host more richly contextualized and in-depth coverage of community-relevant disasters than a national news media outlet would (Rashid 2011), we select the *Santa Barbara Independent*, a hyperlocal paper that covered the disasters as they occurred in their coverage area.

The qualitative analysis of the *Santa Barbara Independent* encompassed a four-month period between December 5, 2017, to April 5, 2018. A total of 1146 articles were reviewed. In effort to minimize the impact of bias and to maximize the depth of coverage, there were several steps taken in part of the newspapers' stories evaluation.

We established the following six-step protocol:

- Stage 1: Coding of articles mentioning the Thomas Fire or articles with any relation to the 1/9 debris flow disaster (using the terms “debris flow,” “mudslides,” or “floods”).
- Stage 2: Independent coding of disaster related articles (from Stage 1) that directly mention vulnerable groups.
- Stage 3: Independent coding of vulnerable populations (from Stage 2) for specific social vulnerable groups mentioned.
- Stage 4: Specific social vulnerable groups were compared amongst research members, and disagreements between researchers were discussed and democratically resolved. Seven major vulnerable groups were selected.
- Stage 5: A tally of the number of articles mentioning a major vulnerable group was noted in another independent coding effort.
- Stage 6: The final count of each researcher’s tally against the Stage 5 coding criteria are combined, resulting in Table 3.

Furthermore, we aim to increase the precision of our analysis’ completeness by coding from multiple perspectives (White 2006), reducing the influence of any one researcher’s personal bias on the outcome**.** To decrease the likelihood of unintentionally missing any articles mentioning the Thomas Fire and debris flow during the four-month period, at least two research members evaluated each month’s worth of stories in the *Santa Barbara Independent* to make sure all articles were counted and downloaded. This resulted in 285 out of 1146 articles to be reviewed in Stage 2. Next, each coder performed Stage 2 and 3 of the content analysis independently before democratically converging results. This allowed social vulnerable groups to emerge naturally without the influence of pre-selected vulnerable groups.

Social Vulnerability Index (SoVI)

Using Cutter’s original framework as our model, a total of 63 variables were extracted from the United States Census Bureau’s American Community Survey (ACS) over the year range of 2016-2017 for Santa Barbara County and Ventura County, California (table 1). Because Cutter’s study examined a dataset subdivided at the county and county-equivalent level, not all of the variables selected for input into their model were immediately applicable to a block-group-level context. In particular, Cutter’s input criteria for “Commercial and industrial development”, “Rural/urban”, Infrastructure and lifelines”, and “Medical services” are sensible given the heterogeneity of development that is captured when communities are grouped together at the county level, but these facets of social vulnerability may not be represented in a comparatively meaningful way when applied to the primarily residential Census block groups that were affected by the Thomas Fire. Furthermore, to capture nuances in racial disparities which may be more apparent at a block-group scale than at a county-level scale, the three Census racial minority groups with populations representing more than 1% of the study area’s total population (Asian

people, Hispanic people, and African American people) were not aggregated into a summative "non-white" category as was done in Cutter's study. We also captured the oft-mentioned language barrier that persists as an obstacle in the dissemination of pre-disaster mitigation and real-time evacuation information (Peguero 2006).

Additionally, we included a number of variables that were not included in the Cutter study, including public transportation dependence (which - when disrupted - can disadvantage individuals who are not able to reach disaster relief centers and resource repositories) (Morrow 1999); concentration of vacant houses per block group (in a wildfire context, risks to households adjacent to unhardened and unmaintained properties increase profoundly) (Collins 2009); the ratio of employees of the armed forces versus the total population within the labor force (to capture any correlations associated to the concentration of residents of our study area who are employed by the United States government at Vandenberg Air Force Base in Santa Barbara County and who may have been unduly affected by the fire). We are further motivated to produce SoVI localized to areas affected by the Thomas Fire and the associated Santa Barbara County debris flows in light of concerns raised by other researchers about the sensitivity of SoVI to its spatiotemporal context (Wigtil 2016).

All data were then relativized by forming ratios between two opposed values (eg. high median household income versus low median household income, for instance), or by converting the parameter into a percentage of the total population per block group. Ultimately, the following 18 variables were ultimately prepared:

Relativized variable	**Source/Justification**
Vacant houses per total housing units (2 variables)	Collins (2009), commenting on compounded fire risk to properties adjacent to unmaintained parcels
Ratio of those who take public transportation versus single motorists (2 variables)	Morrow (1999), commenting on lack of access to disaster relief resource centers
Ratio of armed force employees to total population in labor force (2 variables, 1 shared)	Possible relationship to the geography of workers at Vandenberg AFB
Ratio of unemployed civilian population to total in labor force (2 variables, 1 shared)	Cutter (2003): Unemployment criterion
Ratio of seniors to total population in block group (2 variables, 1 shared)	Cutter (2003): Age criterion
Ratio of minors to total population in block group (4 variables, 1 shared)	Cutter (2003): Age criterion
Ratio of English-non-proficient speakers to English-proficient (native and non-native) speakers, ages 18-64 (17 variables)	Peguero (2006) on inequity of access to pre-disaster mitigation and also emergency information

Ratio of those without a high school education to those with at least a 4-year bachelor's degree (2 variables)	Cutter (2003): Education criterion
Percent households with a median household income of $200,000 or more (2 variables)	Cutter (2003): Socioeconomic status criterion, income subcriterion
Percent of households below the poverty line (3 variables)	Cutter (2003): Socioeconomic status criterion, income subcriterion
Ratio of total owners to total renters by permanent structure (16 variables)	Cutter (2003): renter criterion
Mobile homes per total housing units (3 variables)	Cutter (2003): Residential property criterion
Ratio of people claiming SNAP to people who do not claim SNAP (2 variables)	Cutter (2003): Socioeconomic status criterion, income subcriterion
People who claim Social Security against total population (2 variables, 1 shared)	Cutter (2003): Age criterion; Socioeconomic status criterion, income subcriterion
Ratio of two-parent families versus single-parent families (3 variables)	Cutter (2003): Family structure criterion
Asian people per total population (2 variables, 1 shared)	Cutter (2003): Race and ethnicity criterion
Black people per total population (2 variables, 1 shared)	Cutter (2003): Race and ethnicity criterion
Hispanic people per total population (2 variables, 1 shared)	Cutter (2003): Race and ethnicity criterion. Also Morrow (1999)

Table 1: The list of all relativized variables that were assembled before being introduced into the principal component analysis (PCA) for reduction into a social vulnerability index (SoVI) after the model set by Cutter (2003).

A principal component analysis (PCA) using a Quartimax rotation and an eigenvalue greater than 1 was performed within the open-source JASP package and then in the proprietary IBM Statistical Package for the Social Sciences (SPSS) to reduce the variable count into principal components used in our index. The resulting index is presented as follows:

PC Designation	Dominant factors	Variance
1	- Public transport - High unemployment - Few seniors and few minors	17.128%

	- English proficiency - No high school education - Low median household income - Below poverty line - Claims SNAP - Does not claim Social Security - Hispanic - renting	
2	- Drives alone - Minors - Claims Social Security - Not black - Not Asian - More mobile home residents in tract	14.382%
3	- Many vacant houses in tract - Public transport - High unemployment - More mobile home residents in tract	9.931%
4	- Few vacant homes in tract - Public transport - Little armed forces employment - Black - Asian	8.780%
5	- Common armed force employment - Owners - Few mobile home residents in tract	7.743%
		Total: 57.964%

Table 2: The principal components resulting from the IBM SPSS inputs from the US Census Bureau described in Table 1. Five principal components are identified, with the first principal component used for the spatial analysis in this study.

Principal Component 1 (PC1) and Principal Component 2 (PC2), which account for a combined variance of 31.81%, account for the principal components that are (respectively) thematically representative of socially vulnerable populations in this region (public transport-dependent, Hispanic, workforce-age, renters, low median household income, no high school education, claims SNAP benefits) and more resilient populations (neither black nor Asian, people not in workforce - minors and elderly people, Social Security claimants). The presence of "more mobile home residents per tract" as aligning with PC2 (the *less* vulnerable population's principal component) appears to contradict the assertion by Cutter (2003) that tracts with a large number of mobile home residents are more vulnerable. However, Kusenbach (2009) briefly reviews the

reality that mobile home communities may be socioeconomically heterogeneous. PC2 and PC3 capture a comparable variance spread that positively correlates to mobile home ownership or rentership, suggesting that there are two major types of mobile home residents in the Ventura and Santa Barbara County area. Those that (1) are demographically similar to the less vulnerable population of PC2, and (2) those that residents of tracts with a higher PC3 rating - that is, public transportation-dependent tracts with large numbers of vacant homes and high unemployment, which are all markers of a financially distressed community (table 2). Note that the total accounted-for variance spread is rather low for a social vulnerability index, and likely contributes to the heteroskedastic nature of certain input variables such as the pre-discussed mobile home residency data.

For the purposes of the analysis, we recover the regression score of PC1 for every Census block group affected by the Thomas Fire, output the result as a table, and then join it to Census block groups based on each block group's unique ID number. A map of block groups classed by SoVI regression score is visualized as an additional choropleth map (Figure 4).

Results

Qualitative Analysis

Content analysis of the *Santa Barbara Independent* presented a diverse canvas of social vulnerable groups. Of the 285 articles (out of 1146) evaluated by the research members a total of 17 groups emerged during the analysis. The 17 groups are: children, elderly, students, workers/working class, delicate, speaking/reading language other than English, ethnicity other than White, undocumented, homeless, inmate, pets/livestock, disabled, Sign Language, non-evacuees, public-transportation riders/drivers, homeowners/renters, and local business people. These were the semi-final vulnerable groups that were chosen after conducting the independent analysis. Groups that were not referenced often or were not coded by multiple researchers (homeless, inmate firefighters, pets/livestock, non-evacuees, public transportation-dependent people, renters, and local business owners) were not considered part of the final major vulnerable groups. These groups are not less important than the major groups selected, but were instead mentioned the least compared to the overall vulnerable groups. Therefore, 7 out of the 17 vulnerable groups are not part of Table 3. After evaluating the remaining 10 vulnerable groups research members concluded the best way to identify extremely sensitive groups often foreseen such as delicate (hospitalized/sick or psychiatric patients), Sign Language, and disabled was to merge them all into one group labeled "sensitive group." This narrowed down the 10 groups to 7 major vulnerable groups shown in Table 3.

Due to the independent coding conducted by each research member the number of articles mentioning major vulnerable groups differentiated. To best articulate these results Table 3. was created by calculating the average of each research member's major vulnerable group-article

mention as well as its standard deviation. As shown in Table 3. children were most mentioned as major vulnerable group, four out of five months, with a high frequency in January. The second most significant group is the elderly population that exclusively appears in January publishings. Other vulnerable groups such as people with language barrier, working class and sensitive populations were seldom discussed in the publications while undocumented and ethnicity were least significant.

Major vulnerable groups	December	January	February	March	April
Chronically ill/predisposed to illness/disabled (sensitive)	2.0 ± 2.2	2.5 ± 2.4	0.3 ± 0.5	0.0 ± 0.0	0.0 ± 0.0
Children	3.0 ± 3.8	16.5 ± 1.2	2.3 ± 3.0	3.0 ± 2.2	0.0 ± 0.0
Elderly people	1.0 ± 1.4	5.5 ± 4.8	0.8 ± 1.0	0.5 ± 0.6	0.0 ± 0.0
Undocumented people	0.0 ± 0.0	1.5 ± 1.7	1.5 ± 1.0	1.3 ± 1.0	0.0 ± 0.0
Ethnicity other than White	0.8 ± 1.0	1.3 ± 1.3	0.5 ± 1.0	0.0 ± 0.0	0.0 ± 0.0
Speak/read language other than English	2.8 ± 2.5	1.5 ± 1.9	0.0 ± 0.0	0.3 ± 0.5	0.0 ± 0.0
Workers/working class	1.8 ± 2.1	1.8 ± 2.1	2.3 ± 2.6	0.8 ± 1.0	0.0 ± 0.0

Table 3. The final outcome of the content review coding convergence within the context of this study. The table identifies - by month - the averaged number of articles that each of the participating researchers coded to each of the final vulnerable group categories.

Quantitative analysis

The properties surveyed by Cal Fire in association with the Thomas Fire can be broadly classified into the following geographic regions:

1) City of Ventura (706 structures)
2) Upper Ojai Valley (332 structures)
3) Matilija Valley (57 structures)
4) California Route 150 at the Ventura/Santa Barbara County line (67 structures)
5) Montecito area (47 structures)

Clusters of destroyed structures were also clustered in the peripheries of the Lower Ojai Valley (Meiners Oak and Oak View areas) and scattered throughout the Santa Susana Mountains to the

north of California Route 126 (The Santa Paula Freeway), all within the fire perimeter.

There were three census block groups that suffered the greatest extent of damage (in terms of percentage of structures very badly damaged or destroyed) were located in the city of Ventura (two block groups) and in the Upper Ojai Valley (one block group) (see figure 3).

In the City of Ventura, the vast majority of badly damaged and destroyed properties were situated to the north of Foothill Boulevard and were overwhelmingly concentrated in two subdivisions located on the wildland-urban interface (respectively in neighborhoods centered on Skyline Road, and in a larger complex centered on the roads Via Ondulando and Colina Vista (see figure 3). Additional higher-density structures near the wildland-urban interface of the City of Ventura, such as the Hawaiian Village Apartments, were also damaged and/or destroyed at the fire's southern perimeter (Hamm 2017). Property damage in these two block groups were notably evaluated at the parcel level (as destroyed/not destroyed) by the *Los Angeles Times* (Krishnakumar 2017).

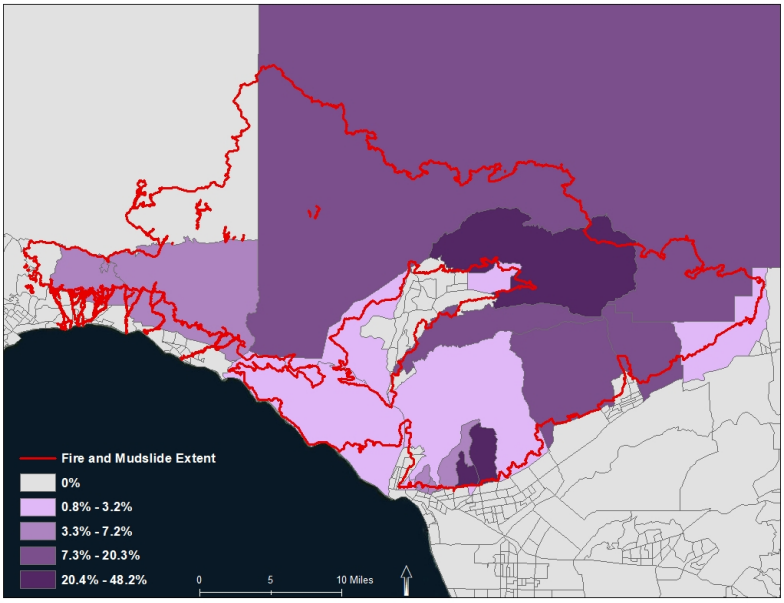

Figure 3: The extent of the Thomas Fire in Santa Barbara and Ventura Counties, California, superposed over Census block groups binned by count of structures that are at least 50% damaged or completely destroyed, according to the 2018 assessment of Cal Fire inspectors.

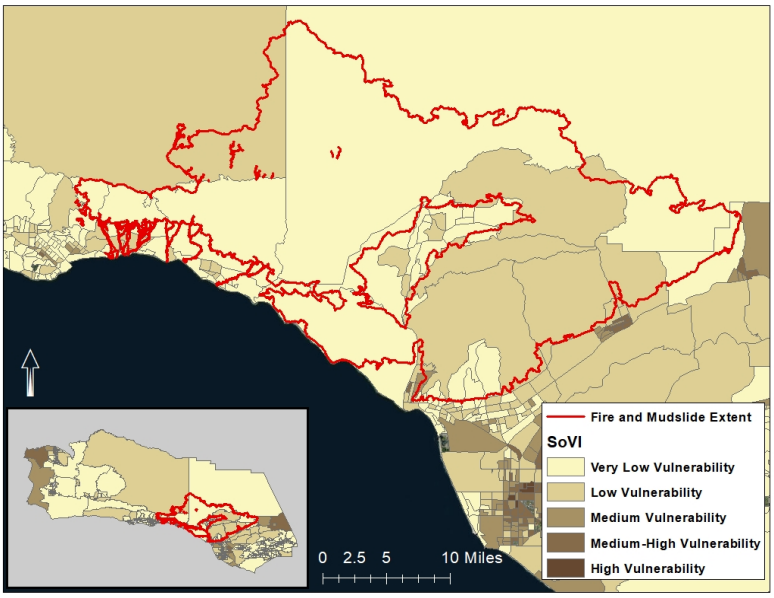

Figure 4: The extent of the Thomas Fire in Santa Barbara and Ventura Counties, California, superposed over Census block groups. A social vulnerability index (SoVI), modified from the county-scale investigation by Cutter et al. (2003), is performed on all Census block groups for both Santa Barbara and Ventura Counties. All block groups encompassed by this study's SoVI are portrayed in the inset map at the lower left-hand corner of the figure.

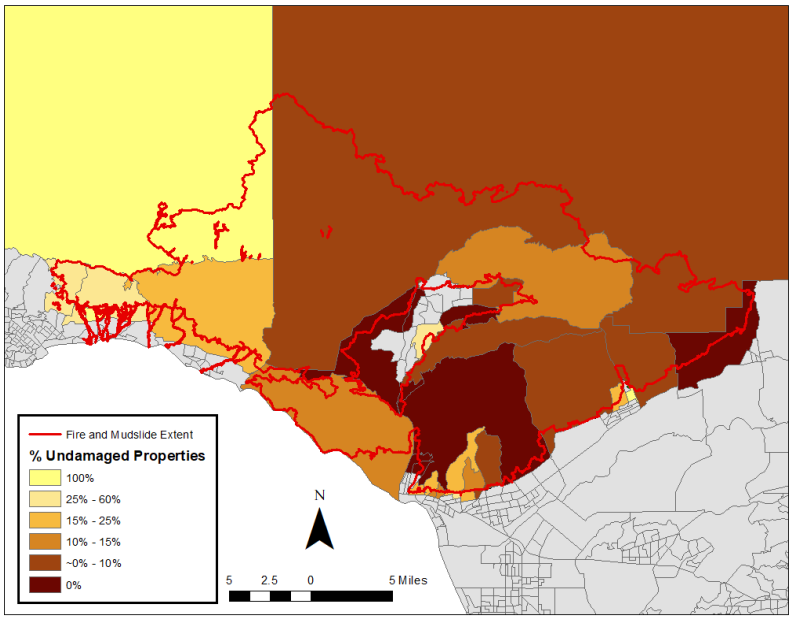

Figure 5: Choropleth map of Census block groups in Santa Barbara and Ventura Counties that were impacted by the Thomas Fire, in term of the ratio of buildings that received a superficial to no damage rating by Cal Fire inspectors (1-9%). Lighter values on the map indicate *more* relatively undamaged properties amongst those that were inspected. A value of 0% indicates that no inspected property in the Census block group experienced very light damage.

Smaller clusters of destroyed structures in Matilija Canyon (northwest of the city of Ojai) and off of California State Route 150 by the Santa Barbara-Ventura County line (totaling 124 structures) were either badly damaged or destroyed. These two clusters were (with some exceptions across the Santa Barbara County line) grouped into a single Census block group also incorporating most of the northern third of Ventura County (see figure 3, and also additional treatment in Discussion). Press coverage of Matilija Canyon's destruction was presented by the Santa Barbara-based hyperlocal newspaper *Noozhawk* (Bolton 2017) but was otherwise not featured in coverage by other reporting agencies, and did not register in our content analysis of the *Santa Barbara Independent*.

The Santa Barbara County cluster contains by far the largest share of preserved structures (rated by Cal Fire as suffering only superficial damage in each structure). Destroyed properties are in the foothills above Montecito and Summerland are paired in three small subclusters. The content analysis illuminated potential reasons why such an anomalous reading might be the case, and is explored in the Discussion section.

Note that we did not establish a strong correlation between building damage in any given Thomas Fire-affected Census block tract and with our social vulnerability index (see Figures 6 and 7), and an overview in table 4. The implications of this lack of correlation are addressed in the Discussion section.

County: Block Group (major roads)	% Structures undamaged (from total) (from total inspected)	% badly damaged/ destroyed structures (from total) (from total inspected)	Social vulnerability index (SoVI) rating
Ventura: CT17, BG1 (Via Ondulando/Colina Vista)	25/1037 (2.41%) 25/388 (6.44%)	337/1037 (32.50%) 337/388 (86.86%)	-0.41431 (very low)
Ventura: CT18, BG1 (Skyline Drive)	21/278 (7.55%) 21/155 (13.55%)	121/278 (43.52%) 121/155 (78.06%)	-0.56916 (very low)
Ventura: CT9.03, BG3 (UOV, Ojai Avenue north)	25/340 (7.35%) 25/202 (12.38%)	164/340 (48.23%) 164/202 (81.19%)	-0.04513 (low)
Ventura: CT9.02, BG1 (UOV, Ojai Avenue south)	2/276 (0.72%) 2/60 (3.33%)	56/276 (20.29%) 56/60 (93.33%)	-0.31686 (very low)
Ventura: CT4, BG1 (CA-150 from Santa Paula to UOV)	2/261 (0.77%) 2/43 (4.65%)	41/261 (15.71%) 41/43 (95.35%)	+0.16856 (low)
Ventura: CT1, BG1 (Transverse Ranges)	6/505 (1.19%) 6/106 (5.66%)	95/505 (18.81%) 95/106 (89.62%)	-0.77313 (very low)
Santa Barbara: CT17.06, BG1 (Transverse Ranges)	0/559 (0.00%) 0/1 (0.00%)	0/559 (0.00%) 0/1 (0.00%)	-0.39612 (very low)

Santa Barbara: CT15, BG1 (Montecito uplands)	15/544 (2.76%) 15/41 **(36.58%)**	21/544 (3.86%) 21/41 **(51.22%)**	-0.38952 (very low)
Santa Barbara: CT17.06, BG1 (Carpinteria / Summerland uplands)	7/715 (0.98%) 7/40 (17.5%)	29/715 (4.06%) 29/40 (72.5%)	-0.39612 (very low)

Table 4: A compilation of the Census block groups discussed in this study, grouped according to the clustering of structures inspect by Cal Fire in 2018 in the wake of the containment of the Thomas Fire. The following categories are compared: (1) the ratio of relatively undamaged structures (rated by Cal Fire as 1-9% damaged) to (a) the total number of structures in the Census block group and (b) the total number of structures in the Census block group inspected by Cal Fire; (2) the ratio of severely damaged structures (rated by Cal Fire as 50% damaged or higher, or as destroyed) to (a) and (b); and (3) the social vulnerability index rating of the Census block group as defined within this study.

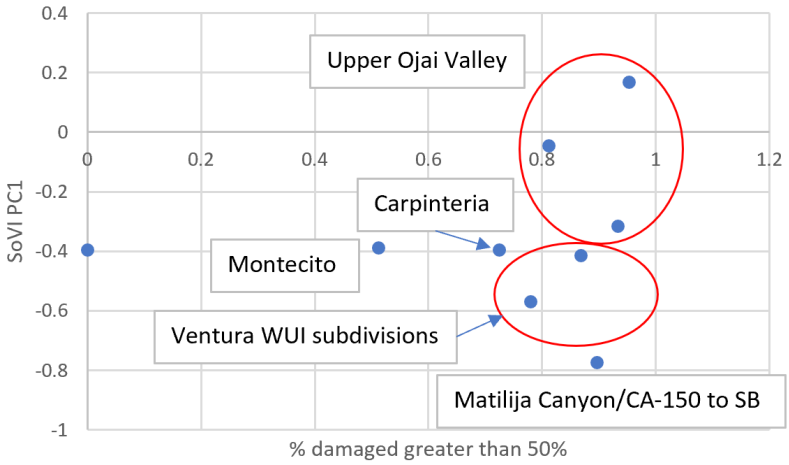

Figure 6: The SoVI rating mapped against percentage of structures damaged to a greater extent than 50% (by OSFM criteria applied by FIRESCOPE-trained DINS teams), graphed for the Census block groups included in Table 4.

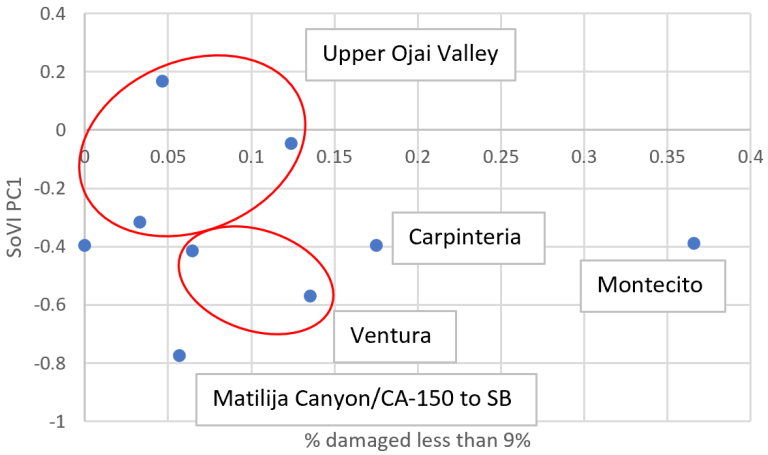

Figure 7: The SoVI rating mapped against the % of structures less than 9% damaged (by OSFM criteria applied by FIRESCOPE-trained DINS teams), graphed from Census block groups included in Table 4.

Discussion

Elements of the hazard resistance narrative for communities affected by the Thomas Fire each captured a separate but incomplete element of this analysis. The limitations of a purely geospatial and statistical spatial approach, and that of a purely content-analytical approach, become very evident when compared to the details of socially vulnerable groups discussed by the *Santa Barbara Independent* within the context of our study.

The content analysis identified a number of vulnerable groups that were not evident or obvious from our spatial data. For instance, predominantly Hispanic/Latino agricultural laborers in Ventura County were compelled to continue working the fields despite poor air quality and an inadequate disaster and evacuation information pipeline (Hayden 2017). This population was amongst the groups that were neglected by the geospatial analysis. As a first note, the affected workers were not necessarily residents of Census block groups that fell within the Thomas Fire perimeter, and were not necessarily employed in Census block groups that were directly disturbed by the fire. Even if the workers were disrupted directly from agricultural parcels that burned, this particular analysis did not capture information that could satisfactorily constrain the dimensions of this population's vulnerability; of major note were interviews with representatives of the advocacy group Central Coast Alliance United for a Sustainable Economy (CAUSE), who noted that agricultural laborers in Ventura County were often compelled to work without access to N95 protective masks even as the Thomas Fire's soot clouded the air (Santa Barbara Independent 2018). In some instances, of whom the *Santa Barbara Independent* explicitly called out in their report, farm owners in Ventura County aggressively rejected the attempts of aid

workers to provide free N95 masks to agricultural laborers. Farm owners who were compelling their laborers to continue were openly flouting explicit and directed Cal/OSHA mandates by doing so (Hayden 2017).

The content analysis called attention to other disproportionately disadvantaged populations that were not readily represented in the geospatial analysis (see table 3). This included: at least one disabled individual who were unable to evacuate their residence in the aftermath of the Montecito debris flow and was trapped for several days (eg. Yamamura 2018b); psychiatric patients of Aurora Vista del Mar Hospital, along California Route 33 (the Ojai Freeway) north of downtown Ventura, who escaped the facility to flee the fire front, which eventually consumed the hospital (eg. Welsh 2017a); speakers of the Spanish and American Sign Languages, who were not directly addressed by any one article in our newspaper content analysis but for whom resources were provided by relevant county institutions in press briefings (eg. Romo 2018); undocumented individuals, for whom hundreds of families in the burn area were reportedly disrupted, and were unable to claim disaster relief due to their status (eg. Welsh 2018a); and homeless individuals in the area, who were not mentioned in any article with the exception of a single passing statement from Santa Barbara Police Chief Lori Luhnow that the Santa Barbara Police Department was dispersing homeless encampments along railroad tracks one day before the onset of the 1/9 debris flow (Welsh 2018b).

In some situations, the content analysis registered and enriched the narratives of disproportionately disadvantaged populations that *were* also visible in the geospatial analysis. For instance, speakers of Spanish who are not also strong English speakers were likely deemed at risk by writers at the *Santa Barbara Independent* of having inconsistent access to critical disaster management information. The newspaper began publishing certain informational reports in both English and Spanish as the Thomas Fire disaster progressed. (eg. Santa Barbara Independent 2017). Additionally, the *Santa Barbara Independent* registered significant disruptions to the lives of children (eg. Salcido 2017), who might suffer from increased food insecurity in the wake of school cancellations if they depend on meals supplied through their campus. Both populations are furthermore disproportionately susceptible to adverse environmental conditions such as poor air quality, which was documented extensively by the *Santa Barbara Independent* but was not always explicitly linked to either population in their reports (eg. Welsh 2017b). Non-white individuals were also classed as a grouping in the content analysis, and the *Santa Barbara Independent* noted that nearly half of those who were killed by the 1/9 debris flows were persons of color, despite the overwhelmingly Caucasian demography of the city of Montecito (Welsh, 2018a). Age, race and language proficiency are data that are collected and collated by the United States Census Bureau's American Community Survey and were all used in the social vulnerability index created for this study.

Separately, certain individuals might become significantly more vulnerable to the imminent natural hazards for reasons that aren't directly related to physical and/or mental health or to systematic intersectionalities such as race, gender, or class. In Santa Barbara County, residents of

Montecito and Carpinteria were repeatedly put on notice for evacuation from the fire and debris flow risks, fatiguing many residents who would ultimately decide to refuse to heed evacuation orders on the expectation that the disaster would not actually come. Cognizant of this, the fire chief of the Santa Barbara County Fire Department cited this reason for being very conservative in putting residents of affected areas on notice. This effect compounded an erosion of trust in Santa Barbara County's emergency response workflow as a result of false alarms during the Thomas Fire. The evacuation situation was also complicated by the fact that the Santa Barbara County Fire Department designated "mandatory" and "voluntary" flooding evacuation zones without any regard for positions of threatened homes immediately adjacent to the creeks that carried the mudflows. All in all, 21 people - of the 23 that were killed due to the Thomas Fire and its aftereffects (Dolan 2018) - were killed because they did not evacuate, regardless of their rationale. However, most of the individuals who were killed lived within designated "voluntary" evacuation zones (prepared to leave home at a moment's notice), and not those who refused to evacuate while within "mandatory" evacuation zones. (Yamamura, 2018a) Secondly, owners of animals (both household pets and larger animals such as horses and livestock) were discussed as part of the content analytical approach due to the presence of advice column articles on how owners might best care for their animals in a disaster context (namely - but not exclusively - relating to evacuations) (eg. Wellman, 2017). News reports documenting this phenomenon were later also published (eg. Kelly 2018). Previous researchers have reported that those who are logistically incapable of evacuating with their animals will often refuse to evacuate and instead remain in high-risk zones. (Heath 2001a, Heath 2001b). In the wake of the Thomas Fire and the 1/9 debris flow, the *Santa Barbara Independent* identified the anxieties of owners who were barred from returning home to feed their animals after evacuating; and those who evacuated initially, but ignored later evacuation calls after having negotiated the logistical difficulty of doing so the first time. Advocacy organizations such as the Santa Barbara Humane Society and the Santa Barbara Equine Evacuation and Assistance Team reported significant strain as unsustainable numbers of evacuated animals were indefinitely placed in their care; in some cases the organizations were charged with the rescue and recovery of animals, despite concerns about a lack of training in that regard (Kelly 2018). These factors all converge to indicate that a lack of an infrastructure that can support animal evacuations also indirectly endangered many residents of the study area. We regard an investigation into this dynamic as a fruitful line of future inquiry.

The content analysis also enriched observations made from the geospatial analysis. For instance, in the singular block group of Montecito that was affected by the Thomas Fire, a striking 36.58% of Cal Fire DINS-inspected properties were recorded as nearly completely undamaged. The properties that were seriously damaged or destroyed in this Census block group were broadly clustered into two neighborhoods, while many of the more dispersed properties in the block group survived the fire almost completely unscathed, a salient but otherwise indeterminate observation. However, the *Santa Barbara Independent* reported on the presence of private firefighter forces that were dispatched directly by insurance companies in the interest of hardening their wealthy client's properties *in situ* as the hazard from the Thomas Fire became

more tangible to their homeowners (Brugger 2017). Despite this, the success of these private firefighting efforts cannot be assessed in this study as no spatial information on the operations of these firefighting forces is readily available to confirm a relationship to the houses that were unscathed versus those that were destroyed. Therefore an explicit causative association with their efforts to properties that survived the fire completely intact cannot be directly made at this time. The synthetic contribution of content analysis nevertheless raises the question as a direction of future inquiry; uneven access to firefighting resources in Montecito is nevertheless a striking social inequity.

It should be noted that with the exception of the possible relationship discussed in the last paragraph with respect to the Upper Ojai Valley, there is no correlation between structure damage and social vulnerability in the Census block groups that were affected by the Thomas Fire and subsequent debris flows. This is not an entirely unexpected outcome - measures of vulnerability of a community to destruction by wildfire depends largely on whether or not a community is capable of organizing itself to marshal capital and collective volunteer effort in order to ensure that homes across a neighborhood are fire-hardened and whether pre-disaster readiness plans are in place and rehearsed. The capability of a community's residents to perform these mitigating actions tends to depend on social context, with more privileged communities generally finding the agency to act (Collins 2009, Ojerio 2011, Poudyal 2012). However, good defensibility - largely predicated on the socioeconomic context of the disaster-afflicted community - does not guarantee the resilience of a community against an impending biophysical risk. The only possible exception to this paradigm may be Montecito, where the survivability of homes may be directly be controlled by the ability of extremely wealthy property owners to purchase insurance plans that include *in situ* private firefighting protection.

Our quantitative analysis also conversely offered grounds for future exploration of our qualitative analysis. For instance, a rural stretch of Ojai Avenue (California Route 150) separating the Ojai Valley in the west from Santa Paula in the east, colloquially called the "Upper Ojai Valley", is home to the Thomas Fire's namesake (the Thomas Aquinas College). Media coverage this area was notably sparse, with a number of newspaper articles outside the scope of our content analysis presenting the Ojai Valley as "saved" from the Thomas Fire or otherwise "flanked" by the Thomas Fire even as the Upper Ojai Valley had been almost completely burned (for example, Vogue Magazine 2017). By the modified social vulnerability index prepared in this study, the most socially vulnerable block groups severely affected by the fire were situated in this region, although this area does not register as very socially vulnerable relative to other block groups outside of the burn area in both Santa Barbara and Ventura Counties. This disparate media disaster coverage has been previously observed by Rovai and Rodrigue (1998), who have noted that more vulnerable areas will be less likely to take the names of the disasters affecting them, and are generally less likely to garner media attention and to be accorded a robust emergency response in the wake of a natural disaster - the researchers particularly noted that, in the cases of the 1994 Northridge Earthquake in metropolitan Los Angeles and to the 1992

Ferndale earthquake in Humboldt County, northern California, neither of the relatively well-off communities of Ferndale or Northridge suffered the most severe degrees of infrastructural damage, and yet were both exceedingly featured in media coverage. This attention is correlated to a far more rapid recovery progression than that which was observed in other poorly-featured communities. This dynamic might also be at play in the greater Ojai Valley, and may be a fruitful direction for future investigation.

Limitations

In several cases, an insufficient spatial resolution specifically makes it difficult to clarify the reasons why deviations persist in our data. This scale-dependent discrepancy becomes clear in Ventura County Census block group 1, Census Tract 17, which encompasses much of the Santa Susana Mountains and the sparsely populated northern third of Ventura County's area, where two clusters of inspected structures - one within Matilija Canyon (to the northwest of the city of Ojai) and another in a stretch of California State Route 150 near the border with Santa Barbara County - were agglomerated in spite of their relative remotenesses to each other. Potential differences in the social contexts of each community might also exist. This is also a likely factor in the fire-affected Montecito block group, where the social vulnerability index factor endangered to the Thomas Fire is not significantly different from those of comparable WUI-associated block groups that were severely damaged by the fire elsewhere. It is possible that the spatial resolution of this Census block group is insufficient, and the actual demography of the block group is more heterogeneous than the aggregated SoVI might imply.

As a final caveat, it should be noted that the hyperlocal *Santa Barbara Independent* was chosen in our study because its readership is likely to be stakeholders in news relating to both the Thomas Fire and the 1/9 debris flows that affected properties in Montecito and Carpinteria, Santa Barbara County. However because the majority of the individuals affected by the Thomas Fire are residents of Ventura County, and particularly of the cities of Ventura and of the Ojai Valley, there may be lapses in content coverage regarding the Thomas Fire where topics deemed less relevant to residents of Santa Barbara County. The extent of this bias is best assessed if our content analysis was to be expanded into a hyperlocal Ventura County media outlet, whether it is the *Ventura County Star* or a sister publisher.

Conclusion

This study was designed as a validation of mixed-methodology research in the particular context of wildfire hazard science, and as part of a greater and enduring effort to bridge the divide between quantitative (physical) and qualitative (social) approaches to academic inquiry (Turner, 2002; Gall 2015). This has been historically performed in the context of pre-disaster risk mitigations, and in the context of floods and extreme weather (eg. Rebotier 2019). Integrating Cutter's (2003) social vulnerability index as a statistical complement and a newspaper content analysis to a traditional geospatial analysis is a novel triangulation method in the fire science

context. We apply it to Ventura and Santa Barbara Counties to probe the compounding effects of social inequity on communities devastated by the disaster and evaluate our results through the interpretivist epistemological framework of Howe (2012).

Every fruitful outcome of this research project originated at the intersection of our quantitative and qualitative analyses. Although no strong correlations were found between two wings of the quantitative analysis - assessments of building damage extent, and the development of a study area-specific social vulnerability index - our newspaper content analysis offered a means to contextualize the trends that were eminent in the spatial analysis, and a means of exploring the existence of vulnerable groups that are not well-suited for structure of the Census data that is used in that spatial analysis. Conversely, as it came to be when attempting to interpret the anomalously high building survival rates were identified in Census block group tracts associated with the city of Montecito in Santa Barbara County, the qualitative aspect of our study also revealed natural gaps in the content analysis that cannot be resolved based on our synthesis.

Because most of our content analysis insights were not spatially well-localized, and not all trends from the spatial analysis are readily explained from our qualitative evaluation, the most immediate and targeted way to further triangulate the narrative would be to conduct semi-structured interviews of groups that had been interviewed in course of the *Santa Barbara Independent*'s own coverage of the Thomas Fire disaster, including but not restricted to advocacy groups like CAUSE (if further evaluating the plight of Ventura County's agricultural workers); Santa Barbara Fire Department, to localize and then evaluate the effectiveness of the operations of the private firefighter battalions during the Thomas Fire, who were likely working outside the command structure and coordination of public fire departments.

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