“The Fire Keeps Burning”
Understanding the Impacts of Wildfires on Households and Across Communities

By

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DISSERTATION

Submitted in partial satisfaction of the requirements for the degree of

DOCTOR OF PHILOSOPHY

in

Geography

in the

OFFICE OF GRADUATE STUDIES

of the

UNIVERSITY OF CALIFORNIA

DAVIS

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2024

ABSTRACT

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"The Fire Keeps Burning:" Understanding the impacts of wildfires on households and across communities.

(Under the guidance of Clare Cannon)

This dissertation work studies the long-term impacts of wildfires by bringing together the bodies of literature on disaster recovery, place attachment, and post-disaster displacement, to better understand the impacts of wildfires on households and across communities. Wildfires pose a growing threat to human health through mental and physical health impacts, and longer-term impacts such as contamination or pollution. While much of the current wildfire scholarship contributes exceptional work on how wildfires impact communities and households in the acute phase following a wildfire, there remains work to be done to identify how post-wildfire needs vary by demographics like race and class, and how post-fire needs change over time in the months to years following a wildfire. Where many quantitative studies more narrowly focus on wildfire incidence and potential future exposure as a measurement of inequality, this dissertation advances the field in three key ways.

First, by including qualitative data from over 4,000 households, this research contributes to wildfire social science by exploring mixed-methods hypotheses derived from disaster theories to understand dynamics of wildfire-household interactions. Second, this study explores the factors that contribute to need duration following a wildfire—necessities like food, water, and shelter, as well as other needs including internet access, cell phone service, and transportation. By studying the households that have persistent needs, this research contributes to wildfire recovery literature by identifying specific high-risk subgroups for post-wildfire interventions. Wildfires affect entire communities, not just individual households – and understanding the factors that influence the

social vulnerability of these communities is vital. Third, this research explores the factors that influence post-wildfire Quality of Life, highlighting the disproportionate impact of the 2018 Camp Fire on locally displaced households, which represent a population of theoretical and practical significance for wildfire recovery.

Findings suggest that longitudinal monitoring and evaluation efforts are needed to continue to meet the needs of vulnerable households affected by wildfires and other disasters. Results indicate that qualitive variables, and the hypotheses derived from them, offer insight into different facets of recovery in a largely quantitatively validated field. Future research should focus on specific regional dynamics of identified socio-environmental interactions by including historical and qualitative data to measure relative risk, recovery, and resilience.

"The design of a book is the pattern of a reality controlled and shaped by the mind of the writer. ... We wanted to see everything our eyes would accommodate, to think what we could, and, out of our seeing and thinking, to build some kind of structure in modelled imitation of the observed reality."

John Steinbeck, 1941, in *The Log from the Sea of Cortez*

DEDICATION

This work is dedicated to the people of California and the participants who, by sharing their experiences, made it possible. It is my hope that this work truthfully represents their experiences and pays tribute to the people and places affected by wildfire. This dedication extends to all those affected by wildfires and other disasters, and to the others that this research may serve.

AWKNOWLEDGEMENTS

Thanks are due to my dissertation committee for their support, invaluable guidance, and endless patience throughout my graduate school journey. Their perspective and feedback have been instrumental in my academic development. Many thanks are owed to Tom and Irva for their encouragement and guidance throughout my dissertation. The unwavering support and efforts of Clare Cannon throughout my time at Davis, but particularly in this final year, are deserving of special recognition and appreciation. Together, this trio have worked hard to support me, and I lack the words and space to adequately reflect how much I value their time and expertise.

I treasure the collaboration and support of my friends and colleagues from the Geography Graduate Group – from 200AN to weathering pandemic-era Qualifying Exams, the defining feature of my time at Davis has been the camaraderie and collaboration of friends from the GGG.

I'd like to thank my family for their encouragement, from Mom and Dad to Chris and Debbie, to my brother Will. Whether it was listening to me grapple with tough courses or cheering me on during the writing process, you all are the best cheer squad that a scholar could hope for.

To Ryan, whose insight I value second only to his friendship.

In addition to those listed above, there are three people that are the most deserving of my thanks and recognition. The first is a top-notch editor, whose feedback helped clarify the most verbose sections of my writing. The second is a most supportive therapist who shepherded me through the inevitable trials and stressors of graduate school. The third is the best wife a husband could ask for, whose patience and grace during these first six years of marriage supported my efforts to pursue this degree, which means so much. The name of all three people is Holly, and if I am due any praise, I share it as I have shared the past 13 years of my life - with her.

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CHAPTER 1: INTRODUCTION

Wildfire in the American West is dynamic and complex. The size and severity of wildfires, which are unplanned fires that burn forests, grasslands, and other wild lands, have been increasing for decades, fueled by climactic conditions favorable to wildfire, such as prolonged drought, high ambient temperatures, and dead or dry vegetation (Williams et al. 2019; Goss et al. 2020; Xu et al. 2020; Westerling et al. 2006; Syphard et al. 2007). While wildfires have historically accompanied anthropogenic activity (Anderson 2005; Pyne 2021), decades of wildfire suppression tactics have led to the accumulation of vegetation that fuels wildfires (Pyne 2017; Syphard et al. 2007). Recent fire scholarship (Radeloff et al. 2018a; Mockrin et al. 2015; G. Simon 2017) highlights how the social, demographic, and physical dimensions of wildfire produce and shape fire vulnerability, particularly in exurban and suburban communities occupying historically fire-prone areas (see also Schumann et al. 2024; Palaiologou et al. 2019; Davies et al. 2018). Compounding the issue is the growing number of people moving into areas that abut or overlap with this vegetation, called the wildland-urban interface (WUI), thus increasing human exposure to wildfires (Kumar et al. 2022a; Alexandre et al. 2014; Hammer et al. 2007; Radeloff et al. 2018a). As more people move to the WUI, they join the estimated five million Californian households in buying, building, or rebuilding in areas characterized by heightened wildfire risk (Burke et al. 2021; Buechi et al. 2021a; Alexandre et al. 2014; Mockrin et al. 2015; H. Anu Kramer et al. 2021a). Although recent record-breaking wildfires, like the 2018 Camp Fire, have garnered scholarly attention (Chase and Hansen 2021a; Hamideh, Sen, and Fischer 2022; Schulze et al. 2020; Silveira et al. 2021) our understanding of the biophysical conditions of wildfire risk remains more comprehensive than our understanding of the

populations that face a growing wildfire risk (Thomas et al. 2017; Cutter, Schumann, and Emrich 2014).

Development into the WUI has been accompanied by longer and drier fire seasons, which in turn give rise to fires that are both more frequent and more intense and thus, more costly in terms of financial and human losses (Eriksen and Simon 2017; Wang et al. 2021; CALFIRE 2024). While fire risk has increased uniformly across the WUI, vulnerability to fire (how impactful a given fire event will be) varies widely. Despite media coverage of wildfires emphasizing the role of climate change, further investigation reveals a long-standing and structurally maintained inequality that implicates everything from smoke regulation (Engel 2013; Burke et al. 2022) to suburban development (G. Simon 2017; Hammer et al. 2007; H. Anu Kramer et al. 2021a) to the differential risks of housing construction pushing further into the WUI (Haynes et al. 2019; Radeloff et al. 2018a). Together, the climate-driven conditions, population growth patterns, and abundant fuels contribute to deadlier and more destructive wildfire seasons, as evidenced by California wildfires in 2017 and 2018, where over 17,000 fires burned over 3.5 million acres, destroying 35,000 households, and impacting communities across the state (CALFIRE 2024; 2024). With wildfires growing in frequency and severity and rising numbers of people living in and moving to the WUI areas (H. Anu Kramer et al. 2021a; Mockrin et al. 2015), there is a pressing need for wildfire recovery research.

Households recovering from wildfires face immediate threats in the form of physical health impacts (Aguilera et al. 2021; Rosenthal, Stover, and Haar 2021), and diminished mental health outcomes (Silveira et al. 2021; M. R. G. Brown et al. 2019b; To, Eboreime, and Agyapong 2021). Studies into wildfire impacts tend to focus on the destruction of physical assets such as homes and other goods (Nauslar, Abatzoglou, and Marsh 2018; Maranghides et al.

2021), quantifying these impacts in terms of economic losses (Boustan et al. 2017; Wang et al. 2021). However, more recent research has recognized the health impacts of wildfires, from physical health (Xu et al. 2020; Finlay et al. 2012) particularly smoke inhalation (Black et al. 2017; Burke et al. 2022) to mental health (To, Eboreime, and Agyapong 2021; Silveira et al. 2021; Rosenthal, Stover, and Haar 2021). Larger wildfires can damage communication infrastructure and displace larger amounts of people, such that information needs following disasters are also being recognized as significant metrics for risk-avoidance and recovery (Steelman et al. 2015; McCaffrey, Velez, and Briefel 2013; Benda et al. 2020). Disaster recovery research in general (Barile, Binder, and Baker 2020; Finucane et al. 2020) and wildfire recovery in particular (Rosenthal, Stover, and Haar 2021; Akter 2023) highlight the regional impacts of disasters and the lingering effects of wildfires on affected communities.

Problem Statement

As evidenced by the literature reviewed above and in the body of each chapter of this dissertation, there is a dearth of research that brings together political, physical, and social systems and concerns regarding post-fire recovery in California at the household level. While recent qualitative wildfire research explores the recovery at an organizational level (Rosenthal, Stover, and Haar 2021; Moloney et al. 2023), my research draws on inductive coding at the household level, coding open-ended questions derived from Clifford et al.'s (2010) *Key Methods in Geography* to explore survey results contributed by those affected by both 2017 and 2018 wildfires across California (Clifford et al. 2016).

Recovery is operationalized in the chapters of this dissertation in distinct ways. Chapter 2, which is informed by open-ended qualitative data from over 4,000 households, explores recovery as it relates to post-wildfire household needs, need type, and how these needs change

over time. Chapter 3, which focuses on 1,800 households affected by the 2018 California wildfires, looks at the relative duration of needs after a wildfire and the demographic factors that may contribute to needs and need duration. Chapter 4 treats recovery as a Quality of Life issue, comparing the relative shift in Quality of Life between households affected by the 2018 Camp Fire. While a more thorough discussion of these concepts is pursued in each of the chapters, I argue that the impacts of wildfire resonate across regions and over time and that for many households the wildfire is still figuratively "burning." This dissertation specifically investigates the uneven impacts of wildfires felt by households across the state to clarify the complex role that fire plays in creating, perpetuating, and recreating differential vulnerabilities across California.

This research is important because it brings together structural, physical, and social concerns in new ways that can help stakeholders to better understand how communities recover and respond to wildfires. Doing so provides greater insight into the needs of those affected by wildfire, which can inform policies for disaster recovery. By investigating the social, political, and physical factors of post fire communities, through this project, I seek to understand the determinants that shape whether people decide to stay or leave after a fire, and how their circumstances shape their post-wildfire Quality of Life. This would fill a gap in the research by investigating the long-term social effects of fires, a gap that has persisted in part because of the difficulties in securing data from displaced populations in a region characterized by cyclical fire events. Ultimately, this dissertation seeks to reconcile these different scales to investigate more deeply how the impacts of wildfires disseminate within and across affected communities over time.

Study Site and Positionality

The Case for California

For numerous reasons, I have selected Northern California as a study site for my dissertation research. Since the 1980s, the intensity and size of California wildfires have increased, with fifteen of the twenty largest fires in California's history in the last twenty years, and ten of the most damaging fires happening in the last five (CALFIRE 2024; Buechi et al. 2021a; Schumann et al. 2024). In the same time period, since the 1970s, suburbanization has occurred throughout the American West, with nearly 40% of new development between 1970 and 2000 occurring near or in the WUI (FEMA, n.d.; Alexandre et al. 2014; Radeloff et al. 2018a). In the face of increased demands for housing and record-setting wildfire seasons, California must choose between development and wildfire risk. The implications of wildfires extend beyond structural damage and bodily harm to include the federal, state, and local government agencies tasked to fight these fires–with estimated fire mitigation costs in the billions of dollars (Wang et al. 2021; Boustan et al. 2017; Dittrich and McCallum 2020). A legacy of fire suppression policies, paired with longer, more severe wildfire seasons and risky development into the WUI make California in general and the town of Paradise in particular, ground zero for my research (Syphard et al. 2007; Chase 2015; Maranghides et al. 2021).

Paradise, California

The November 2018 Camp Fire, the deadliest and most destructive fire in California history, killed 86 townspeople and burned over 150,000 acres, leveling nearly all the structures in the towns of Paradise and Magalia located in Butte County (Maranghides et al. 2021; Butte County District Attorney et al. 2020). Geographically, Paradise is in the Sierra-Cascade foothills of Butte County, California, 15 miles Northeast of Chico and 21 miles north of the county seat of Oroville.

Initially a mining region that transitioned to a lumber economy, the foothill communities of Butte County saw a sharp increase in the amount of development in the 1970s, culminating in the incorporation of Paradise into a township in 1979. The accelerated development is associated with an influx of retirement-age residents who moved to Butte County from urban areas to enjoy its rural setting and take advantage of a relatively low cost of living. For fixed-income families, Paradise offered amenities like cooler summers, a slower-paced lifestyle, and living in a forested environment. By the early 2000s, the unincorporated portion of Butte County experienced even greater residential development spurred by the booming statewide demand for housing ("Butte County General Plan," n.d.)

Paradise is in a transition zone, between the Sacramento Valley and the Sierra Nevada foothills. It is a unique area with a mixture of chaparral, oak, and pine woodland, which acts as a buffer between the valley below and the coniferous forest above. Paradise Ridge, or "The Ridge" as locals refer to it, lies between the Butte Creek and Feather River, a heavily forested portion of the foothills overlooking the Sacramento Valley. Within Butte County, Paradise and Magalia were known for their affordable housing, which provided room for families and a reasonable commute to nearby employment in Chico and Oroville (Collins 2005; Chase 2015; "Butte County General Plan," n.d.).

Positionality Statement

Having grown up in the nearby town of Durham, California (17 miles Southwest of Paradise) with both sets of grandparents from Paradise, I have a personal connection to the town and knew many families who were directly impacted by the 2018 Camp Fire, including my father. While this dissertation research seeks to be applicable to communities throughout California, I retain several ties to the Ridge communities that inform my perspective as a researcher. As a privileged community member returning to Paradise from an outside

organization (U.C. Davis) I balance my relationships within the community (including those I maintain with partners at CSU Chico) and my position as a researcher at Davis. I take seriously the ethical and academic ramifications of conducting research in a community that is, quite literally, close to home. The Ridge Recovery survey was granted exempt status through the Institutional Review Board permissions. When an academic conducts research on vulnerable subjects, it raises ethical questions of the extractive nature of that research (Valentine and Aitken 2014). This may be exacerbated by my dual affiliations with Ridge Communities as well as UC Davis. However, giving back to impacted communities- is crucial to resolving these ethical concerns, and I believe that my research will benefit not just Paradise but communities across California that are recovering from wildfires.

Statement of Organization

This dissertation is organized as follows. This first chapter will lay out the relevant literature and motivations that informed my research. The three middle chapters (chapters 2-4) are formatted as standalone journal articles organized around one of the research questions presented above and will include the hypothesis, data, methods of analysis, findings, and discussion, including implications for the literature and post-fire recovery policies. In the fifth and final chapter, I discuss the conclusions drawn from the dissertation research, presenting overall findings and avenues of future research.

For example, in Chapter 2, I will answer the first research question – *Understanding wildfire impacts: What connections can be made across communities impacted by wildfires?* - by examining differences in needs from more than 4,000 households reporting their post-wildfire needs, the coding follows from Clifford et al. (2010), while the strength of the relationships will be calculated using linear regressions (Lilja 2016). Wildfire social science research offers rich

insight into the impacts of wildfires on affected communities that more qualitative research to date might omit in the search for more universally applicable strategies to enhance wildfire recovery. Using data collected consistently by 4095 households affected by California wildfires in 2017 and 2018, my research explores the differences between short and long-term wildfire impacts. In the context of this data, short term needs correspond to needs reported by respondents in the week following the wildfire, while long term refers to needs reported at the time of survey – which was typically 4-6 months post-wildfire. I find many similarities among impacted households in the week following the wildfires, and more needs reported by households affected by the 2018 wildfire season. My results suggest that while many aspects of wildfire impacts may be similar shortly after a wildfire, long term effects vary by wildfire and household. These findings contribute to wildfire social science research by highlighting how wildfire impacts differ across years and communities.

In Chapter 3, I analyze survey results from post-fire communities across California to assess whether and how socioeconomic factors predict post-wildfire need duration. The inductive and deductive coding follow from Clifford et al. (2010), while the strength of the relationships will be calculated using linear regressions (Lilja 2016). The 2018 wildfire season in California caused unprecedented damage and loss of life. Recent wildfires in intervening years underscore the threat these hazards pose, and this chapter seeks to advance our understanding of the different and differential impacts of wildfires using survey data collected primarily from households affected by northern California households, with central and southern California households less represented within the survey data. 1,800 respondents reported how long their household had gone without various resources, from essentials (food, water, shelter, etc.,) to other amenities such as internet access, cell phone service, and transportation. One respondent replied for each

household. I use binary logistic regression to predict whether and to what extent demographic variables explained differences in duration among households. Potential explanatory variables included age, household size, race, education, employment, and household tenure. Needs varied across different respondent demographics, with reported needs assumed to be felt by all household members, including respondents. Advanced age was associated with enduring needs for clothing and shelter. Larger households were more likely to report transportation, shelter, and financial needs. Education beyond a bachelor's degree operated similarly to a protective factor, decreasing the likelihood of a household going without resources. Home tenure, for instance, increased the likelihood that a household would go without water, but decreased the likelihood that a household would go without essentials like food and shelter. By understanding which demographic factors can predict needs, this research contributes to wildfire recovery literature and identifies specific high-risk subgroups for post-wildfire interventions. Wildfires affect entire communities, not just individual households – and understanding the factors which influence the social vulnerability of these communities is vital.

Chapter 4 investigates post-wildfire Quality of Life, asking how disaster displacement impacts Quality of Life following the 2018 Camp Fire**.** Chapter 4 relies on analysis of data from the Ridge Recovery survey collected from respondents who were affected by the Camp Fire to explore post-fire migration patterns and how they relate to and inform post-wildfire Quality of Life. This survey used change of address information to identify households that lived in ZIP codes affected by the Camp Fire, which were invited to participate in the online survey. 684 households participated in the survey, and this chapter explores the social factors that influenced change in Quality of Life. Factors including wildfire risk perception, and place attachment and identity are examined across three groups of individuals: those currently living in Camp Fire

affected communities (Paradise, Magalia, and other Ridge Communities,) locally displaced households outside of the footprint but within the Butte County, and households that relocated outside of the county. Compared to locally displaced households within the county, residents currently living in Ridge Communities were 16 times more likely to report an increase in their Quality of Life between 2018 and 2023, while households that relocated outside of Butte County were 5 times more likely. Findings highlight locally displaced households as a subject of theoretical and practical significance to research on wildfire recovery.

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CHAPTER 2: UNDERSTANDING WILDFIRE IMPACTS: WHAT CONNECTIONS CAN BE MADE ACROSS COMMUNITIES IMPACTED BY WILDFIRES?

Abstract

Qualitative wildfire research offers rich insight into the impacts of wildfires on affected communities that more quantitative research to date might omit in the search for more universally applicable strategies to enhance wildfire recovery. My research brings together qualitative and quantitative social science research to explore the short and long-term impacts of wildfires using data collected from 3,038 households affected by California wildfires in 2017 and 2018. I find many similarities among impacted households in the week following the wildfires, and more diverse needs reported by households affected by the 2018 wildfires. Results suggest that while many aspects of wildfire impacts may be similar shortly after a wildfire, long term effects vary by wildfire and household. The findings of this study contribute to wildfire social science research to better understand which aspects of wildfire recovery are consistently felt across years and communities.

Introduction

The size and severity of wildfires in the western United States have been increasing for decades, fueled by climactic conditions favorable to wildfire, such as prolonged drought, high ambient temperatures, and dead or dry vegetation (Williams et al. 2019; Goss et al. 2020; Xu et al. 2020; Westerling et al. 2006; Syphard et al. 2007). While wildfires have historically accompanied anthropogenic activity (Anderson 2005; Syphard et al. 2007), decades of wildfire suppression tactics have lead to the accumulation of vegetation that fuel wildfires (Pyne 2017). Compounding the issue is the growing number of people moving into areas that abut or overlap with this vegetation, called the wildland-urban interface (WUI), thus increasing human exposure

to wildfires (Kumar et al. 2022a; Alexandre et al. 2014; Hammer et al. 2007; Radeloff 2024). Taken together, climate-driven conditions, growth patterns, and abundant fuels contribute to deadlier and more destructive wildfire seasons. This is evidenced by California wildfires in 2017 and 2018, where over 17,000 fires burned over 3.5 million acres, destroying 35,000 households and impacting communities across the state (CAL FIRE 2022; CALFIRE 2024).

The multi-wildfire event in the fall of 2017 marked the beginning of an unprecented new era of wildfires in California in terms of wildfire magnitude and destructiveness (A. X. Li, Wang, and Yung 2019; Nauslar, Abatzoglou, and Marsh 2018). Beginning October 8, 2017, a series of wildfires burned across Northern California, spanning eight counties, causing 44 fatalities, burning over 240,000 acres of land and destroying nearly 9,000 structures (CAL FIRE 2022). The Tubbs, Atlas, Nuns, and Pocket Fires were among the most destructive, displacing more than 90,000 people across Napa and Sonoma Counties (Wong, Broader, and Shaheen 2020). Over $11 billion in insured damages were reported across the eight counties, collectively making the series of wildfires the most destructive and costly in California history at that time (Wong, Broader, and Shaheen 2020).

The effects of the 2018 wildfire season also included record-setting wildfires such as the Camp Fire, which alone destroyed nearly 19,000 structures and claimed 85 lives, making it the deadliest wildfires and the single costliest disaster worldwide in 2018 (Maranghides et al. 2021; Butte County District Attorney et al. 2020; “Bushfire & Wildfire Risks | Munich Re,” n.d.). Much of the qualitative research about the Camp Fire in the intervening years (e.g. (Chase and Hansen 2021b; Hamideh, Sen, and Fischer 2022; Schulze et al. 2020) has demonstrated the lingering impacts of wildfire disasters. Studies about the 2018 California wildfires indicate that

the costs are nearly 150 billion dollars, with much (59%) of that sum caused by indirect economic impacts (Wang et al. 2021).

The broader effects of wildfires often extend beyond the immediately impacted community and can involve housing access, healthcare, and social service availability (Rosenthal, Stover, and Haar 2021; Grajdura, Qian, and Niemeier 2021). Those who evacuated had to rely on emergency shelters, family, friends, and other temporary housing options in outlying areas (Wong, Broader, and Shaheen 2020; Chase and Hansen 2021b). Households that did not evacuate likely remained in nearby communities that experienced resource strain because of the wildfires. When disasters displace communities, affected populations are faced with immediate and long-term economic, health, and social impacts (Arcaya, Raker, and Waters 2020; Graif 2016).

Studies into wildfire impacts tend to focus on the destruction of physical assets such as homes and other goods (Maranghides et al. 2021; CALFIRE 2024), quantifying these impacts in terms of economic losses (Boustan et al. 2017; Wang et al. 2021). However, more recent research has recognized the health impacts of wildfires, from physical health (Xu et al. 2020; Finlay et al. 2012), particularly smoke inhalation (Black et al. 2017; Doubleday et al. 2020; Kochi et al. 2012; Liu et al. 2015), to mental health (M. R. G. Brown et al. 2019b; Rosenthal, Stover, and Haar 2021; D. P. Eisenman and Galway 2022; Silveira et al. 2021). In the case of more rural wildfires, information needs following disasters are also being recognized as significant metrics for risk avoidance and recovery (Steelman et al. 2015; McCaffrey, Velez, and Briefel 2013; Benda et al. 2020). As we look towards a future with more frequent and more severe wildfires compounded by worsening climate effects and increasing numbers of people at risk, it is vitally important to understand the many ways that wildfires impact households.

While prior research has discussed how wildfires impact physical and mental health, there exists a limited literature that more broadly consider household needs following wildfires. Needs assessments in post-disaster contexts can inform responding organizations about the priorities of the affected households, and when aggregated, can also guide response and delivery of resources from larger disaster response organizations (Blatner et al. 2003; Blackman, Nakanishi, and Benson 2017). Beyond the aforementioned focus on individual aspects of wildfires, such as health (Finlay et al. 2012), there is a paucity of research on how the needs of households impacted by wildfire compare across regions and time. This study, which examines and identifies the needs of households impacted by the 2017 and 2018 California wildfires, is part of the "***W***ildfires and ***H***ealth: ***A***ssessing the ***T***oll in ***No***rthern ***Ca***lifornia Study," abbreviated as the: WHAT Now, CA? Study. Existing scholarship that explores needs across different communities following wildfires is limited. Such assessments offer a wider perspective of post-disaster contexts and can offer insight into the dynamic needs of affected households while providing opportunities for emergency response organizations to incorporate strategic planning and resource deployment. The WHAT NOW, CA? survey contributes to wildfire social science by offering rich insight into the needs of households affected by the 2017 and 2018 wildfires. While there have been studies on specific disaster outcomes such as mental health effects and the role of community cohesion and resilience, there is a paucity of research that explores the variety of needs and whether or how they change, particularly for such a comprehensive sample size.

This study explores how reported needs differed among respondents from the two wildfire seasons, seeking to identify whether and to what extent differences exist between respondent's needs one week following the wildfire and at the time of the survey. These needs are organized into four broad categories, physical, health, air, and information, which are derived

from prior wildfire studies. After a review of the relevant wildfire literature, I list several hypotheses which refine my wider exploration of 2017 and 2018 cohorts before explaining my methodology and data characteristics. Then, I discuss how needs differ between time categories and how the findings from this work provide information that can be useful to county and state health departments, disaster preparedness and response agencies, and non-profit organizations to prepare for and respond to future wildfires.

Literature Review

Wildfires have been linked with considerable damage to physical assets, requiring impacted households to evacuate and seek out necessities like food, water, and shelter (California Department of Fish and Wildlife 2021; FEMA 2016). Households often require basic needs like food, clothing, and stable housing following a wildfire. Prior research has found that populations with lower resources are less able to meet these basic needs, or recover more slowly after a disaster (Edgeley and Paveglio 2017; Arcaya, Raker, and Waters 2020; DeFraites et al. 2020; Davies et al. 2018; Clay et al. 2018). Often, impacted communities may experience interrupted service from utilities such as gas, water, and electricity, which can lengthen evacuation and prolong recovery. In the context of our survey, these basic needs included essentials such as food, water, shelter, clothing, and utilities. While these necessities such as shelter are often provided in the days following disasters, availability may be limited, leading to a diverse range of experiences as evacuees seek managed evacuation shelters, hotels/motels, or alternative accommodation from friends or family. Qualitative research into the longitudinal impacts of wildfires on communities (Kirsch et al. 2016; Blatner et al. 2003) reveals how needs change between communities over time. Although basic needs might be widely reported by

wildfire-impacted households, the duration of these needs may vary based on individual and community resources.

Wildfire studies identify a range of physical and mental health sequalae which can impact affected households. Wildfires are known to cause direct health sequalae such as burns (Finlay et al. 2012), exacerbate existing chronic illness (Aldrich and Benson 2007), and have been linked with adverse mental health outcomes (D. P. Eisenman and Galway 2022). Wildfire exposure can impact health via exposure to the flames or smoke, or indirectly via contaminants in the soil or waterways a following wildfire (DeFraites et al. 2020; Finlay et al. 2012). The adverse health impacts of wildfires can disproportionately affect vulnerable populations, including younger and elderly populations (Finlay et al. 2012), who may not be as self-sufficient as adults and face obstacles that could increase odds of wildfire exposure (Levac, Toal-Sullivan, and O'Sullivan 2012). Wildfires negatively impact mental health, with several studies linking wildfire exposure with depression, anxiety, and trauma in survivors (Silveira et al. 2021; M. R. G. Brown et al. 2019b; D. P. Eisenman and Galway 2022). Post-wildfire mental health impacts have been shown to have a pronounced impact on youth (Schulze et al. 2020; M. R. G. Brown et al. 2019b; Scannell et al. 2016).

A growing body of research is also emerging that investigates the health impacts of smoke and harmful small particulate matter exposure (Liu et al. 2015; Black et al. 2017). These include the effects of inhalation (Aguilera et al. 2021) as well as mental health (D. P. Eisenman and Galway 2022). In the context of this survey, many households requested Personal Protective Equipment (PPE) in the form of masks, or else filtration systems for their residence. Given the prevalence of these responses in the short term (1 week) following the wildfires, these responses were given their own emergent category to ensure that this area of research was considered.

Disasters influence social determinants of health such as housing, employment, and access to the internet. Increasingly, scholars have advocated for the inclusion of internet access specifically, and information more generally, as a determinant of health (Benda et al. 2020; Turcious 2023; Early and Hernandez 2021). In addition to disaster-related disruptions such as evacuation notices, lack of internet can influence diverse aspects of health and recovery including tele-healthcare, remote employment, and resource allocation (Benda et al. 2020). Disruption of information due to wildfires can disproportionately impact poorer households who could lack the social resources to access private healthcare providers, have more tenuous employment options, and have fewer economic resources to replace any losses or relocate elsewhere. For rural communities, this "digital divide" that separates those with internet access or internet-capable devices like cell phones (and can use them proficiently) can pose a significant barrier (Pinnock, Poberezhets, and Drummond 2023). Wildfires can harm individual wellbeing (Rosenthal, Stover, and Haar 2021; Finlay et al. 2012), limit access to healthcare (DeFraites et al. 2020; Hamideh, Sen, and Fischer 2022), impact housing availability (Chase and Hansen 2021b), induce a need for rapid and reliable information (Benda et al. 2020), and affect economic stability (Wang et al. 2021), all of which threaten vulnerable populations. To understand how these needs are realized by wildfire affected households, I look to the survey responses.

Data and Methods

Survey Data

Data for this survey were collected between February 2018 and March 2020 via online Qualtrics surveys of eligible households, which I define as being in a county affected by the 2017 or 2018 California wildfires or by the smoke those fires produced. A large convenience sample was enrolled, with 4,095 participant households. Adult (18+) survey respondents answered questions on behalf of their household. There was no further restriction, as the goal was to

capture the variety of post-wildfire needs and experiences. The survey was informed by previously deployed post-disaster survey instruments, by reported experiences in the media (social and traditional), and by consultations with health department epidemiologists and public health officers on question formulation and content. English and Spanish language versions were available. Spanish versions were translated by native speakers of Mexican Spanish who were also bilingual and reviewed extensively by native Spanish speakers at one of the county health departments. This study was approved by the University of California, Davis, Institutional Review Board (R21ES029693; P30ES023513).

Recruitment occurred using various media, including print, radio, and substantial social media efforts to reach a broad public. Respondents from across California participated, with 49 counties represented in the survey. The counties included Butte, Napa, Shasta, Sonoma, and Mendocino counties. Of these, Butte and Sonoma Counties represented 60% of surveyed households, with 983 and 1,519, households respectively. Survey respondents answered questions on behalf of their household. Of the 4,095 households that participated, 74% (n=3,038) answered one or both key questions. 1) What was your household's greatest need one week after the wildfires*?* 2) What is your household's greatest need currently? Regarding this second question, "currently" varied according to when the respondent completed the survey. Over 70% (n=1592) of 2017 respondents answered by April of 2018 (5 months after the October 2017 wildfires), while over 80% (n=1534) of 2018 respondents replied by July 2019, (over 7 months after the November 2018 Camp Fire. Other parts of the survey covered evacuation experiences during the wildfires, sociodemographic characteristics, losses (home, source of income, family members or close friends, pets), newly occurring health symptoms—both physical and mental—as well as pre-existing conditions before the fires.

Coding Methodology

Qualitative coding was used to characterize and code the responses to the open-ended questions (Clifford et al. 2016). Survey responses were with randomly assigned, with unique household identifiers. All responses were systematically categorized using a codebook developed by two coders. All responses were systematically categorized using a codebook developed by two coders. We used emergent coding methodology to identify common themes (hereafter referred to as major themes) and sub-themes. Given the temporal element of the survey questions, we identified two time periods: immediate, or needs that occurred in the week following the wildfire, and time-of-survey (ToS); however, we further classified responses that were reported by a given household for both immediate and ToS as a third category: persistent. "Persistent" refers to needs and impacts identified at both time points, in which a household reported the same need for both key questions. Although both survey prompts asked for the greatest need (in the week following the wildfire and at the ToS), respondents varied in their responses. Some provided multiple needs in a single response, while others provided a single need. Because we used all the information provided by households that reported more than one need, we recorded 4,168 needs across the 3,038 households with reported needs. The following response contains more than one type of need:

> *Adequate rest, emergency equipment/masks, gasoline, water, food. I had to sleep in my car as there was nowhere else to go. I thought I was safe, but on the third night I awoke in the middle of the night and with the flashlight I could see my car was full of floating ash. I had been sleeping, breathing all this in for days. I still had no mask. I went to two hospitals, and they were overrun and had [run] out of masks, as did all the stores.*

Here, I identify physical needs (e.g., gasoline, food, water, shelter), health needs (e.g., adequate rest), air needs (e.g., floating ash and need for masks), and information needs (e.g., a safe place to go for sleep and supplies, warnings about air quality).

Qualitative methods: Thematic analysis

Based on the emergent coding methodology adapted from (Clifford et al. 2016) we developed a codebook that contained detailed inclusion and exclusion criteria for major themes and sub-themes (Appendix A). Needs were coded into four major themes: physical, health, air, and information. Here, we distinguish between Air needs, which include smoke impacts as well as Personal Protective Equipment or PPE, and the other major needs categories to highlight the increasingly widespread impacts of wildfire smoke. Because the inclusion criteria for the WHAT NOW, CA? survey included households that were affected by wildfire smoke and not solely respondents who were directly affected by the flames, the "Air" category illuminates how wildfire smoke as distinct from direct wildfire damage poses a health risk. The health theme was divided into physical health and mental health. Survey responses could contain one, many, or all the major themes. The branching relationships between major and sub-themes are presented in Appendix A. We established intercoder reliability by giving subsets (n=50) of responses to be coded independently by the two coders using the same codebook. Results were compared to identify discrepancies, that were then discussed until coders came to 100% agreement. This continued until an intercoder reliability of >80% agreement between coders was established and maintained. This process ensured high agreement and accuracy between coders. After the >80% agreement was established, the codebook was fixed and the remaining uncoded answers were split between coders by survey cohort.

Health-related responses were further delineated as either a need or an impact. The distinction between needs and impacts emerged upon reviewing survey responses that explicitly provided information about how a respondent was impacted (e.g., health effects) rather than their needs (e.g., resources). Health needs were defined as physical or psychological requirements for

a person's well-being, and health impacts were defined as physical or psychological effects on a person's well-being.

Quantitative methods: Cross Tabs

I use cross-tabulation tables to describe the relationship between reported post-wildfire needs and wildfire season. I set the 2017 and 2018 wildfire seasons as the rows and the reported needs by major themes across the immediate and ToS time categories. From these cross-tabulations, I calculated the risk difference between the 2017 cohort relative to the 2018 cohort as well as the relative risk of a household experiencing that need at a given time category. The decision to report risk differences in addition to Odds Ratios was informed by Holmberg and Anderson's approach, who describe the potential for Odds Ratios to misrepresent or exaggerate differences (Holmberg and Andersen 2020). All statistical modelling was performed using SPSS version 29.

Given the extant literature reviewed above, my initial research question about any potential differences between these two wildfire seasons were refined into five hypotheses comparing respondent needs from the fires in 2017 to those in 2018:

H1: That physical needs will be universally high for both survey cohorts.
H2: That there will be no difference between health needs (universally high).
H3: That mental health needs will be universally small in the short term but increase over time.
H4: That the need for air quality/PPE will not be significantly different.
H5: That the need for information related needs will not be significantly different.

Results

Of the 4,095 households that participated in the survey, 3,038 households (74.4%) reported needs by answering one or both questions related to their greatest post-wildfire needs. Respondents included households that lost their homes to wildfires; households that did not lose their housing to the wildfires but evacuated; those that were exposed to wildfire smoke but did

not evacuate; and still others that hosted families or friends that were directly affected. A quarter of households (n=1046) either did not report having needs or did not answer the open-ended questions and were therefore excluded from this analysis and therefore the sample size for this analysis was 3,038. Over 2,000 households (49.9%) answered both questions related to their greatest needs, while 995 (24.3%) respondents answered a single question, compared to the 1,057 (25.8%) of respondents who did not report a need or left the question blank.

Descriptive Statistics of the Sample

Data are from the WHAT-NOW CA? survey respondents (N = 4095) from wildfire-affected households across California. Some respondents answered questions related post-wildfire needs but provided partial or no demographic data. These results are reported in the "Missingness" row of each column. Demographic question response rate (*n*/*N*) ranges from 99.6% to 83.2% for the demographic variables, with fewer respondents indicating their race. Table 1 presents descriptive demographic statistics reported by respondents in the surveys who reported needs on behalf of their households. Surveys were not intended to be representative of common administrative units (e.g., counties, census block groups), so I cannot compare these to externally available statistics. For the full sample, respondents average 62 years old; most are women, and nearly half are college graduates. Nearly three-quarters are homeowners, and more than 75% are White. Demographically, in households with reported needs, respondents were predominantly white (94.9%), and female (80.5%), and for three quarters of these households, a member of the household was the homeowner (74.2%).

	2017 Households (n=2208) *N* (%)	2018 Households (n=1887) *N* (%)
Sex		
Female	1571 (71.2%)	1445 (76.58%)
Male	360 (16.3%)	277 (14.68%)
Missing	277 (12.5%)	165 (8.74%)
Age (yrs)		
18-35	360 (16.3%)	362 (19.18%)
36-45	316 (14.3%)	323 (17.12%)
46-55	355 (16.1%)	301 (15.95%)
56-64	444 (20.1%)	357 (18.92%)
65 or older	393 (17.8%)	336 (17.81%)
Missing	340 (15.4%)	208 (11.02%)
Race		
White	1631 (73.8%)	1449 (76.79%)
African American/Black	8 (0.4%)	2 (0.11%)
Native American	16 (0.9%)	19 (1.01%)
Asian/Pacific Islander	52 (2.8%)	14 (0.74%)
Multiple races	90 (4.9%)	100 (5.30%)
Other	39 (2.1%)	14 (0.74%)
Missingness	372 (16.8%)	289 (15.32%)
Educational level		
High school graduate or equivalent	63 (2.9%)	125 (6.62%)
Some college, but no degree	361 (16.3%)	422 (22.36%)
Trade or Associate's degree	274 (12.4%)	285 (15.10%)
Bachelor degree	635 (28.8%)	445 (23.58%)
Graduate degree	512 (23.2%)	336 (17.81%)
Missingness	363 (16.4%)	274 (14.52%)
Housing status		
Homeowner	1581 (73.2%)	1350 (71.54%)
Renter	593 (26.9%)	501 (26.55%)
Other	21 (1.0%)	28 (1.48%)
Missingness	13 (0.6%)	8 (0.42%)

Table 2.1: Descriptive Summary Statistics of Respondents Answering On Behalf Of Surveyed households. Discrepancies between reported demographics and population sizes are due to not all survey respondents answering both needs and demographics questions.

Figure 2.1 presents four major themes – physical, health, air, and information needs – from one or both time points. Physical needs predominated immediately following the wildfire and continued to be the most common at all time points. Air was the second most reported immediate need, but precipitously dropped for persistent and ToS periods. In contrast, the health

needs, which included both physical and mental health needs, were the second most reported among persistent need and newly reported at the ToS.

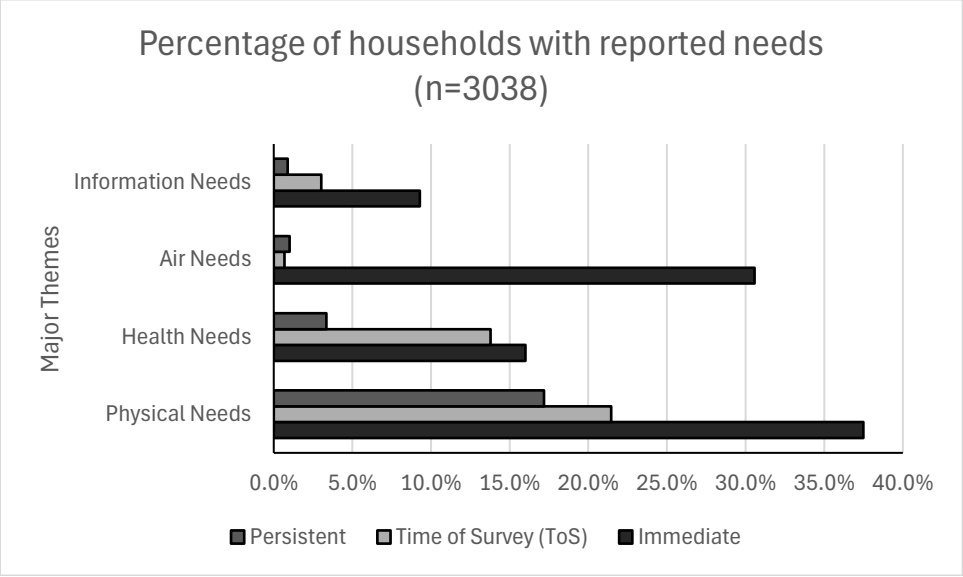

Figure 2.1 is a clustered bar chart of percents reporting major themes (physical needs, air needs, health needs, and information needs), among households with reported needs. Bars /Colors represent three different time categories: immediately following the wildfires; at time of survey (ToS) and Persistent. As some households reported multiple themes, themes are not mutually exclusive. Timepoints are mutually exclusive.

Physical needs

Physical needs were the most frequently identified necessity among survey responses. A physical need includes necessities like food, water, clothing, shelter, and other items that materially assist recovery, such as money. Respondents that reported a physical need frequently listed more than one in their responses, especially in the immediate phase (Figure 2.2). Given the results presented in table 2.2, I find that respondents reporting after the 2017 wildfires households were 9% less likely to report an immediate physical need and 18.5% less likely to report a ToS physical need than respondents for the 2018 wildfires.

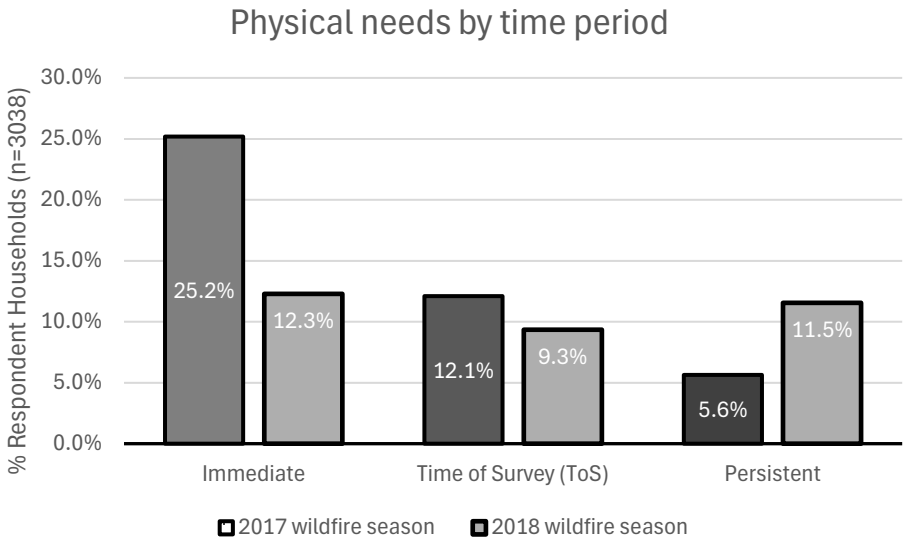

Figure 2.2 is a clustered bar chart of percents reporting the percentages of Physical needs between the two survey cohorts, among households with reported needs. Bars /Colors represent three different time categories: immediately following the wildfires; at time of survey (ToS) and Persistent. Time categories are mutually exclusive.

Physical Needs	Short-Term	Time of Survey
Risk Difference	-9.2%	-18.5%
Relative Risk Risk Ratio, (C.I)	.762 (.699 to.830)	.453 (.403 to.509)
Odds Ratio	.663 (.582 to .755)	.353 (.304 to .411)

Table 2.2: Risk Difference For Reported Physical Needs. 2017 respondent needs rates to 2018 respondent needs rates. Risk difference is calculated by subtracting the percent of 2018 respondents with needs from the percent of 2017 respondents with needs. Relative risk is calculated by dividing the percentage of 2017 respondents with a need by the percent of 2018 households with a need.

Health needs

Health care and sustained health care access were challenges for many survey respondents in the weeks to months following the wildfires. Nearly 500 (n=488) health-related responses were reported, spanning physical and mental health needs and impacts (Figure 2.2). Examples of physical health needs include restored health or a sanitary home. Mental health needs include generalized support or explicit requests for professional services. Nearly four

times as many households reported mental health needs immediately following the wildfire and at the ToS as did households with persistent mental health needs. Given the results presented in table 2.3, I find that 2018 households were slightly more likely to report a physical health need than 2017 respondents. There were not sizeable differences between respondents from 2017 that report health needs compared to respondents from 2018. Households from 2017 were 0.4% and 0.6% for less likely to report health needs for immediate and ToS time categories respectively. Our findings for the risk estimate of having a mental health need, presented in table 4, were more distinct, with respondents from the 2017 cohort 2.2% less likely to report an immediate mental health need and 5.6% likely to report a ToS mental health need than 2018 respondents.

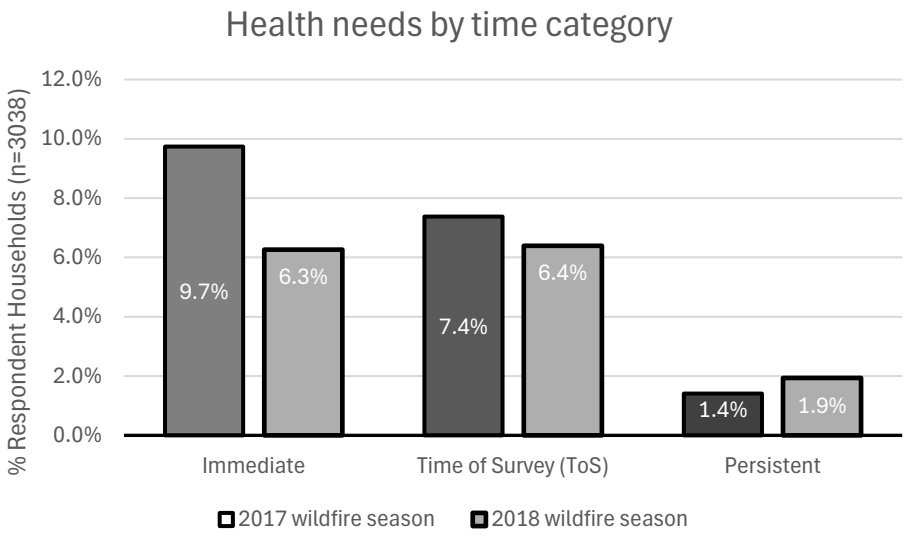

Figure 2.4 is a clustered bar chart of percents reporting the percentages of health needs (physical and mental) between the two survey cohorts, among households with reported needs. Bars /Colors represent three different time categories: immediately following the wildfires; at time of survey (ToS) and Persistent. Time categories are mutually exclusive.

Health Needs	Short-Term Relative Risk, (C.I)	Time of Survey Relative Risk, (C.I)
Risk Difference	-0.4%	-0.6%
Relative Risk	.934 (.735 to 1.20)	.743 (.489 to 1.13)
Odds Ratio	.930 (.711 to 1.22)	.738 (.481 to 1.13)

Table 2.3: Reports Risk Difference For Reported Health Needs. 2017 respondent need rates are compared to 2018 respondent needs rates. Risk difference is calculated by subtracting the percent of 2018 respondents with needs from the percent of 2017 respondents with needs. Relative risk is calculated by dividing the percentage of 2017 respondents with a need by the percent of 2018 households with a need.

Mental Health Needs	Short-Term Relative Risk, (C.I)	Time of Survey Relative Risk, (C.I)
Risk Difference	-2.2%	-5.6%
Relative Risk	.732 (.584 to .916)	.521 (.424 to .641)
Odds Ratio	.715 (.561 to .910)	.491 (.392 to .615)

Table 2.4: Reports Risk Difference For Reported Mental Health Needs. 2017 respondent need rates are compared to 2018 respondent needs rates. Risk difference is calculated by subtracting the percent of 2018 respondents with needs from the percent of 2017 respondents with needs. Relative risk is calculated by dividing the percentage of 2017 respondents with a need by the percent of 2018 households with a need.

Air needs

Air needs were identified by more than a third of respondents (n = 984) and can be characterized by reports desiring improved air quality (the majority) and access to Personal Protective Equipment (PPE) such as masks and filters. Nearly all (95%) of these needs were identified in the immediate time point of the survey. As one respondent put it, "good air quality was the biggest concern", which was the top air need. Masks and filters, which clear the air of harmful air pollutants, represented the remainder of reported needs. There was a precipitous decline in air-related needs after the immediate time point, though a diminished few reported better air quality as persistent across the time periods (Figure 2.5). Given the results presented in table 5, I find that 2017 households were 14.8% less likely to report an immediate air need, compared to a more modest 1.1% decrease in risk difference in their likelihood to report a ToS air need compared to 2018 respondents.

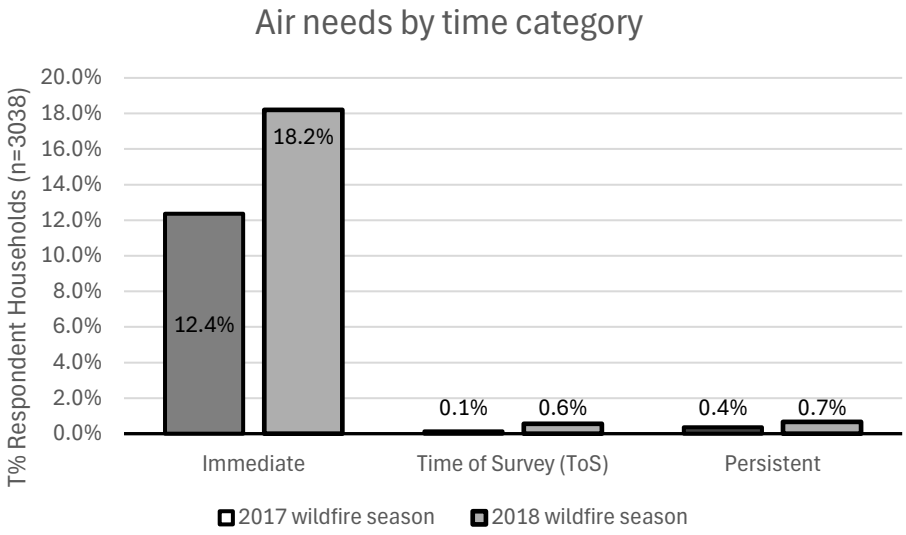

Figure 2.5 is a clustered bar chart of percents reporting the percentages of air needs between the two survey cohorts, among households with reported needs. Bars /Colors represent three different time categories: immediately following the wildfires; at time of survey (ToS) and Persistent. Time categories are mutually exclusive.

Air Needs	Short-Term Relative Risk, (C.I)	Time of Survey Relative Risk, (C.I)
Risk Difference	-14.8%	-1.1%
Relative Risk	.515 (.458 to .580)	.142 (.050 to .410)
Odds Ratio	.425 (.365 to .494)	.141 (.049 to .407)

Table 2.5: Reports Risk Difference For Reported Air Needs. 2017 respondent need rates are compared to 2018 respondent needs rates. Risk difference is calculated by subtracting the percent of 2018 respondents with needs from the percent of 2017 respondents with needs. Relative risk is calculated by dividing the percentage of 2017 respondents with a need by the percent of 2018 households with a need.

Information needs

Information was a dynamic need for households, with 402 households reporting information-related needs across all time points (Figure 2.6). Information needs represented numerous aspects of recovery, from the location and wellbeing of loved ones to insurance paperwork, to the long-term health effects of smoke inhalation. Lack of current and reliable information was seen as an immediate need for many of the impacted households. Given the results presented in table 2.6, I find that 2017 households were slightly (<1%) less likely to

report an immediate information need and 1.2% less likely to report a ToS information need than 2018 respondents.

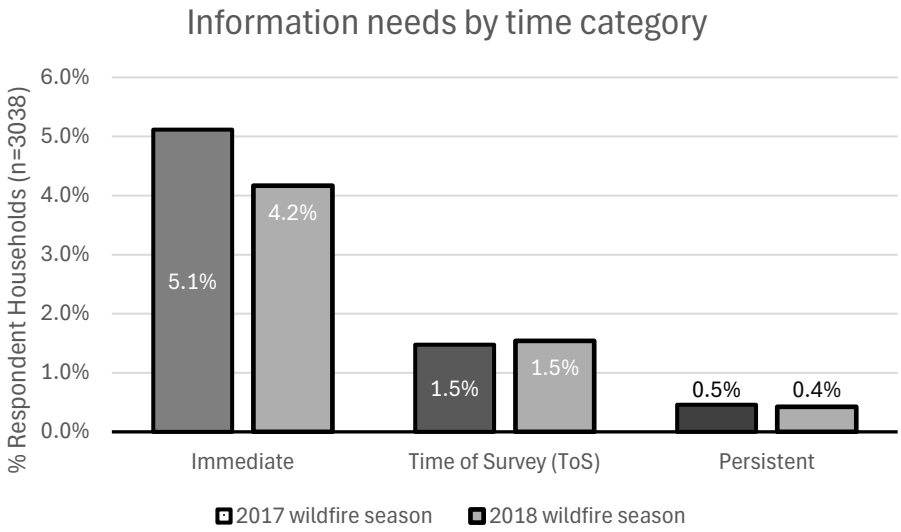

Figure 2.6 is a clustered bar chart of percents reporting the percentages of information needs between the two survey cohorts, among households with reported needs. Bars /Colors represent three different time categories: immediately following the wildfires; at time of survey (ToS) and Persistent. Time categories are mutually exclusive.

Information Needs	Short-Term Relative Risk, (C.I)	Time of Survey Relative Risk, (C.I)
Risk Difference	-0.7%	-1.2%
Relative Risk	.903 (.723 to 1.13)	.6.27 (.427 to .920)
Odds Ratio	.897 (.705 to 1.14)	.619 (.418 to .918)

Table 2.6: Reports Risk Difference For Reported Information Needs. 2017 respondent need rates are compared to 2018 respondent needs rates. Risk difference is calculated by subtracting the percent of 2018 respondents with needs from the percent of 2017 respondents with needs. Relative risk is calculated by dividing the percentage of 2017 respondents with a need by the percent of 2018 households with a need.

Discussion

I wish people had a better understanding of my needs: They gave us a case of [graham] crackers (I needed supplies, real food and personal hygiene supplies)

Wildfires affect households in many ways, as shown by the responses of the 3,038 households in California that reported their needs following the 2017 and 2018 wildfires. Survey responses highlighted needs at three time points: immediately following the wildfire, at the ToS (i.e., a few months after wildfires), and persistent (at both time points). My results illustrate the dynamic

nature of post-wildfire needs over time and across communities. We differentiated between households' needs by sorting them in four major themes: physical needs, health needs, air needs, and information needs. Heads of house responded for all household members, with some responses reporting a single "greatest need," while others provided a more comprehensive list of multiple needs in a single response. More than 2,800 respondents reported needs during the immediate time point, with 1,100 related to physical needs. Housing was a top physical need, alongside other immediate needs for air-quality related PPE and access to up-to-date information. In comparing the relative risk of reporting a need between households surveyed about their needs following the 2017 and 2018 wildfire seasons, I found modest differences. These findings raise questions about post-wildfire recovery and the resources available of households affected by wildfires, especially in the weeks to months following a wildfire.

Given my null hypothesis that there would be no statistically significant difference between households from different wildfire seasons, the finding in table 2.2 that 2017 households were 18.5% less likely to report an ToS than 2018 respondents was interesting. Physical needs, which encompass necessities such as food, water, and shelter, are some of the most noticeable impacts of wildfires and are prerequisites for recovery (Maslow 1943; Block 2011). One respondent household described how wildfire impacts had regional effects, writing that "Even living ten miles away from the fire itself we were unable to find groceries stocked in stores and had to drive further away to buy milk, meat, and vegetables."

Moreover, disasters, including wildfires, are associated with displacement (Graif 2016) and so respondents with housing needs faced a tight housing market, consistent with research on wildfires (Chase and Hansen 2021b), particularly wildfires in Californian contexts (Chase 2015; G. L. Simon and Dooling 2013a). The loss of housing and subsequent displacement could have a

"ripple effect" on other aspects of life, including employment. In the words of one respondent, "I lost everything I owned, and I bounced around staying with family and friends for several months. Lost my home, furnishings and my job in one night!" Naturally, given the destruction of wildfires like the Camp and Woolsey fires, shelter-related needs were a leading concern for affected households, with long-term housing dominating ToS needs for households affected by 2018 wildfires. Tight pre-wildfire housing markets, alongside mass displacement, prolonged recovery trajectories, especially for lower-income households (Chase and Hansen 2021b; Davies et al. 2018). The responses above highlight how wildfires can disrupt employment and economic stability, which can have lasting impacts for more vulnerable communities which might face economic or structural barriers to recovery (Davies et al. 2018).

Research into the health impacts of wildfires is growing, linking wildfires to direct health impacts (Rosenthal, Stover, and Haar 2021; Finlay et al. 2012), and adverse mental health (Silveira et al. 2021; M. R. G. Brown et al. 2019b), including adverse physical and mental health impacts related to smoke (Aguilera et al. 2021; Liu et al. 2015; D. P. Eisenman and Galway 2022). Given the results presented in tables 2.3, I find that 2017 households were slightly less likely to report a physical health need than 2018 respondents (.04% and .06% less for immediate and ToS needs, respectively). Respondents with physical health needs reported many different challenges as they, or those in their household, sought medical attention. As one respondent framed their greatest need as:

> *Medical care for the two ill elders who were brought to our house when they were evacuated from the fire. ... Getting pain medication for her was our top priority and it was hard because Kaiser was shut down. We could not get through to doctors, nurses, or the pharmacy for many days ... Medical professionals were not available because their own houses burned down, plus medical offices were closed due to fire damage or smoke.*

While the obstructing effects of disasters on healthcare has been noted by (DeFraites et al. 2020) and (Briggs, Cherian, and Rosales 2021), the positionality of healthcare providers as wildfire victims is less commonly studied in the literature. Nevertheless, these responses make clear how the broader effects of wildfires have widespread and lingering impacts on healthcare availability as healthcare providers themselves take steps towards recovery.

My findings for the risk estimate of having a mental health need, presented in table 2.4, indicates that 2017 households were 2.2% less likely to report an immediate mental health need and 5.6% less likely to report a ToS mental health need than 2018 respondents. Interestingly, mental health needs increased at ToS compared to the short term period following the fire. Research on wildfires in Australian and Canadian contexts has revealed that those exposed to wildfires displayed symptoms of post-traumatic stress disorder, anxiety, and depression (Belleville et al. 2021; Akter 2023; Bryant et al. 2018; M. R. G. Brown et al. 2019a). These findings are substantiated by California wildfires (Hamideh, Sen, and Fischer 2022; Schulze et al. 2020; A. R. Brown 2022) as well as respondents, who reported feelings of anxiety and trauma related to their wildfire experience. Respondents to open-ended questions reported similar mental health impacts, including anxiety and trauma. Some responses that mentioned mental health also mentioned existing community networks and social media groups, which have been linked with increased community cohesion following wildfires (Ludin, Rohaizat, and Arbon 2019; Townshend et al. 2015). Similar to the physical health needs, respondents seeking mental health help also noted wildfire-related obstacles, saying that:

> *We all have the same stories and no one can get appointments because either counsellors are booked for month, or don't take our insurance or are on prolonged vacations or are dealing with their own losses.*

Ultimately the challenges described by respondents requires further research to understand, with many potential factors that could explain the 5.6% decrease between 2017 and 2018 households ToS mental health which are beyond the scope of the present study. Post-wildfire mental health is a nuanced topic, as evidenced by recent studies on the subject (A. R. Brown 2022; Hamideh, Sen, and Fischer 2022; Chase and Hansen 2021b).

Wildfire smoke, which has been linked with negative physical and mental health impacts (D. P. Eisenman and Galway 2022; Kochi et al. 2012; Black et al. 2017), was frequently mentioned in responses for the week following the wildfires. Given the results presented in Table 2.5, I find that 2017 households were 14.8% less likely to report an immediate air or PPE need, and 1.1% less likely to report a ToS air-related PPE need than 2018 respondents. One common response which mentioned filters, "... ended up purchasing several filters (which were impossible to find in week one) and a pressure washer to tamp down ash in our yard. We needed air!" Responses also frequently mentioned masks in addition to filters, as well as a more general need for improved air quality. While 984 households reported air and PPE related needs, 932 (94.7% of air needs) were short-term. Many of the households that reported air-related needs in the long term at ToS asked about the potential lingering health impacts of wildfire smoke inhalation.

During a disaster, reliable information on available resources can be difficult to obtain, or be out-of-date by the time it reaches households, leading many households to rely on family, friends, neighbors and the internet for information. Over 400 households identified information needs, some reporting that "It was hard to get specific and accurate information and misinformation abounded." Others, seeking information, said that "Since people were not in their homes or at work, our communication networks were compromised." Given the results presented in table 2.6, I find that 2017 households were only slightly less likely to report information needs

than 2018 households, with a 0.7% risk difference for immediate information needs and a 1.2% difference for ToS information needs. Many responses mentioned a need for evacuation warnings, or more consistent guidance through the period immediately post-wildfire. Informational needs coincided with many other needs, including needs for housing as well as physical and mental health needs. Access to both generalized wildfire information, particularly via the internet, raises an additional equity concern for affected communities. Higher-income populations have been found to be more likely than lower-income populations to seek information for health protection when exposed to wildfire smoke (Burke et al. 2022; 2021). Broadband internet has become an increasingly important resource for impacted households, with Benda et al (2020) calling for access to broadband internet's inclusion as a social determinant of health that can link households to healthcare, employment, and other specialized information sources crucial for recovery (Benda et al. 2020).

Ultimately, my hypotheses that needs would not differ was disproven, with all need types aside from physical health needs showing statistically significant differences between the 2017 and 2018 survey cohorts. While households responding to the 2018 wildfires were more likely to report needs than 2017 households, the variation across need types and time categories invite further study. Looking to the future of wildfire research, we can use these findings to better understand how communities differ but face limits with qualitative data, which can lack the explanatory power to understand the causal mechanisms that allow some communities to meet their needs, or meet their needs quicker, than others.

Limitations and future research

There are some limitations of my study that merit consideration. First, this was a retrospective survey, which means that respondents were asked at the time of the survey to

identify their greatest need one week after the wildfire. Some respondents listed a variety of needs rather than individual "greatest" needs, and all listed needs were included. My findings represent responses from 50 California counties but make no claims to broader representativeness of participant households to the broader population at the county or state level. In comparison with the demographics of Butte, Sonoma, and the other represented counties, the percentage of Hispanic respondents was lower than the general population. This likely occurred in part because data collection was through an online survey, which would not have reached those without internet access, regardless of having a Spanish version available. More than 70% of survey respondents were homeowners, but, given recent work highlighting the "property bias" in wildfire scholarship (Chase and Hansen 2021b), future research could intentionally seek out renters' and lower-income resident perspectives.

Conclusion

We need people to understand that this is not 'over' for us. Their lives resumed 'normalcy' within a couple weeks. We are still not normal.

This study compares household needs following the 2017 and 2018 California wildfire seasons. Findings reflect four major need categories: physical needs, air quality, health — both physical and mental — and information. While qualitative coding revealed common needs across the 4,096 households, quantitative analysis revealed that many households had needs that lingered months after the wildfires – as the quotes from respondents above make clear. In their path towards recovery and "normalcy," households reported needs: shelter, medical care, masks and information in the week following the fire and mental health care and housing at the time of the survey. These data reveal that while key differences exist across time categories between households affected by the 2017 wildfires compared to those impacted by the 2018 households,

more work remains to identify contributing factors that can improve or impede recovery, or needs being met.

My findings can help inform health and emergency services providers based on the potential for interventions at different time periods following a wildfire. Physical needs were the most reported, with a variety of basic needs in the short term that consolidated into housing needs in the months following the wildfire. Efforts to address persistent unmet housing needs should take note of potential regional housing availability constraints that can exacerbate the long term impact of wildfire disasters. Responses highlighted obstacles to short-term and long-term access to health care, both mental and physical. Internet access and ways to distribute reliable, current information via the internet also offer potential ways to meet some of the needs reported by surveyed households.

Data Availability

The data cannot be made publicly available upon publication because they contain sensitive personal information.

Funding

Funding for this project was made possible by the National Institute of Environmental Health Sciences: R21ES029693; P30ES023513.

Ethical Approval

All protocols of the ***WHAT-Now, CA? Study*** (Wildfires and Health: Assessing the Toll in Northern California) were reviewed and approved by The University of California, Davis Institutional Review Board before any recruitment or data collection.

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Chapter 3: THE LONG ROAD TO RECOVERY: PREDICTIVE FACTORS FOR POST WILDFIRE HOUSEHOLD NEEDS

Abstract

The 2018 wildfire season in California caused unprecedented damage and loss of life. Recent wildfires in intervening years underscore the threat these hazards pose, and this study seeks to advance our understanding of the different and differential impacts of wildfires using survey data collected from households across the state. 1,800 households reported how long their household had gone without various resources, from essentials (food, water, shelter, etc.,) to other amenities such as internet access, cell phone service, and transportation. One respondent replied for each household. Ordinal logistic regression was used to predict whether and to what extent demographic variables explained differences in duration among households. Potential explanatory variables included age, sex, household size, race, education, and household tenure. Different needs influenced different household characteristics. Age, household size, and race and ethnicity increased the likelihood of a household being more likely to go longer without essential resources. Education beyond a bachelor's degree operated similarly to a protective factor, decreasing the likelihood of a household going without resources. Home tenure, for instance, increased the likelihood that a household would go without water, but decreased the likelihood that a household would go without essentials like food and shelter. By understanding which demographic factors can predict how respondents have unmet needs, this research contributes to wildfire recovery literature and identify specific high-risk subgroups for post-wildfire interventions. Wildfires affect entire communities, not just individual households – and understanding the factors that influence the social vulnerability of these communities is vital.

Introduction

Globally, climate change has contributed to prolonged severe droughts, high ambient temperatures, and dead or dried forested areas, conditions that are highly favorable to wildfires (Williams et al. 2019). Without substantial action, current projections indicate that wildfires will increase in intensity, frequency, and burn area, as evidenced by recent record-breaking wildfires affecting increasingly larger numbers of people across the American West (Williams et al. 2019; Goss et al. 2020; Xu et al. 2020; Westerling et al. 2006; Pyne 2017). Further contributing to wildfire risk are the growing population centers in the Western United States, particularly in Northern California, where development has grown substantially into surrounding wildland and vegetated areas known as the wildland-urban interface (WUI) (Radeloff et al. 2018; Syphard et al. 2007; Li et al. 2022; Heather Anu Kramer et al. 2019). California has the nation's highest number of WUI housing, located mostly along the coastal range and Sierra Nevada mountains, with an estimated five million households – nearly half of all housing units in the state (Li et al. 2022; H. Anu Kramer et al. 2021; Chase and Hansen 2021). The volatile combination of a drier, warmer climate and increasing WUI development means growing numbers of people face unprecedented risks and increased vulnerability to wildfires, which threaten their lives, homes, and health.

However, the consequences of these wildfires are not felt equally. Vulnerability to environmental hazards, or the potential for an individual or community to be harmed (Adger 2006; Intergovernmental Panel On Climate Change (IPCC) 2023), is well studied in disaster research (Adger 2006; Cutter, Mitchell, and Scott 2000; Cutter, Boruff, and Shirley 2003; Morrow 1999), with much recent scholarship exploring wildfire vulnerability (Davies et al. 2018; Kolden and Henson 2019; Lambrou et al. 2023; Modaresi Rad et al. 2023; Palaiologou et al. 2019; Wigtil et al. 2016). In the literature, vulnerability is broken into three aspects: 1)

exposure (i.e., the physical conditions which may increase wildfires), 2) sensitivity (i.e., how susceptible exposed populations are to wildfire impacts), and 3) adaptive capacity (i.e., the ability for populations to both prepare for and recover from wildfires) (Kolden and Henson 2019; Lambrou et al. 2023). Disaster research since Cutter's seminal works (e.g. Cutter et al. 2000, Cutter 2003), has explored broad applications of vulnerability indices, with an emphasis on quantifying exposure, with wildfire probability calculated using the biophysical 'fire triangle' of weather, topography, and fuel (Pyne 2017; Lambrou et al. 2023; Pyne 2021). The efficacy of these vulnerability indices is debated in the literature (Rufat et al. 2019; B. Flanagan et al. 2020; Rufat et al. 2020), with a central argument highlighting disconnect between index vulnerability scores and the realized human costs of disasters. In response, a growing number of studies are emerging that explore social vulnerability to wildfires, which emphasize the social dimensions of wildfires by focusing on community sensitivity and adaptive capacity. They also develop how these facets of vulnerability have been shaped by social, political, and economic conditions.

In the last two decades, contributions to the wildfire literature on social vulnerability have increasingly made contributions to the social dimensions of wildfires, including studies that investigate risk perceptions (Radeloff et al. 2018), evacuation decision-making (Grajdura, Qian, and Niemeier 2021), and post-event displacement (Chase and Hansen 2021). Less attention has been paid to specific demographic factors as they relate to a households' likelihood of experiencing a need. As social vulnerability is increasingly studied in both wildfire (Lambrou et al. 2023), and other disaster research (Wood, Sanders, and Frazier 2021; B. E. Flanagan et al. 2011), it is vital that scholars link the important social components to the differential impacts.

Literature Review

Warm temperatures, low humidity, and strong winds, also known as "Red Flag" conditions, can accelerate the spread of wildfires, as was the case in the November 2018 Camp Fire when the flames spread at nearly an acre a second (Butte County District Attorney et al. 2020; Maranghides et al. 2021) When wildfires spread rapidly, people can be unprepared to make the decision to evacuate or shelter in place (Grajdura, Qian, and Niemeier 2021). Advanced age can impair wildfire response and has been associated with decreased wildfire perception and heightened vulnerability (Melton et al. 2023; Byrnes and Sandoval-Cervantes 2022). Sex also has bearing on evacuation decisions. Men are less likely to evacuate or evacuate later than women (Grajdura, Qian, and Niemeier 2021; Eriksen 2013; Paveglio et al. 2014). Income and other socioeconomic variables including educational attainment have been shown to effect household concern and evacuation status, with higher income households more likely to evacuate (Paveglio et al. 2014; Simon 2017) The length of time a resident has lived in a community may also influence their risk perception of wildfires' potential to threaten their homes or personal health (Mozumder et al. 2008). Those living in an area for longer periods had stronger beliefs around personal safety than those living in the same area for shorter time (Bonaiuto et al. 2016; Blondin 2021; Czaika and Reinprecht 2022). Furthermore, successful fire prevention efforts can contribute to a false sense of security that future fires will be quickly and successfully contained, and may alter evacuation behavior (McFarlane, McGee, and Faulkner 2011; Dupey and Smith 2019).

Whether a household can evacuate is another pressing issue. While automobile travel is central to participating in many aspects of American life, households may not have or maintain sufficient transportation options for all household members in a disaster scenario. While more rural communities may be more likely to rely on personal vehicles than urban populations, the built environment in rural WUI environments may also limit suitable evacuation routes or play a

role in household evacuation decisions (Grajdura, Qian, and Niemeier 2021). Youth and elderly populations are generally limited in resources and self-sufficiency and may face obstacles as they move out of harm's way (Toledo et al. 2018). Elderly and people with disabilities may have mobility constraints or concerns, increasing the burden of care during a wildfire evacuation (Masri et al. 2021; Thompson, Garfin, and Silver 2017). Physical and cognitive disabilities, regardless of age, can also lower compliance with mandatory evacuation orders (Thompson, Garfin, and Silver 2017). For communities with higher elderly populations, especially in rural areas, evacuation can be hampered by increased social and geographic isolation (Grajdura, Qian, and Niemeier 2021; Mozumder et al. 2008; Wong, Broader, and Shaheen 2020).

Communities often require basic needs like food, clothing, and stable housing following a wildfire. Prior research has found that populations with lower resources are less able to meet these basic needs, or recover more slowly, after a disaster (Clay et al. 2018; Masri et al. 2021). Often, impacted communities may experience interrupted service from utilities such as gasoline, water, and electricity, which can prolong evacuation and delay community recovery. In addition to the direct health sequalae such as injuries (Cameron et al. 2009; Cleland et al. 2011; Shusterman, Kaplan, and Canabarro 1993), exacerbation of existing chronic illness (Grant and Runkle 2022; Rosenthal, Stover, and Haar 2021), and deteriorating mental health outcomes (Silveira et al. 2021), households can experience a range of enduring needs. In the context of our survey, these needs included essentials such as food, water, shelter, electricity and clothing, in addition to other needs like cell service, internet access, transportation, and adequate money. Impacted households may lose their home to a wildfire or may be evacuated for extended periods of time as they rebuild. While essentials are often provided in the days following disasters, long-term resources may not be universally available.

Disasters, including wildfires, disproportionately impact poorer households due to a combination of factors such as homeownership, a lack of property insurance, unstable employment, and fewer economic resources to replace any losses or relocate elsewhere (Davies et al. 2018; Lambrou et al. 2023; Palaiologou et al. 2019; Byrnes and Sandoval-Cervantes 2022). Mass displacement can contribute to a tighter market as households seek out short- and long-term housing, stressing an already burdened housing stock and posing additional barriers for displaces households who are forced to compete for the limited vacant housing or migrate (Chase and Hansen 2021; Hori and Schafer 2010). The housing recovery process of displaced populations highlights inequities across different socioeconomic groups affected by wildfires, with higher-income households more likely to be able to migrate or rebuild to resolve their housing needs in the short-term (Chase and Hansen 2021). While rebuilding is common, particularly in WUI areas following a wildfire, short term housing supply constraints in rural communities and long-term financial costs associated with rebuilding and insuring at-risk households favor households with greater access to financial resources (Alexandre et al. 2014; H. Anu Kramer et al. 2021). When wildfires threaten the economic stability (Wang et al. 2021), physical wellbeing (Shusterman, Kaplan, and Canabarro 1993), and health care systems (Rosenthal, Stover, and Haar 2021) of impacted communities, the most vulnerable can lose jobs, be exposed to harm, and face greater barriers when accessing healthcare.

Addressing the wide array of needs that arise after wildfires and other disasters requires research like needs assessments, which allows households to communicate the different and dynamic impacts of wildfires to community leaders, government officials, and researchers. Existing scholarship which connects social vulnerability to concrete needs following wildfires is limited. Such assessments offer a wider perspective of post-disaster contexts and can improve

understanding of the dynamic needs of affected households while providing opportunities for emergency response organizations to incorporate strategic planning and resource deployment. This survey highlights nine factors which contribute to enduring needs for households affected by the 2018 wildfires. While there have been studies on specific disaster outcomes such as mental health effects and the role of community cohesion and resilience, the research presented here addresses a gap in research that operationalizes social vulnerability by exploring how long households go without essentials.

Purpose of the Study

This research, which examines factors associated with the needs of households impacted by the 2018 Northern California wildfires is part of the "***W***ildfires and ***H***ealth: ***A***ssessing the ***T***oll in ***No***rthern ***Ca***lifornia Study", abbreviated as the: WHAT Now, CA? Study. The findings from this work provide information that can be useful to county health departments, preparedness and response agencies, medical providers, policy makers, and non-profit organizations to prepare for and respond to future wildfire threats. In this study, I explore the vulnerability of households affected by the 2018 Northern California wildfires by analyzing whether households reported going without adequate clothing, cellular phone service, electricity, enough money to cover living expenses, food, internet access, safe drinking water, shelter, and transportation. I use the data reported by the respondent households in the WHAT Now, CA? Study to identify social demographics commonly used in wildfire and disaster research at the scale of households and communities (Cutter, Boruff, and Shirley 2003; Davies et al. 2018; Wigtil et al. 2016; B. E. Flanagan et al. 2011; Yu et al. 2021). Socio-economic status indicators, including homeownership, educational attainment, race, and age can often influence wildfire preparation and mitigation (Chase and Hansen 2021; Davies et al. 2018; Melton et al. 2023; Méndez, Flores-Haro, and Zucker 2020). These social attributes are factors associated with increased social

vulnerability to wildfires and describe a households' capacity to respond to and/or escape from an disaster (e.g., too young or too old, lack of vehicle), to absorb losses to wildfire impacts (e.g., loss of employment, housing, or insufficient savings), and to navigate the differential impacts that may persist in the weeks to months following a disaster. From the literature, I formed hypotheses A.

Hypothesis A: That the same variables commonly used for vulnerability indices (age, sex, race/ethnicity, education, etc.,), would predict how long a household would experience needs.

This research contributes to the literature on wildfires and social vulnerability by focusing on the ways in which the different and differential impacts of wildfires affect households. We use the results to inform our recommendations on future mitigation and recovery efforts. First, we describe our data, variables, and methods used to test our research hypotheses. Then we present the results of these findings and discuss the major implications of our results for the broader social vulnerability literature and the wildfire research on recovery. We conclude with a summary of our findings and suggestions for future research.

Data and Methods

Data

Data for this survey were collected between February 2019 and March 2020 via an online Qualtrics survey deployed to eligible households, defined as being in counties impacted by the 2018 Northern California wildfires or by the smoke produced by those wildfires. A large convenience sample was enrolled, in which 1,887 households participated. Survey respondents answered questions on behalf of their household. Respondents included anyone over the age of 18 in households with no further restriction, as the goal of the broader WHAT NOW CA? survey was to capture the experiences of a wide swath of persons, including those impacted by wildfire smoke. The survey was informed by previously deployed post-disaster survey instruments, by

reported experiences in the media (social and traditional), and by consultations with county health department epidemiologists and public health officers on question formulation and content. English and Spanish language versions were available. Spanish versions were translated by native speakers of Mexican Spanish who were also bilingual and reviewed extensively by native Spanish speakers at one of the county health departments. This study was approved by the University of California, Davis, Institutional Review Board (1R21ES029693; 1P30ES023513.).

Recruitment occurred using various media, including print, radio, and substantial social media efforts to reach a broad public. Survey participants were recruited from counties with wildfires and explicitly included others exposed to the smoke from those wildfires or not exposed to the smoke, to ensure exposure contrasts. These counties included: Butte, Shasta, Sacramento, Siskiyou, Sonoma, Ventura, Yolo, Sutter, Yuba, and Placer. Nearly half (48%) of surveyed households were from Butte County. The survey was open from 4 to 12 months post-fire, with the average survey completed five and a half months after the wildfire 80% (1,534) of respondents participated before the end of July 2019. Because the survey was open from about four to nine months post-wildfire these statistics reflect that the majority of respondents completed in the first four months that the survey was available. Survey questions included the respondent's housing tenure, duration of residence there, sociodemographic characteristics, physical and emotional losses, health conditions and symptoms, and unmet needs. This study focuses on the questions which asked each respondent to list how long they had gone without nine types of household needs as a result of wildfire. Participants selected how long they and their household had gone without one or more of the following nine needs: adequate clothing, cellular phone service, electricity, enough money to cover living expenses, food, internet access, safe drinking water, shelter, and transportation. If a household did not go without one or more

need, they selected that they were "never without" that need. Other parts of the survey covered evacuation experiences during the wildfires, sociodemographic characteristics, losses (home, source of income, family members or close friends, pets) newly occurring health symptoms—both physical and mental—as well as pre-existing conditions before the fires.

Dependent Variables

We asked respondents to identify how long they had unmet household needs. The nine needs (cell service, clothing, electricity, food, internet, money, shelter, transportation, and water) were each used as a dependent variable in separate ordinal logistic regressions. Many of these needs were closely linked. For instance, functioning electricity can determine internet access or cell phone connectivity. The survey allowed respondents to select from nine potential categories: (1) Never without, (2) Less than 1 day, (3) 1 day, (4) 2 to 6 days, (5) 1 to 2 weeks, (6) 3 weeks to 1 month without, (7) greater than 1 month, (8) Still without, or (9) Don't know. Figures 2-10 (below), report the percent of respondent households that Never went without (1), went up to one week without (2 through 4), or went one week to several months without (5 through 8) a given need. Overall, 91.6% (n=1729) of households reported at least one category that they never went without. Across all response types, the "never without" category was the most common, with an average of 75.2% of respondents across all nine needs questions. The percentage of households with needs varied greatly, from 8.2% of households reporting unmet transportation needs to 44.8% that went without internet. Category 1, "never without," formed its own variable while categories 2 - 4 "Less Than One Day Without," through "2 to 6 Days Without" formed a second group of respondents who experienced needs for less than one week. Respondents who reported a need that persisted more than one week up and including those that were "Still Without" a need at the time of the survey (categories 5 - 8), were grouped into a new variable called "weeks without." In the ordinal logistic regression model, the ordinal variable (where "Weeks Without"

was held out and compared to those households "Up to One Week Without" and those "never without") was used as the dependent variable for each of the nine needs. I ran nine ordinal regression models, one for each need, to better understand the effects of the independent predictor variables on overall wildfire impacts.

Independent Variables

In addition to the household-level duration questions, the survey included a range of socio-demographic characteristics that are frequently used in disaster research (e.g., Cutter 2003, Davies et al. 2018) (Cutter, Boruff, and Shirley 2003; Davies et al. 2018). Independent variables included age, sex, household size, educational attainment, race and ethnicity, home tenure (owned or rented), evacuation status, employment status, and how long the respondent had lived in that house. While certain independent variables (household size and home tenure) applied to the entire household, the survey respondent was asked to provide information for themselves and other household members. Age was recorded as a continuous variable, entered as age since their last birthday. Sex was asked as a binary (male/female). Household size represented the number of household members, including children under 18. Educational attainment was only provided for adults and asked about the highest level of education each respondent had completed. Survey respondents were asked to indicate both race (Asian, Black, Native American etc.,) and ethnicity (Hispanic or Non-Hispanic). Home tenure information indicated whether the respondent's household was owned, rented, or it was a rent-free living arrangement. Respondents were asked to provide employment status information on behalf of the entire household, including retirees, students, and seasonal employment. Duration in the household was specific to the respondent and provided a range of options from "Less than 1 month" to "Over 12 years."

Statistical Modelling

An ordinal regression model quantifies the strength of the association between a set of independent explanatory variables and the dependent variable. A description of the dependent and the independent variables follows. All statistical modeling was performed using version 29 of SPSS.

Results

Of the 1887 respondents that participated in the broader survey, over 95% (1,800) answered one or more of the needs duration questions. Households that did not respond to any of the key questions were excluded entirely from the analysis, while households that did not answer one or more of the key questions were excluded from the model analysis only for the unanswered question(s). Table 3.1 contains descriptive statistics of the sample. Demographically, respondents were predominately white, (90.7%), female (77.7%), and homeowners (71.3%). While respondents participated from 48 California counties, Butte County households made up 47.8% of the 1,800 households with reported duration needs.

	Total Households (n=1887) *N* (%)	Households with a reported need (n=1800) *N* (%)	Households without a reported need (n=87) *N* (%)
Sex			
Female	1445 (76.58%)	1399 (77.72%)	46 (52.87%)
Male	277 (14.68%)	274 (15.22%)	3 (3.45%)
Missingness	165 (8.74%)	127 (7.06%)	38 (43.68%)
Age (yrs)			
18-35	362 (19.2%)	355 (19.72%)	7 (8.05%)
36-45	323 (17.1%)	320 (17.78%)	3 (3.45%)
46-55	301 (16.0%)	292 (16.22%)	9 (10.34%)
56-64	357 (18.9%)	337 (18.72%)	20 (22.99%)
65 or older	208 (11.0%)	170 (9.44%)	38 (43.68%)
Missingness	336 (17.8%)	326 (18.11%)	10 (11.49%)
Race			
White	1449 (76.8%)	1410 (78.3%)	39 (44.8%)
African American/Black	2 (0.1%)	2 (0.1%)	0 (0.0%)
Native American	19 (1.0%)	18 (1.0%)	1 (1.1%)
Asian/Pacific Islander	14 (0.7%)	13 (0.7%)	1 (1.1%)

Multiple races	100 (5.3%)	99 (5.5%)	1 (1.1%)
Other	14 (0.7%)	13 (0.7%)	1 (1.1%)
Missingness	289 (15.3%)	245 (13.6%)	44 (50.6%)
Educational level			
High school graduate or equivalent	125 (6.6%)	124 (6.9%)	1 (1.1%)
Some college, but no degree	422 (22.4%)	410 (22.8%)	12 (13.8%)
Trade or Associate's degree	285 (15.1%)	278 (15.4%)	7 (8.0%)
Bachelor's degree	445 (23.6%)	432 (24.0%)	13 (14.9%)
Graduate degree	336 (17.8%)	327 (18.2%)	9 (10.3%)
Missingness	274 (14.5%)	229 (12.7%)	45 (51.7%)
Housing status			
Homeowner	1350 (71.5%)	1284 (71.3%)	66 (75.86%)
Renter	501 (26.6%)	480 (26.7%)	21 (24.14%)
Missingness	36 (1.9%)	36 (2.0%)	0 (0.0%)

Table 3.1: Descriptive Summary statistics of total household with reported needs and households with reported needs. Discrepancies between reported demographics and population sizes are due to not all survey respondents answering both needs and demographics questions.

Ordinal Logistic Regression Results

A series of ordinal logistic regression models were performed to investigate how well respondent sociodemographic variables (age, sex, race, length of residence, employment, and education) and household characteristics (home tenure, household size) predicted post-wildfire needs (i.e, adequate clothing, cellular phone service, electricity, enough money to cover living expenses, food, internet access, safe drinking water, shelter, and transportation). Nine separate models (one for each of the needs) were run, with each model including seven predictors and allowing for simultaneous entry of all independent variables. The outcome variable for each model was how long (never, up to one week, or more than one week) a respondent reported going without a key need. All assumptions of logistic regression (independent observations, no multicollinearity, were met. Significant variables and their exponentiated estimates are presented in table 3.2.

	Electricity	Internet	Cell service	Food	Water	Shelter	Clothing	Transport	Finances
Age 65+	0.77*	0.78†	0.93	0.81	0.85	0.83	1.47†	0.96	1.08
Male	1.03	0.86	1.17	1.50*	0.93	1.58*	0.98	1.64*	0.95
HH Size	0.94†	1.00	0.97	0.94	0.99	1.08	1.04	1.08	1.18***
Evacuated	5.53**	8.28***	4.41***	10.77***	10.28***	25.69***	58.73***	7.12***	12.26***
Homeowner	1.30*	1.28*	1.20	0.67*	1.30†	0.74†	0.84	0.63*	0.34***
White	0.98	0.91	0.94	1.35	0.73*	1.01	1.59**	1.02	1.07
Education	0.71***	0.64***	0.67***	0.50***	0.73*	0.80	0.54***	0.48***	0.41***

Notes: † $p < 0.1$, * $p<0.05$, ** $p<0.01$, *** $p<0.001$

Table 2: Exponentiated Estimates Of Ordinal Regression Models Predicting Longer (Weeks – Months) Need Duration

Electricity

A test of the full model for electricity needs was statistically significant ($\chi 2 = 310.39$, degrees of freedom [df] = 7, $p < 0.001$). Nagelkerke's pseudo R2 indicates that the model accounted for 18.9% of the total variance of the outcome. Five of the predictor variables, age, household size, evacuation status, homeownership, and educational attainment were statistically significant predictors of group membership (going at least one week without electricity).

Interpreting Table 3.3 (below), the model shows that respondents 65 or older were less likely (.77) to go longer without electricity (i.e., more than one week) than respondents younger than 65. There was also a similar decrease (.71) in the odds of going longer without electricity for respondents who had a higher education (bachelor's degree or higher) compared to those without a bachelor's degree. An increase in household size was linked to a slight (0.94) decrease in the odds of going longer than one week without electricity, with larger households less likely to go without. Homeowners were 1.3 times more likely to report extended electricity needs. Respondents who evacuated due to the wildfires were 5.5 times more likely to report electricity needs that lasted a week or more.

Electricity	Estimate (S.E)	EXP (B) OR	Wald	95% Confidence Interval Lower, Upper
Age 65+ *	-0.267 (0.136)	0.77	3.866	-0.532, -0.001
Male	0.029 (0.139)	1.03	0.043	-0.244, 0.302
Household Size†	-0.062 (0.035)	0.94	3.11	-0.132, 0.007
Evacuated ***	1.71 (0.108)	5.53	249.971	1.498, 1.922
Homeowner*	0.266 (0.115)	1.30	5.347	0.041, 0.492
White	-0.024 (0.127)	0.98	0.036	-0.273, 0.225
Education beyond BA/BS**	-0.336 (0.106)	0.71	10.149	-0.543, -0.129
$\chi 2$ *** (df)	310.39 (7)			
Nagelkerke	0.189			

Notes: N=1782, † $p< 0.1$, * $p<0.05$, ** $p<0.01$, *** $p<0.001$

Table 3.3. Ordinal Regression Results Explaining Household Duration Without Electricity

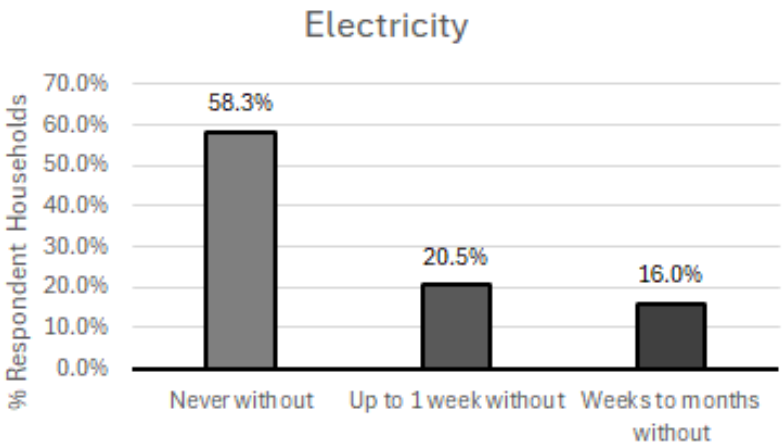

Figure 3.2 is a bar chart presenting the percent distribution of households with electricity needs, among three time periods, "Never without", "Up to 1 week without", and "Weeks to months without.

Internet

A test of the full model for internet needs was statistically significant ($\chi 2 = 469.83$, degrees of freedom [df] = 7, $p < 0.001$). Nagelkerke's pseudo R2 indicates that the model accounted for 27.5% of the total variance of the outcome. Age, evacuation status, homeownership, and educational attainment were statistically significant predictors of group

membership (going at least one week without internet). Age, defined as being 65 or older, and higher educational attainment (a bachelor's degree or higher) were associated with lower odds of going longer without internet. Evacuation and home ownership both increased the odds of a household going weeks to months without internet.

Interpreting Table 3.4 (below), the model shows that respondents 65 or older were less likely (.78) to go longer without internet (i.e., more than one week). There was also a decrease (.64) in the odds of going without internet access for respondents who had a higher education (bachelor's degree or higher) compared to those without a bachelor's degree. Homeowners were 1.3 times more likely to report extended internet needs. Respondents who evacuated due to the wildfires were 8.2 times more likely to report internet needs that lasted a week or more.

Internet	Estimate (S.E)	EXP (B)	Wald	95% Confidence Interval Lower, Upper
Age 65+ †	-.251, (.136)	0.78	3.402	-.518, .016
Male	-.152, (.141)	0.86	1.162	-.427, .124
Household Size	.004, (.035)	1.00	.015	-.064, .072
Evacuated ***	2.114, (.110)	8.2	368.087	1.898, 2.330
Homeowner*	.248, (.115)	1.28	4.654	.023, .474
White	-.094, (.126)	0.91	.551	-.342, .154
Education beyond BA/BS***	-.441, (.106)	0.64	17.290	-.649, -.233
$\chi 2$ *** (df)	469.83 (7)			
Nagelkerke	.275			

Notes: N=1734, † $p< 0.1$, * $p<0.05$, ** $p<0.01$, *** $p<0.001$

Table 3.4. Ordinal Regression Results Explaining Household Duration Without Internet

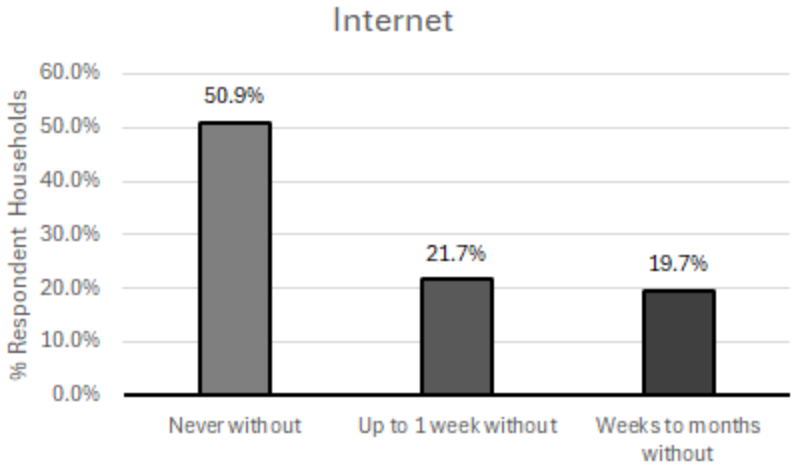

Figure 3.3 is a bar chart presenting the percent distribution of households with internet needs over three time periods: "Never without," "Up to 1 week without," and "Weeks to months without."

Cell Service

A test of the full model for cell phone service needs was statistically significant ($\chi 2 = 211.20$, degrees of freedom [df] = 7, $p < 0.001$). Nagelkerke's pseudo R2 indicates that the model accounted for 14.1% of the total variance of the outcome. Evacuation status and educational attainment were statistically significant predictors of group membership (going at least one week without cell phone service). Higher educational attainment (a bachelor's degree or higher) was associated with lower odds of going longer without cell service while evacuating increased the odds of a household going weeks to months without cell service.

Interpreting Table 3.5 (below), we see that there was a decrease (.67) in the odds of going without cell service for respondents who had a higher education (bachelor's degree or higher). Respondents who evacuated due to the wildfires were 4.4 times more likely to report cell service needs that lasted a week or more.

Cell Service	Estimate (S.E)	EXP (B)	Wald	95% Confidence Interval Lower, Upper
Age 65+	-.075, (.143)	0.93	.275	-.356, .206
Male	.161, (.147)	1.17	1.214	-.126, .449
Household Size	-.028, (.037)	0.97	.551	-.100, .045
Evacuated ***	1.484, (.116)	4.41	163.721	1.257, 1.712
Homeowner	.182, (.123)	1.20	2.211	-.058, .422
White	-.058, (.134)	0.94	.186	-.321, .205
Education beyond BA/BS***	-.405, (.113)	0.67	12.814	-.627, -.183
$\chi 2$ *** (df)	211.20 (7)			
Nagelkerke	.141			

Notes: N=1749, † $p< 0.1$, * $p<0.05$, ** $p<0.01$, *** $p<0.001$

Table 3.5. Ordinal Regression Results Explaining Household Duration Without Cell Service

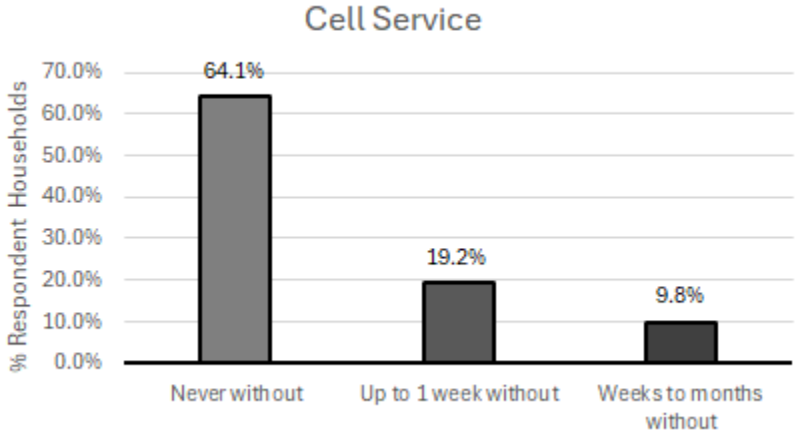

Figure 3.4 is a bar chart presenting the percent distribution of households with cell service needs, among three time periods, "Never without", "Up to 1 week without", and "Weeks to months without."

Water

A test of the full model for safe drinking water needs was statistically significant ($\chi 2$ = 315.61, degrees of freedom [df] = 7, $p < 0.001$). Nagelkerke's pseudo R2 indicates that the model accounted for 22.3% of the total variance. Four of the predictor variables, educational

attainment, race, homeownership, and evacuation status were statistically significant predictors of group membership (needing water for a week or more). Race, defined as respondents identifying as White (excluding those who identified as White and Hispanic), and higher educational attainment (a bachelor's degree or higher) were associated with lower odds of going longer without water. Evacuation and home ownership both increased the odds of a household going weeks to months without water.

Interpreting Table 3.6 (below), the model shows that White non-Hispanic respondents were less likely (.73) to go longer without water needs (i.e., more than one week). There was also a decrease (.73) in the odds of going longer without water access for respondents who had a higher education (bachelor's degree or higher) compared to those without a bachelor's degree. Homeowners were 1.3 times more likely to report extended water needs. Respondents who evacuated due to the wildfires were 10.3 times more likely to report water needs that lasted a week or more.

Water	Estimate (S.E)	EXP (B)	Wald	95% Confidence Interval Lower, Upper
Age 65+	-.160, (.163)	0.85	.966	-.479, .159
Male	-.068, (.173)	0.93	.153	-.406, .271
Household Size	-.011, (.042)	0.99	.072	-.093, .071
Evacuated ***	2.330, (.163)	10.28	204.752	2.011, 2.650
Homeowner†	.261, (.143)	1.30	3.357	-.018, .541
White*	-.314, (.153)	0.73	4.224	-.614, -.015
Education beyond BA/BS*	-.317, (.130)	0.73	5.964	-.571, -.063
$\chi 2$ *** (df)	315.61 (7)			
Nagelkerke	.223			

Notes: N=1739, † $p < 0.1$, * $p<0.05$, ** $p<0.01$, *** $p<0.001$

Table 3.6. Ordinal Regression Results Explaining Household Duration Without Water

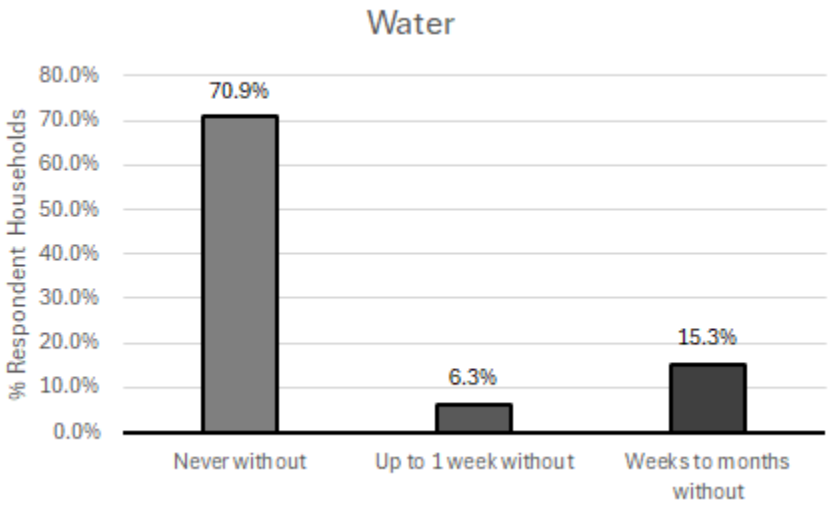

Figure 3.5 is a bar chart presenting the percent distribution of households with Water needs over three time periods: "Never without," "Up to 1 week without," and "Weeks to months without."

Food

A test of the full model for food needs was statistically significant ($\chi 2 = 206.85$, degrees of freedom [df] = 7, $p < 0.001$). Nagelkerke's pseudo R2 indicates that the model accounted for 18.7% of the total variance. Four of the predictor variables, educational attainment, sex, homeownership, and evacuation status were statistically significant predictors of group membership (needing food for a week or more). Homeownership and higher educational attainment (a bachelor's degree or higher) were associated with lower odds of going longer without food. Sex, defined as respondents identifying as male, and evacuation both increased the odds of a household reporting food access issues.

Interpreting Table 3.7 (below), the model shows that respondents who were homeowners were less likely (.67) to go longer without food needs (i.e., more than one week). There was also a decrease (.50) in the odds of going without food access for respondents who had a higher

education (bachelor's degree or higher) compared to those without a bachelor's degree. Male respondents were 1.5 times more likely to report extended food needs. Respondents who evacuated due to the wildfires were 10.8 times more likely to report food access needs that lasted a week or more.

Food	Estimate (S.E)	EXP (B)	Wald	95% Confidence Interval Lower, Upper
Age 65+	-.209, (.209)	0.81	1.001	-.618, .200
Male*	.407, (.200)	1.50	4.157	.016, .798
Household Size	-.065, (.054)	0.94	1.454	-.171, .041
Evacuated ***	2.377, (.238)	10.77	100.100	1.911, 2.843
Homeowner*	-.406, (.167)	0.67	5.929	-.733, -.079
White	.300, (.206)	1.35	2.127	-.103, .703
Education beyond BA/BS***	-.703, (.172)	0.50	16.779	-1.039, -.367
$\chi 2$ *** (df)	206.85 (7)			
Nagelkerke	.187			

Notes: N=1749, † $p< 0.1$, * $p<0.05$, ** $p<0.01$, *** $p<0.001$

Table 3.7. Logistic Regression Results Explaining Household Duration Without Adequate Food

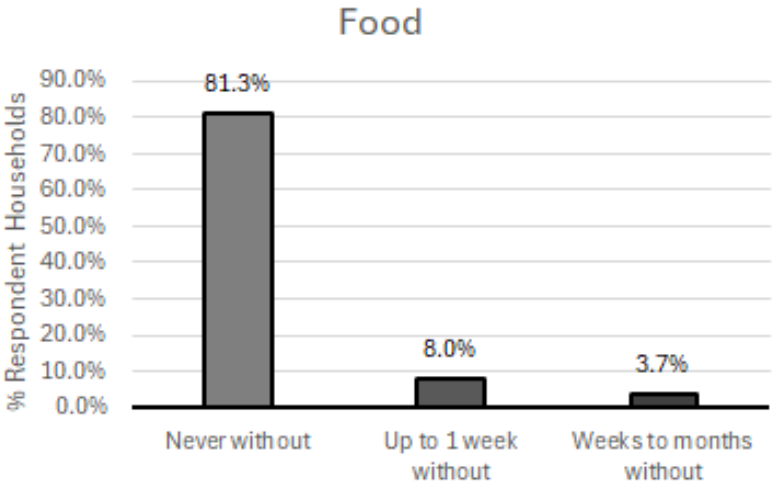

Figure 3.6 is a bar chart presenting the percent distribution of households with food needs, among three time periods, "Never without", "Up to 1 week without", and "Weeks to months without."

Shelter

A test of the full model for shelter needs was statistically significant ($\chi 2 = 285.76$, degrees of freedom [df] = 7, $p < 0.001$). Nagelkerke's pseudo R2 indicates that the model accounted for 23.7% of the total variance. Three of the predictor variables, sex, homeownership, and evacuation status were statistically significant predictors of group membership (needing shelter for a week or more). Homeownership was associated with lower odds of going longer without shelter. Sex, defined as respondents identifying as male, and evacuation both increased the odds of a household reporting shelter access issues.

Interpreting Table 3.8 (below), the model shows that respondents who were homeowners were less likely (.74) to go longer without shelter needs (i.e., more than one week). Male respondents were 1.6 times more likely to report extended shelter needs than female respondents. Respondents who evacuated due to the wildfires were 25.7 times more likely to report shelter access needs that lasted a week or more.

Shelter	Estimate (S.E)	EXP (B)	Wald	95% Confidence Interval Lower, Upper
Age 65+	-.188, (.201)	0.83	.881	-.581, .205
Male*	.456, (.193)	1.58	5.609	.079, .834
Household Size	.076, (.048)	1.08	2.444	-.019, .170
Evacuated ***	3.246, (.301)	25.69	116.083	2.656, 3.837
Homeowner†	-.306, (.162)	0.74	3.561	-.623, .012
White	.011, (.187)	1.01	.004	-.356, .379
Education beyond BA/BS	-.228, (.157)	0.80	2.115	-.535, .079
$\chi 2$ *** (df)	285.76 (7)			
Nagelkerke	.237			

Notes: N=1741, † $p< 0.1$, * $p<0.05$, ** $p<0.01$, *** $p<0.001$

Table 3.8. Logistic Regression Results Explaining Household Duration Without Adequate Shelter.

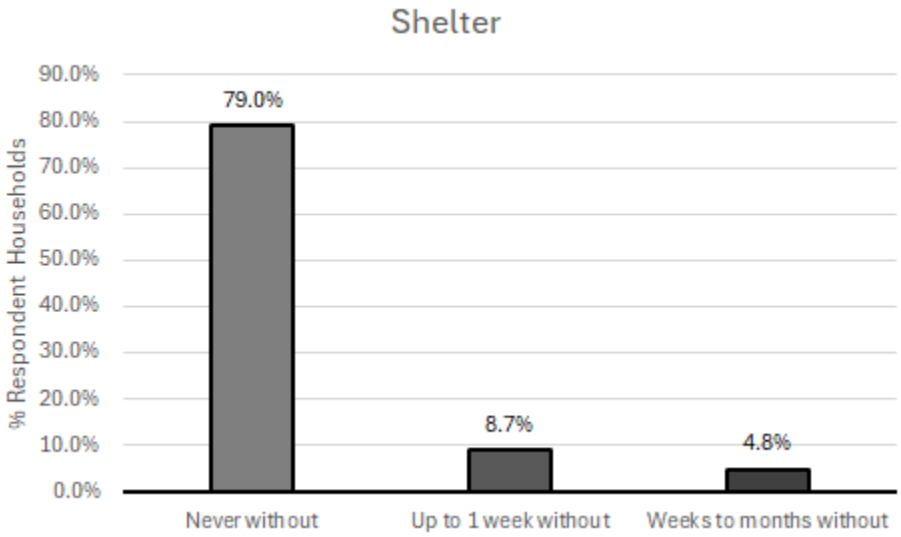

Figure 3.7 is a bar chart presenting the percent distribution of households with shelter needs, among three time periods, "Never without", "Up to 1 week without", and "Weeks to months without."

Clothing

A test of the full model for clothing needs was statistically significant ($\chi 2 = 710.65$, degrees of freedom [df] = 7, $p < 0.001$). Nagelkerke's pseudo R2 indicates that the model accounted for 41.9% of the total variance. Four of the predictor variables, age, race, educational attainment, and evacuation status were statistically significant predictors of group membership (needing clothing for a week or more). Higher educational attainment (a bachelor's degree or higher) was associated with lower odds of going longer without adequate clothing. Age (65 years or older, Race, defined as respondents identifying as White (excluding those who identified as White and Hispanic), and evacuation increased the odds of a household going weeks to months without adequate clothing.

Interpreting Table 3.9 (below), the model shows that respondents who had a bachelor's degree or higher were less likely (.54) to go longer without adequate clothing (i.e., more than one week). Respondents aged 65 and older were 1.5 times more likely to report extended clothing

needs than respondents under 65. Respondents identifying as White were 1.6 times more likely to report extended clothing needs. Respondents who evacuated due to the wildfires were 58.7 times more likely to report clothing access needs that lasted a week or more.

Clothing	Estimate (S.E)	EXP (B)	Wald	95% Confidence Interval Lower, Upper
Age 65+ †	.386, (.158)	1.47†	5.980	.077, .696
Male	-.020, (.173)	0.98	.013	-.358, .319
Household Size	.037, (.042)	1.04	.775	-.045, .119
Evacuated ***	4.073, (.269)	58.73	229.657	3.547, 4.600
Homeowner	-.180, (.140)	0.84	1.651	-.456, .095
White**	.462, (.164)	1.59	7.938	.141, .784
Education beyond BA/BS***	-.607, (.131)	0.54	21.564	-.863, -.351
$\chi 2$ *** (df)	710.65 (7)			
Nagelkerke	.419			

Notes: N=1755, † $p< 0.1$, * $p<0.05$, ** $p<0.01$, *** $p<0.001$

Table 3.9. Logistic Regression Results Explaining Household Duration Without Adequate Clothing

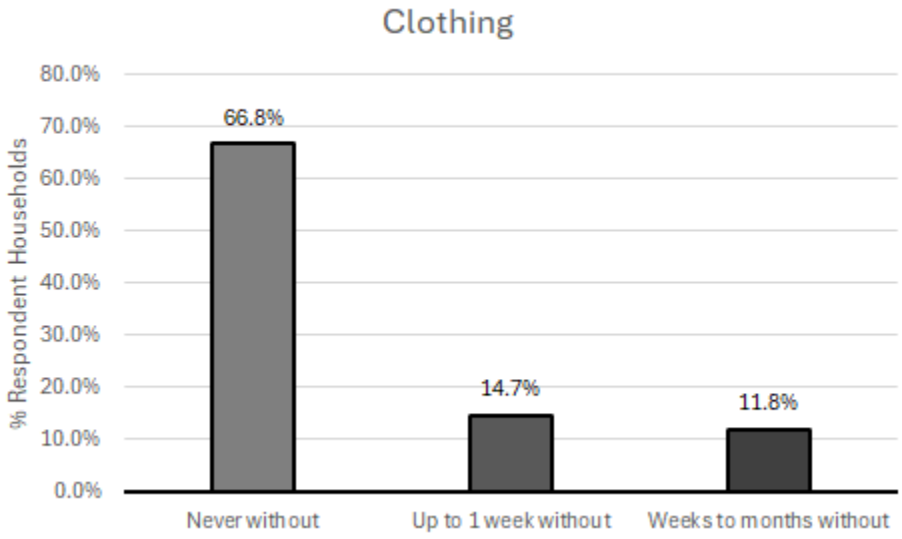

Figure 3.8 is a bar chart presenting the percent distribution of households with Clothing needs over three time periods: "Never without," "Up to 1 week without," and "Weeks to months without."

Transport

A test of the full model for transportation needs was statistically significant ($\chi 2 = 114.92$, degrees of freedom [df] = 7, $p < 0.001$). Nagelkerke's pseudo R2 indicates that the model accounted for 13.0% of the total variance. Four of the predictor variables, sex, homeownership, educational attainment, and evacuation status were statistically significant predictors of group membership (needing transportation for a week or more). Higher educational attainment (a bachelor's degree or higher) and homeownership were associated with lower odds of going longer without adequate transportation. Age (65 years or older), Sex, (respondents identifying as Male), and Evacuation increased the odds of a household going weeks to months without adequate transportation.

Interpreting Table 3.10 (below), the model shows that respondents who had a bachelor's degree or higher were less likely (.48) to go longer without adequate transportation (i.e., more than one week). Homeowners were less likely (.63) to report lasting transportation needs. Respondents identifying as male were 1.6 times more likely to report extended transportation needs than female respondents. Respondents who evacuated due to the wildfires were 7.1 times more likely to report transportation access needs that lasted a week or more.

Transportation	Estimate (S.E)	EXP (B)	Wald	95% Confidence Interval Lower, Upper
Age 65+	-.037, (.255)	0.96	.021	-.536, .462
Male*	.496, (.230)	1.64	4.672	.046, .946
Household Size	.080, (.058)	1.08	1.914	-.033, .194
Evacuated ***	1.963, (.260)	7.12	57.091	1.454, 2.472
Homeowner*	-.462, (.194)	0.63	5.673	-.842, -.082

White	.017, (.227)	1.02	.006	-.428, .463
Education beyond BA/BS***	-.737, (.214)	0.48	11.843	-1.157, -.317
$\chi 2$ *** (df)	114.92 (7)			
Nagelkerke	.130			

Notes: N=1745, † $p< 0.1$, * $p<0.05$, ** $p<0.01$, *** $p<0.001$

Table 3.10. Logistic Regression Results Explaining Household Duration Without Transportation.

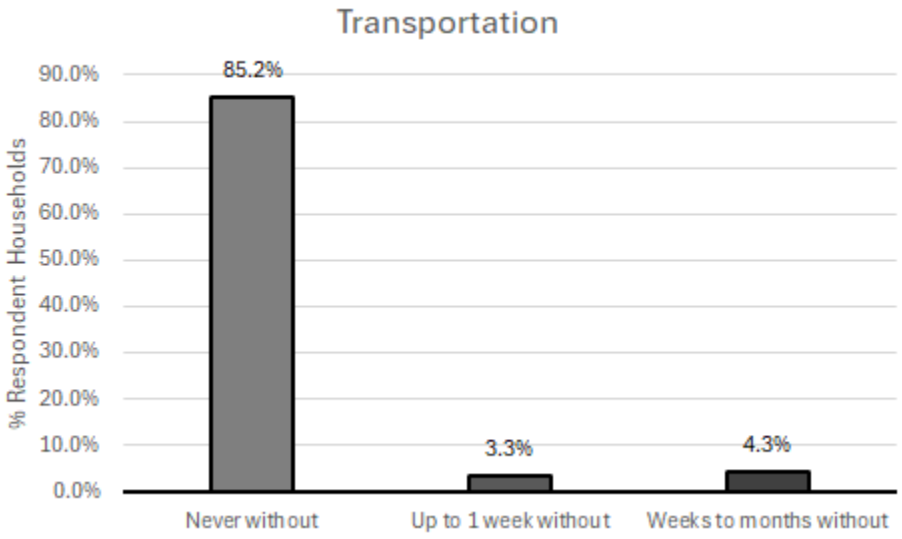

Figure 3.9 is a bar chart presenting the percent distribution of households with transportation needs over three time periods: "Never without," "Up to 1 week without," and "Weeks to months without."

Money

A test of the full model for financial needs was statistically significant ($\chi 2 = 419.99$, degrees of freedom [df] = 7, $p < 0.001$). Nagelkerke's pseudo R2 indicates that the model accounted for 29.1% of the total variance. Four of the predictor variables, Household size, homeownership, educational attainment, and evacuation status were statistically significant predictors of group membership (having adequate financial resources for a week or more). Higher educational attainment (a bachelor's degree or higher) and evacuating were associated with lower odds of going longer without adequate financial resources. Household size,

Homeownership, and evacuation increased the odds of a household going weeks to months without adequate financial resources.

Interpreting Table 3.11 (below), the model shows that respondents who had a bachelor's degree or higher were less likely (.41) to go longer without adequate financial (i.e., more than one week). Homeowners were much less likely (.34) to report lasting financial needs. Larger households were 1.2 times more likely to report extended financial needs per additional household member. Respondents who evacuated due to the wildfires were 12.3 times more likely to report financial access needs that lasted a week or more.

Money	Estimate (S.E)	EXP (B)	Wald	95% Confidence Interval Lower, Upper
Age 65+	.081, (.179)	1.08	.203	-.270, .431
Male	-.056, (.185)	0.95	.090	-.418, .307
Household Size***	.162, (.042)	1.18	14.862	.080, .245
Evacuated ***	2.506, (.178)	12.26	197.397	2.157, 2.856
Homeowner ***	-1.067, (.139)	0.34	58.465	-1.340, -.793
White	.070, (.163)	1.07	.183	-.249, .389
Education beyond BA/BS***	-.897, (.146)	0.41	37.896	-1.183, -.612
$\chi 2$ *** (df)	419.99 (7)			
Nagelkerke	.291			

Notes: N=1759, † $p< 0.1$, * $p<0.05$, ** $p<0.01$, *** $p<0.001$

Table 3.11. Logistic Regression Results Explaining Household Duration Without Finances.

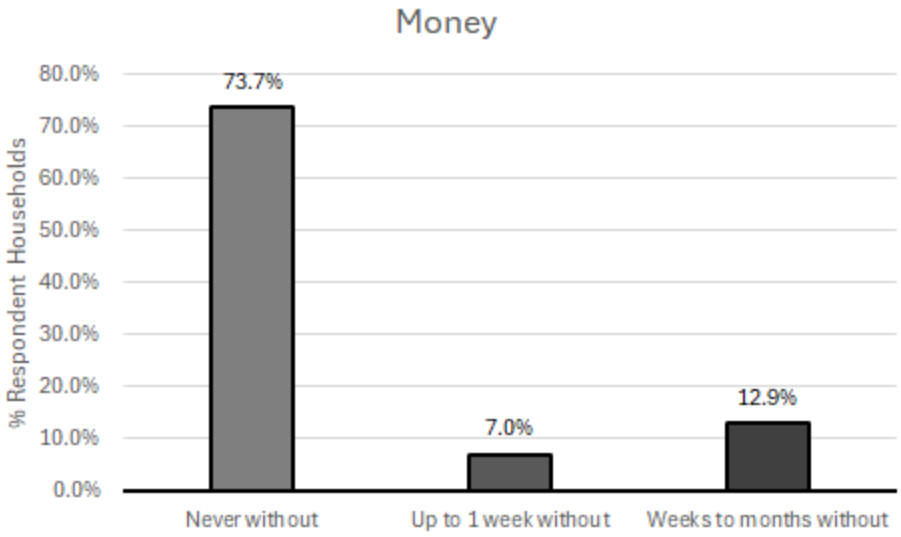

Figure 3.10 is a bar chart presenting the percent distribution of households with financial needs over three time periods: "Never without," "Up to 1 week without," and "Weeks to months without."

Discussion

This study examined whether and to what extent demographic trends could predict post-disaster needs across a community affected by wildfires. I found mixed support for my hypothesis, which held that the same variables used in vulnerability indices (i.e., age, sex, race and ethnicity, education, etc.), would predict whether a household would experience needs. The results complicate how we think about vulnerability to wildfires, showing that some social vulnerability variables, such as education and evacuation status were significant predictors across every model except shelter, while other variables like sex and race were significant predictors of going longer without select needs, (specifically food, shelter, water, and clothing). This variation across the nine model results highlights the complex dynamics of recovery, with demographics like age, sex, or race decreasing the likelihood for some needs, but increasing the odds of prolonged needs for different models. One such example of a mixed result is age. Older respondents (65 or older) were less likely to go longer without electricity, internet, or cell service than those under 65, but more likely to have prolonged clothing needs. Collectively, the variation

in significance and directionality across variables in the models illustrate how the impacts of wildfires can manifest and persist in diverse ways.

The results suggest that there are some common characteristics that link households with enduring needs, namely increased age. Many communities with higher populations of advanced age tend not to prioritize disaster preparedness (Aldrich and Benson 2007). Older adults may face increased obstacles throughout many stages of the disaster process, including during evacuation, and are more vulnerable than other populations following a disaster (B. E. Flanagan et al. 2011; Masri et al. 2021; Aldrich and Benson 2007). In addition to any mobility-related constraints, older adults living in rural WUI areas may face additional obstacles due to social and geographic isolation- this could complicate initial evacuation efforts but also subsequent relocation to shelters and more stable living arrangements (Al-Rousan, Rubenstein, and Wallace 2014; Aldrich and Benson 2007). Furthermore, disasters can also disrupt essential services that allow older adults to live in the community, such as assistance from family caregivers and social services like home-delivered meals, chore services, and personal care (Melton et al. 2023). Al-Rousan et al.'s national survey of adults aged 50 or older found that 15 percent of the sample used medical devices requiring externally supplied electricity (Al-Rousan, Rubenstein, and Wallace 2014). Thus, power interruptions could pose adverse health effects for this group.

Other factors that contributed to enduring needs included both sex (specifically males), and household size. Sex was a statistically significant predictive factor for food and shelter needs that lasted more than one week. Research suggests that men and women recover differently from disasters, particularly when reporting post-disaster mental health impacts (Enarson and Pease 2016; McKinnon 2022; Zabaniotou, Pritsa, and Kyriakou 2021). While males were 1.5 and 1.6 times more likely to report shelter and food needs, respectively, males comprised only 16% of

survey respondents. Households are a common unit of analysis for wildfire exposure research (Collins 2005; Taupo and Noy, n.d.; Eriksen and Simon 2017). Often, increased household size can increase likelihood because the vulnerability of an individual within the household can affect the entire household (Sadri et al. 2018). In areas where size constraints are more pressing (e.g., seatbelts or available beds) the availability of vehicles and shelters that can accommodate larger households becomes a limiting factor. Larger households have been found to take more time to recover from disasters (Taupo and Noy, n.d.). While our results indicate that household size can be a predictive factor of longer needs, as in the case of shelter, clothing, and transportation needs, household members can also offer support and be sources of social reassurance as well.

Educational attainment (i.e., having at least a bachelor's degree) functioned as a "protective factor," predicting a lower likelihood of reporting prolonged needs, including food, water, electricity, and clothing. Most notably these were associated with a 69% decrease (0.41 odds) in the likelihood of reporting post-fire financial needs. Disaster literature suggests possible explanations that address and explain why a higher education might buffer respondents from lasting wildfire impacts (Davies et al. 2018; Frankenberg et al. 2013) which link higher socio-economic status with lower levels of vulnerability to the impacts of wildfire and greater resilience in their aftermath. Respondents with a higher education may have access to a greater amount of social and financial resources than households without college degrees (Simon 2017; Eriksen and Simon 2017). Of course, the converse is true, meaning that those without a bachelor's degree may be more vulnerable to going longer without needs due to wildfires. While the link between a higher education and financial security was beyond the scope of this discussion, other hallmarks of financial security such as homeownership were more nuanced. While homeowners were more likely to go longer without electricity, internet, cell service, and

water, they were less likely to go longer without food, shelter, or transportation. Chase and Hansen (2021) highlight an ownership bias amongst disaster studies whereby home ownership is a protective factor that conveys stability and access to greater resources than renters (Chase and Hansen 2021). While prior research has highlighted the importance of education and agency in implementing post-wildfire mitigation methods (Kolden and Henson 2019; Modaresi Rad et al. 2023), the variety of results from the nine needs models highlights the value of qualitative research which seeks to identify the connections between variables, vulnerability, and the human costs of disasters.

Post-wildfire needs

Post-wildfire needs are a topic of growing interest in disaster research, with recent studies exploring the socioeconomic and demographic factors associated with wildfire recovery. By highlighting how long households went without needs, data from the What Now, CA? survey can invite deeper exploration to inform future disaster recovery efforts. For instance, nearly three hundred households went at least one week without adequate water, nearly twice as many as households that reported persistent water needs (Figure 3.2). Some of the reported persistent water needs may be due to the potential for wildfires to damage water distribution infrastructure, as was the case with the 2018 Camp Fire. Efforts to fight the fire relied heavily on local water sources, which were later found to contain numerous volatile organic compounds (VOCs), including the carcinogen benzene. Shortly after the fire, the Paradise Irrigation District (PID) issued a boil water notice, fearing contamination (Paradise Irrigation District 2018). Subsequent investigation revealed that many of the same pipes that had provided water to residents and firefighters during the Camp Fire had been melted or broken, and had depressurized (Proctor et al. 2020). As a result, toxins from the burning buildings and melted pipes entered the water

system, resulting in benzene and VOC contamination. The scale of the fire damage and the ensuing contamination were unprecedented. Decontamination efforts have added years of testing and rigorous water requirements, which have impeded efforts by those displaced wishing to return and rebuild (Walton 2019). The physical damage of the fire and the contamination of water infrastructure also contributed to acute solastalgia (distress due to environmental change) among survivors (Corin 2021).

The inclusion of cell service and internet access needs is also highly relevant to rural communities, which face a "digital divide" of unequal access to telecommunications (Sandoval and Lantheir 2021). The "divide" is a shorthand that separates those with internet access or internet-capable devices like cell phones (and know how to use them) and those that do not (Pinnock, Poberezhets, and Drummond 2023). Evacuation and age were predictive factors for households that reported enduring electricity, internet, and cell service needs in our survey. Bridging the digital divide for rural communities is an important part of decreasing vulnerability to wildfires.

The results show that adequate financial resources were also an enduring need for many households. Disasters, including wildfires can cause financial distress in the time period between the wildfire and insurance payouts (McConnell et al. 2021). Wildfires can have lingering negative impacts on consumer credit ratings, with direct (e.g., evacuation, rebuilding, and healthcare costs) and indirect impacts on household financial outcomes, although exact costs can be difficult to estimate (Grant and Runkle 2022; Richardson, Loomis, and Champ 2013; Kochi et al. 2012; Wang et al. 2021; Ho et al. 2023; Liao and Kousky 2020). Financial constraints can impact multiple aspects of life, including obtaining basic needs and making routine mortgage

payments that can exacerbate psychological distress (Biswas, Hossain, and Zink 2023; Eisenman et al. 2015).

Limitations and Future Research

I acknowledge some limitations of this research which merit consideration. Although this survey was widely publicized with respondents from 48 California counties, nearly half of surveyed households were from Butte County. That said, I do not attempt to make any statistical generalizations from the sample to the larger population of any county, including Butte. Notably, the survey had a high percentage of non-Hispanic White (72.4%) including respondents (76.8%) and female (76.6%) respondents. In comparison with the demographics of Butte County and the other represented counties represented, the percentage of Hispanic respondents was lower than the general population. This likely occurred in part because data collection was through an online survey, which would have been more difficult to complete in households without computers or internet. More than 70% of survey respondents were homeowners, and future research efforts to include renters' perspectives could even the "property bias" in disaster scholarship (Chase and Hansen 2021). While the broader WHAT NOW CA? survey included many questions about needs, including indirect experiences such as mental health (for more, see chapter 2 of this dissertation and Snyder et al. 2024), this is beyond the scope of the current paper. While each of the models suggests a relationship between higher education and needs which can last for weeks to months after wildfires, the results are statistically significant for only a limited number of other demographic variables.

This research identifies factors that contribute to needs reported by households affected by the 2018 California Wildfires, pointing to many needs but especially to water and stable long-term housing. Though this work extends in the days to months after the wildfires, additional

longitudinal research in these communities can increase our understanding of the evolving and enduring needs that follow disasters. Meeting these needs, with particular attention to socially vulnerable populations, should be a priority across disaster response agencies at federal, state, and local levels. Meeting the needs of socially vulnerable populations may require infrastructure investments to ensure that communities have equal access to clean drinking water following severe wildfires that can damage municipal water systems. Likewise, bridging the digital divide in rural areas may require significant investment and workforce development in rural WUI areas, and these results highlight key areas where needs lingered in the weeks to months following wildfire.

Conclusion

This study provides insight into recurrent, household needs following the 2018 Northern California wildfires. Evacuation was a predictor of whether a household would go longer without needs, with households that evacuated nearly 60 times more likely to go without clothing for more than one week than households that did not evacuate. Higher education (having a bachelor's degree or above) functioned similarly to a protective factor, decreasing the chance that a respondent would report a prolonged need. Conversely, this means that those without a higher education may be more likely to experience needs for greater than one week. Our results complicate the picture of vulnerability. We identified more than one-third of those with needs as having core needs, (food, water, clothing, and shelter), digital communication needs, (electricity, internet, and/or cell service), or 'resource' needs such as transportation and adequate finances. For example, older respondents, and therefore age, was a common predictor for many models, decreasing the likelihood of a respondent over 65 reporting prolonged electricity, internet, or cell service needs, but increasing the odds of going more than one week without adequate clothing.

Homeowners were more likely to go longer without electricity, internet, cell service, and water, but were less likely to go more than one week without food, shelter, or transportation.

Understanding the role that these factors play in understanding wildfire recovery is vital and can inform health and emergency services providers as they allocate resources following a disaster. This includes addressing persistent unmet shelter needs, a byproduct of broader housing availability constraints that can be exacerbated by wildfires and other disasters. These results also prominently represent prolonged water needs, with households reporting going more than one week without adequate drinking water. Collectively, these needs represent gaps between disaster recovery resources and present an opportunity to better communicate and coordinate the roles, responsibilities, and capabilities of involved agencies to the affected public. As communities continue to contend with wildfire disasters, responding agencies and experts can meet communities' needs by using needs assessments with sustained monitoring and evaluation efforts that emphasize collaboration to deliver resources to those that need them.

Data Availability

The data cannot be made publicly available upon publication because they contain sensitive personal information.

Funding

Funding for this project was made possible by the National Institute of Environmental Health Sciences: 1R21ES029693; 1P30ES023513.

Ethical Approval

All protocols of the WHAT-Now, CA? Study (Wildfires and Health: Assessing the Toll in Northern California) were reviewed and approved by The University of California, Davis Institutional Review Board before any recruitment or data collection.

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CHAPTER 4: HOW DISASTER DISPLACEMENT IMPACTS QUALITY OF LIFE FOLLOWING THE 2018 CAMP FIRE

Abstract

Using survey data from 684 northern California households affected by the 2018 Camp Fire, this study explores the social factors that influenced change in Quality of Life in 2023, 5 years after the wildfire. Factors including wildfire risk perception, and place attachment and identity are examined across three groups of individuals: those still within the Camp Fire footprint, locally displaced households outside of the footprint but within the county (Butte County), and households that relocated outside of the county. Compared to locally displaced households within the county, residents within the fire footprint were 16 times more likely to report an increase in their quality of life between 2018 and 2023, while households that relocated outside of Butte County were 5 times more likely. Findings highlight locally displaced households as a subject of theoretical and practical significance to research on wildfire recovery.

Introduction

In the past decade, wildfires (unplanned fires in wildland areas), have burned thousands of homes and incurred billions of dollars in damages across the United States (Buechi et al. 2021b; Chase and Hansen 2021a; Radeloff et al. 2018b; Wigtil et al. 2016b). Amidst a changing climate, which brings with it rising temperatures, limited rainfall, and longer fire seasons, California has witnessed larger and more frequent wildfires that have burned over 10.5 million acres since 2017 (Buechi et al. 2021b; Radeloff, n.d.; CALFIRE, n.d.; Berlin Rubin and Wong-Parodi 2022a). While the ecological and biophysical factors that contribute to wildfires are well studied in the disaster literature, (e.g. Westerling 2006), a growing number of people are at risk of facing wildfires due to human development in the Wildland Urban Interface, or WUI - the area where humans and wildland vegetation meet or overlap (Kumar et al. 2022b;

lawinsider.com 2024). Much of the WUI in California is a volatile combination of wildland fuels and materials used for human habitation (H. Anu Kramer et al. 2021b; G. L. Simon and Dooling 2013b; Syphard et al. 2007; 2012; CAL FIRE 2023). The growing number of people that live in the WUI include as many as five million Californian households, over 45% of state's housing supply, where they are especially vulnerable to wildfire as evidenced by the devastating 2017 and 2018 wildfire seasons (Burke et al. 2021; Buechi et al. 2021a; Radeloff et al. 2018a). Although recent record-breaking wildfires like the 2018 Camp Fire have garnered scholarly attention (Chase and Hansen 2021a; Hamideh, Sen, and Fischer 2022; Schulze et al. 2020; Silveira et al. 2021) our understanding of the biophysical conditions of wildfire risk remains more comprehensive than our understanding of the populations that face a growing wildfire risk (Thomas et al. 2017; Cutter, Schumann, and Emrich 2014).

With wildfires growing in frequency and severity, and rising numbers of people living in and moving to the WUI areas (H. Anu Kramer et al. 2021a; Mockrin et al. 2015), there is a pressing need for wildfire recovery research. Households recovering from wildfires face immediate threats in the form of physical health impact (Aguilera et al. 2021; Rosenthal, Stover, and Haar 2021), and diminished mental health outcomes (Silveira et al. 2021; M. R. G. Brown et al. 2019b; To, Eboreime, and Agyapong 2021). Prior disaster studies (c.f. Barile et al 2019; Brown et al 2019; Papanikolau et al 2012) have used Quality of life (QoL), as a metric of wellbeing to measure post-disaster recovery, encompassing aspects of physical and mental health, as well as social wellbeing and environmental satisfaction (Barile, Binder, and Baker 2020; Papanikolaou, Adamis, and Kyriopoulos 2012; Nussbaum, Sen, and World Institute for Development Economics Research 1993; Teoli and Bhardwaj 2024). Results suggest that wildfire exposure can affect mental health and QoL for several years after a disaster, although

many studies highlight the differential impacts which may vary based on age, sex, and education (Papanikolaou, Adamis, and Kyriopoulos 2012; Sanders, Bowie, and Bowie 2003; Shalaby et al. 2024). Research focusing on post-disaster relocation (C.f. Barile et al 2019; Greer et al 2020; Fussell and Lowe 2014) has linked relocation with detrimental mental and physical health, suggesting that displaced households may exhibit elevated levels of psychological distress compared to households which return to the disaster-affected area (Barile, Binder, and Baker 2020; Greer et al. 2020; Uscher-Pines 2009; Fussell and Lowe 2014).

This study aims to identify the key explanatory variables for change in QoL for residents impacted by the Camp Fire in 2018. QoL has been used to measure post-disaster wellbeing and can provide insight into how households recover from disasters like wildfires. The Camp Fire was unique among recent California in its displacement of 56,000 people and the destruction of the town of Paradise (Butte County District Attorney et al. 2020). Figure 4.1 shows several of the communities in Northeast Butte County, such as Paradise and Maglia, which I refer to as "Ridge Communities" due to their location on a foothill ridge defined by Butte Creek and the Feather River (Chase and Hansen 2021a; Ballard and Evans 2012). While the Camp Fire was particularly devastating to Ridge Communities, the effects of the fire extended far beyond the fire footprint to the nearby Butte County cities of Chico and Oroville, which absorbed the displaced populations (Urseny 2019; Wade 2019; Associated Press 2019). Drawing on the extant literature reviewed above, we asked households affected by the Camp Fire about their QoL before explaining my methodology and data characteristics. Then, I discuss how QoL differs across three geographic cohorts, and the factors that influence QoL, including personal demographics and other factors including risk perception and place attachment. I conclude by discussing how the findings from this work contributes more broadly to the scholarship on wildfires and wildfire recovery.

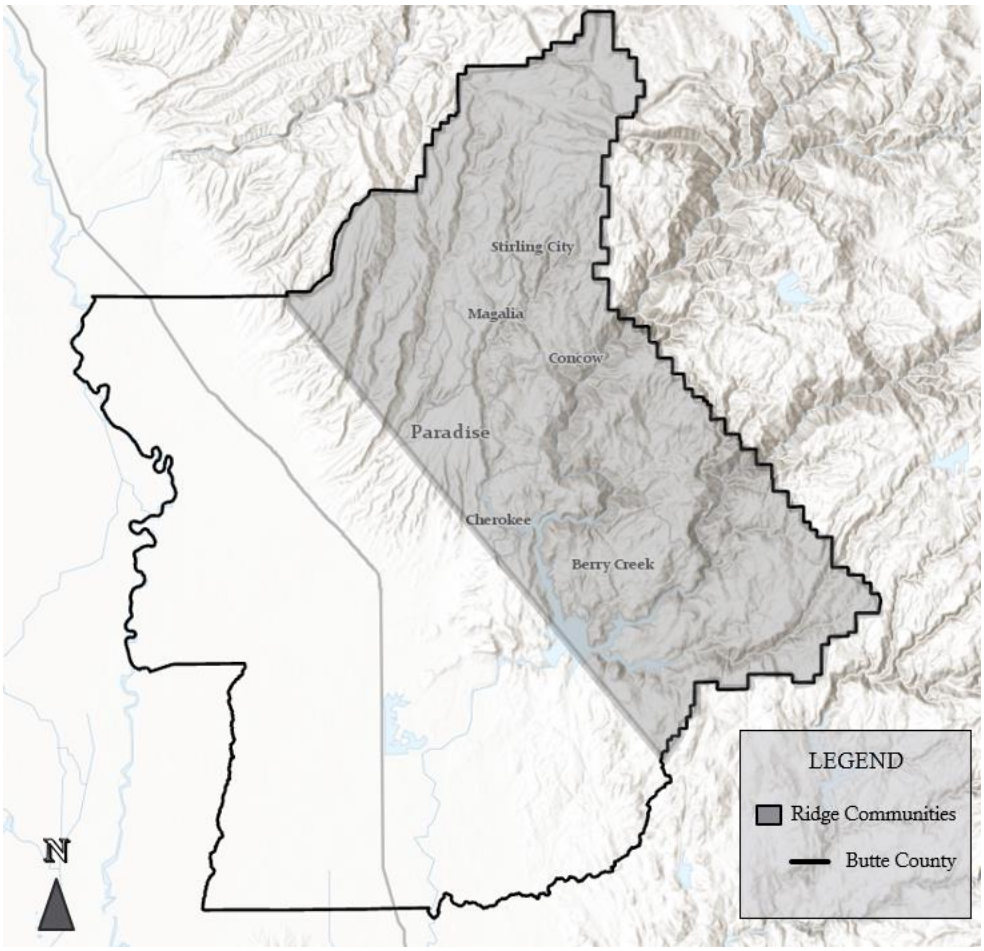

Figure 4.1: Butte County Ridge Communities (Shaded)

Literature Review

Change in Quality of Life

Quality of life (QoL) is an important concept in disaster research and is defined as an individual's perception of their lifestyle and well-being. It holds a variety of implications depending on the scale and scope of factors that impact an individual's health and recovery in the aftermath of disaster (Nussbaum, Sen, and World Institute for Development Economics Research 1993; Teoli and Bhardwaj 2024). QoL is important for wildfire research (c.f. Papanikolaou 2012; Felix and Afifi 2015) because of the lingering health impacts that follow wildfires (Papanikolaou, Adamis, and Kyriopoulos 2012; Felix and Afifi 2015; Sullivan and Sagala 2020a). For example, Papanikolaou et al. (2012) assessed QoL before and after a wildfire, noting

negative physical and mental health impacts, such as heightened stress and depression, resulting in decreased QoL. Research has found similar results for tornadoes (Greer et al. 2020), hurricanes and floods (Graif 2016; Barile, Binder, and Baker 2020; Shigemoto and Kawachi 2020), earthquakes (Ardalan et al. 2011), and industrial and technological disasters (Annang et al. 2016). Studies on the lingering physical health impacts of displaced households have found that older adults face relatively worse health outcomes over time. This is consistent with the broader literature on wildfire impacts on older adults (Sanders, Bowie, and Bowie 2003; Kamo, Henderson, and Roberto 2011; Melton et al. 2023). Other factors that may affect QoL for displaced households include access to social resources (Uscher-Pines 2009; Kamo, Henderson, and Roberto 2011) and perceived risk (Perlaviciute et al. 2017).

While many disaster studies have used QoL measurements to highlight the adverse health impacts of disaster exposure, others have also noted the limited yet positive outcomes as well, such as reflected in more resilient social relationships among earthquake-affected communities compared to the general population (Ardalan et al. 2015, 2011). And while the literature on QoL suggests that demographic variables such as age, (Scannell et al. 2016; Kamo, Henderson, and Roberto 2011) sex/gender, (Zabaniotou, Pritsa, and Kyriakou 2021; Spence, Lachlan, and Burke 2007) race (Graif 2016; Davies et al. 2018) and socio-economic status (Rovai 1994; Sullivan and Sagala 2020b; 2020b; Tobin et al. 2006; Davis 1998) may influence the impact of disasters on a public wellbeing, whether or not a person decides to relocate may also effect QoL. Just as wildfires themselves can negatively impact mental health, post-disaster relocation has been linked to negative physical and psychological health outcomes (M. R. G. Brown et al. 2019b; Barile, Binder, and Baker 2020; Papanikolaou, Adamis, and Kyriopoulos 2012; A. R. Brown 2022; Hori and Schafer 2010).

Place Attachment and Displacement

Place attachment is an emotional, symbolic, and psychological attachment to a place (Low and Altman 1992; Anton and Lawrence 2016). This is an important concept for wildfire researchers to understand because of how place attachment can influence wildfire exposure and post-fire recovery (Chase and Hansen 2021a; Anton and Lawrence 2016). Wildfire researchers have operationalized place attachment by studying wildfire risk perception (Bonaiuto et al. 2016; Brenkert-Smith 2006) adoption of fire-mitigating behavior (Anton and Lawrence 2014; Nawrotzki et al. 2014), post-fire migration intent (Berlin Rubin and Wong-Parodi 2022b), and post-fire wellbeing (Greer et al. 2020; Jones and Walker 2023). Studies typically approach place attachment as an explanatory variable by exploring how it effects disaster experiences (Greer et al. 2020; Bonaiuto et al. 2016; Anton and Lawrence 2016) or uses it as an outcome variable, such as how it shapes fire survivors' attachment to place (Swapan and Sadeque 2021; Berlin Rubin and Wong-Parodi 2022b; Jones and Walker 2023; Zheng et al. 2019). This paper builds on this research by using measures of place attachment as explanatory variables. The place attachment variables I operationalize include duration in place, wildfire-related home loss, amenity values, and sense of belonging. I use these to better understand how multiple dimensions of place attachment influence post wildfire assessments of QoL.

Place attachment in disaster contexts has been shown to increase with length of residence (Anton and Lawrence 2014; Raymond, Brown, and Weber 2010; Nawrotzki et al. 2014). Such research has measured place attachment using variables that measure the length of residence, the relationship between place and identity, and intention to stay in a place for the long-term. Likewise, research has shown that the disaster survivors that tend to rebuild (Nawrotzki et al. 2014; Tinoco 2023) do so for numerous place based social and environmental reasons including connection to rural landscapes (Anton and Lawrence 2014; 2016), proximity to family and faith groups (Graif 2016; Lewicka 2011), and generational ties to a region (Blondin 2021). Attachments like these can also result in amplified negative effects after a wildfire, as landscape changes due to fire can also impact place attachment (Bonaiuto et al. 2016). These negative impacts may be further amplified by displacement, resulting in a loss of belonging or

community, and contribute to heightened perceptions of risk and threat(Adams 2016). Place attachment is, therefore, an important factor in disaster recovery because it can influence a households' decision to stay, rebuild, or relocate following a disaster.

Focusing on disaster displacement, research has shown higher place attachment to be associated with negative outcomes across a variety of disaster types (hurricanes, earthquake, wildfires), with a majority of studies linking displacement to increased health issues and higher mental health burdens (Graif 2016; Papanikolaou, Adamis, and Kyriopoulos 2012; Barile, Binder, and Baker 2020; Bukvic and Owen 2017; Cutter, Schumann, and Emrich 2014; Goetz 2013; Hori and Schafer 2010). Studies that highlight factors associated with disaster displacement suggest that displaced survivors exhibit higher levels of psychological symptoms than disaster survivors who return to their original homes (Uscher-Pines 2009). Research that specifically studies the physical health impacts of relocation are limited, though researchers have found that relocated older adults experienced relatively more severe physical health impacts over time (Kamo, Henderson, and Roberto 2011; Uscher-Pines 2009; Sanders, Bowie, and Bowie 2003).

Beyond health impacts, QoL for displaced populations is influenced by their ability (or inability) to re-establish social ties (Sanders, Bowie, and Bowie 2003; Rumbach, Makarewicz, and Németh 2016) and their perceived risk from future disasters (Perlaviciute et al. 2017). In their study of post-Katrina resident displacement, Graif (2016) found that further distances were linked with lower distress scores among vulnerable families (Graif 2016). The influence of disaster displacement on QoL, however, is an understudied subject (Uscher-Pines 2009). Though many disaster studies (c.f. Barile et al 2020; Graif 2016; Siskar and Evans 2021; Tinoco 2023; Tobin et al 2006) acknowledge disaster impacts for locally displaced people, those populations are rarely the focus of research (Graif 2016; Barile, Binder, and Baker 2020; Tobin et al. 2006; Tinoco 2023; Uscher-Pines 2009; Siskar and Evans 2021). Some, such as Blondin (2021) and Tinoco (2023) focus on households that remain or rebuild within the disaster area while others (Chase and Hansen 2021; Graif 2016) study destinations of community members post-

disaster (Chase and Hansen 2021a; Graif 2016; Barile, Binder, and Baker 2020; Tinoco 2023; Blondin 2021). Moreover, what scant literature there is does not agree on a standard distance for key issues such as what is "local" and what is "distant," (Uscher-Pines 2009) with 50 km/30 miles used in some studies (c.f. Johnston et al), while others (Clark et al 2014) have used 30km/18 miles (Johnston et al. 2021; Goebel et al. 2015; W. Clark, Deurloo, and Dieleman 2006; W. A. V. Clark, van Ham, and Coulter 2014). Many more studies do not deal explicitly with distance, but instead focus on the "regional effects" of wildfires (Chase and Hansen 2021a; Anton and Lawrence 2016; Johnson and Carswell 2021). While the hazard and disaster literatures present a consensus regarding demographic and geographic variables and socioeconomic status, proximity to the disaster-affected area, and social attachment as key predictors of post-disaster QoL, they have yet to standardize the metrics for assessing how this work. This study aims to help fill in this gap by testing the following hypotheses, derived from above literature:

H1: In the wake of wildfires, demographic and Socioeconomic variables will predict changes in QoL, and specifically persons of advanced age, minority group status, renters, and women are more likely to experience a negative change in quality of life.

H2: That QoL will differ between households that remain or rebuilt within a Ridge Community, households that were locally displaced within Butte County, and households that moved outside of California.

H3: That households which report high feelings of unsafety, lower confidence, and higher perceived wildfire risk are more likely to have a negative QoL after the Camp Fire.

Importantly, this study explores these hypotheses with particular attention to place (remained/rebuilt in a Ridge community, locally displaced in Butte County, moved out of the county) to understand change in QoL. This represents an important contribution to the wildfire literature by centering locally displaced households, as a population of interest that has received relatively little attention thus far.

Study Site

Background

The Camp Fire is the deadliest, most destructive wildfire in California history and was the costliest natural disaster worldwide in 2018 (Chase and Hansen 2021a; CALFIRE 2021; "California Wildfire Was World's Costliest Natural Disaster in 2018, Insurer Says" 2019). The fire began early on November 8th, 2018, spreading rapidly to Town of Paradise, and ultimately burning over 153,000 acres. Though often discussed in the context of subsequent wildfires, the Camp Fire is notable as a standalone disaster that had an extreme impact on the communities in Butte County. What makes the Camp Fire especially unique was the displacement of over 56,000 people caused by the destruction of nearly 19,000 structures, nearly 90% of the town of Paradise (Chase and Hansen 2021a; 60 Minutes 2018; Butte County District Attorney et al. 2020).

It is hard to overstate the impact of the Camp Fire on Butte County. Like much of California, the area was suffering from limited housing availability. Many people in the community were still recovering from the 2017 catastrophic Oroville Dam crisis and the more recent Carr Fire, which had burned the town of Redding (70 miles North of Chico) in July of 2018 (CALFIRE 2021; Vahedifard et al. 2017). Thus, the Camp Fire struck on the heels of two other localized disasters and with a regional housing shortage, making it harder for the 50,000 displaced people to find resources like housing. Many evacuees camped in parking lots before moving into semi-permanent shelters where a Norovirus outbreak then occurred. In the following days, Norovirus cases were reported in eight of the nine evacuation shelters across Butte and Glenn Counties, creating a Hobson's choice for evacuees, who had to decide between makeshift encampments or risk infection at shelters that provided a higher level of support and resources (Karmarkar 2020).

The effects of the Camp Fire persisted long after the initial blaze was fully contained on November 25th, 2018, and much of the qualitative research about the Camp Fire in the intervening years has demonstrated the lingering impacts of wildfire disasters (Chase and Hansen 2021a; Hamideh, Sen, and Fischer 2022; Schulze et al. 2020). The 'ripple effect' of wildfire impacts can extend beyond the immediately impacted community and can impact housing access, healthcare, and social service availability (Chase and Hansen 2021a; Rosenthal, Stover, and Haar 2021).

Data and Methods

This research studies households with pre-fire addresses in Paradise and Magalia affected by the Camp Fire. Using a modified version of Chase and Hansen's (2021) strategy, we identified affected households through aggregated change of address data collected from the United States Postal Service by a third-party data broker, DataAxle. The company provided change of address data between 2018 and 2023 for households in affected ZIP codes. The Change of Address (COA) data is publicly available for a fee and was used to identify household addresses for participation in our Ridge Recovery Survey. While the DataAxle data contained demographic information, including age, household size, and home value, for this study only the COA information was used to mail invitations to current home addresses of households that in 2018 had permanent addresses in either Paradise or Magalia ZIP codes. 8,112 households living within ZIP codes affected by the Camp Fire were invited to participate in the survey, though many had moved across the United States in the years since the Camp Fire (Figure 4.2). 634 households that responded completed the survey across the United States participated (Figures 4.2, 4.3, 4.4) The survey was available beginning in January 2023, roughly 4 and a half years after the fire. All protocols of the Ridge Recovery Survey were reviewed and approved by the University of California, Davis Institutional Review Board prior to any recruitment or data

collection (1958929-1). Consent was obtained prior to taking the online survey, in accordance with the IRB.

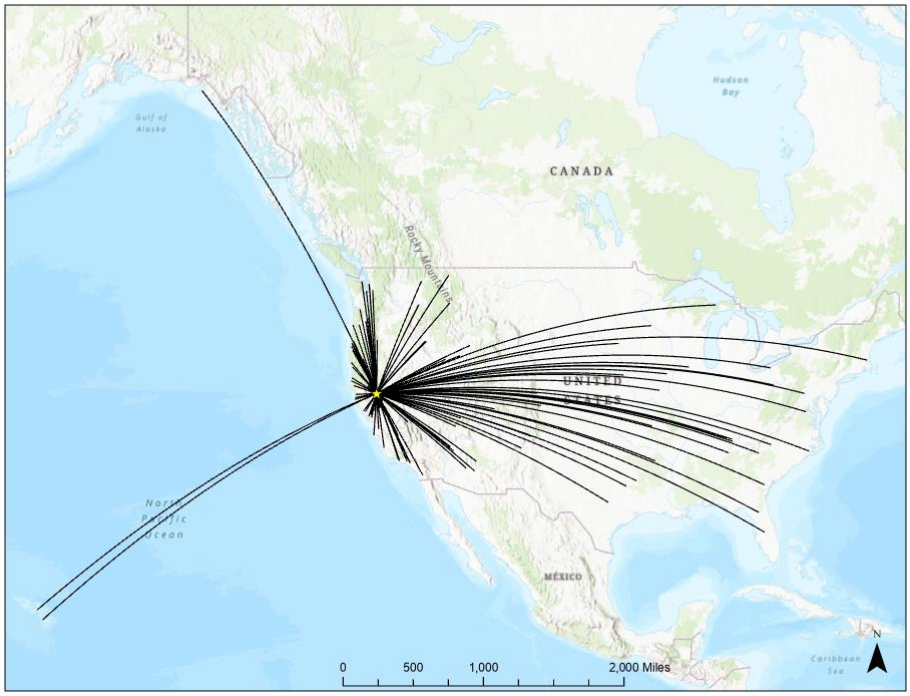

Figure 4.2: Distribution Of Respondent Households Across United States

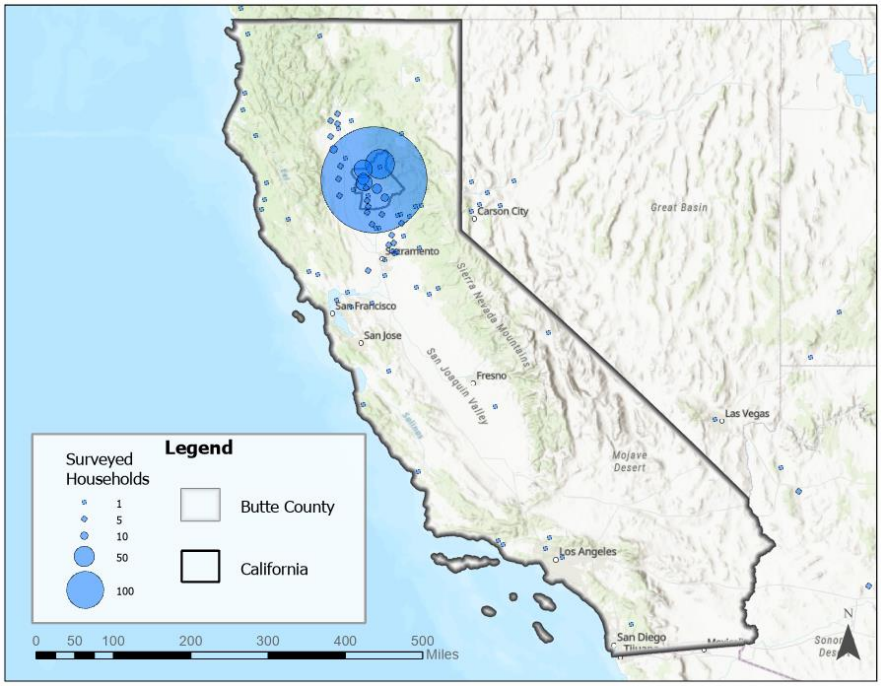

Figure 4.3: Concentration of Respondent Households Within California

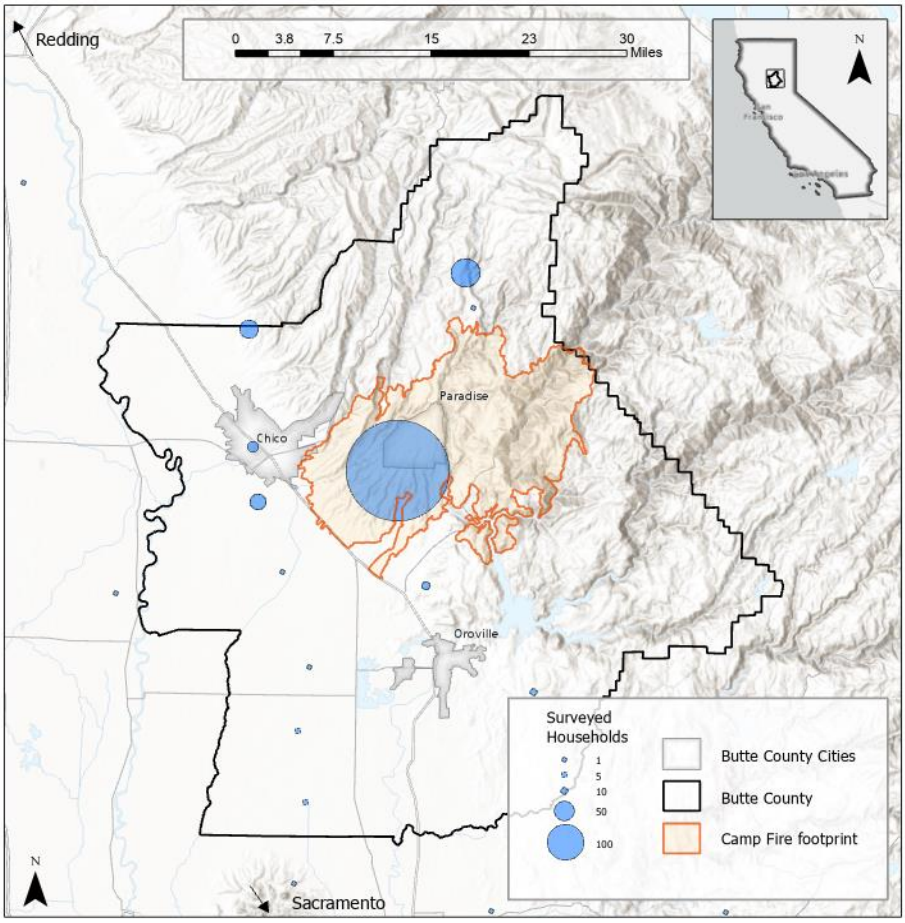

Figure 4.4: Concentration of Respondent Households Within Butte County

Adult (18+) respondents were eligible to participate in the survey. Households affected by the Camp Fire were recruited via mailed survey invitations (Figure 3), fliers posted in public areas in Chico and Paradise, and tabling at community events. Materials and survey questions were printed in English. The survey included questions about residents' pre- and post-fire quality of life, their perceptions of risk and safety, their location at the time of the survey, how long they had lived in their pre-fire household, and sociodemographic variables (i.e., age, race, ethnicity, sex, education). A total of 684 households completed the survey, resulting in an 8.4% response rate. This response rate is consistent with recently published averages of 7% (Dillman, Smyth, and Christian 2014) and represents a sample size typical in disaster social science research,

where fewer than one in four studies rely on sample sizes greater than 400 participants (Greer et al. 2020; Norris 2006).

Measures

Dependent Variables

Quality of Life, or QoL, is an established research metric used in post-disaster contexts to understand the lingering effects of wildfires and other disasters (Graif 2016; Papanikolaou, Adamis, and Kyriopoulos 2012; Nussbaum, Sen, and World Institute for Development Economics Research 1993; Barile, Binder, and Baker 2020; Annang et al. 2016). To measure QoL, we asked respondents of the Ridge Recovery Survey to retroactively rate several factors relating to their 2018 quality of life, including their perceived safety, convenience of their home's location, the environment, their cost of living, community, and overall quality of life. For comparative purposes, respondents then ranked their current QoL by answering the same questions across the same six areas. At both time points, respondents ranked their QoL on a 5-point Likert scale, with 1 corresponding to lower QoL and 5 with high QoL. The change in rating (2023 rating minus 2018 rating) survey created a range of values from -4 to 3. Overall, 46.7% (n=315) of respondents felt that their 2023 QoL was lower than their 2018 QoL, 35% (n=236) of households with no difference between their 2018 and 2023 QoL, and 8% (n=54) whose 2023 QoL was higher than their pre-fire QoL. The remaining 10.3% (n=79) answered only one of the QoL questions, or did not answer either question, and were excluded. Put differently, over 80 percent of households stayed the same or felt worse off. In the binary logistic regression model, the dichotomous variable (where negative and neutral change values were coded as 0 and positive values as 1) was used as the dependent variable. We created a binary dependent variable to better understand the effects of the independent predictor variables on overall quality of life.

Independent Variables

Demographics

In addition to the QoL questions, the survey included a range of socio-demographic questions that are frequently used in disaster research including: age, (Scannell et al. 2016; Kamo, Henderson, and Roberto 2011) sex/gender, (Zabaniotou, Pritsa, and Kyriakou 2021; Spence, Lachlan, and Burke 2007) race (Graif 2016; Davies et al. 2018) and socio-economic status (Rovai 1994; Sullivan and Sagala 2020b; 2020b; Tobin et al. 2006; Davis 1998). While certain independent variables (household size and home tenure) applied to the entire household, the survey respondents were asked to provide information about themselves. Age was recorded as a continuous variable and dichotomized with 65 years or older versus younger. Sex was asked as a binary (Male/Female). Household size represented the number of household members, including children under 18. Educational attainment was only provided for respondents and asked about the highest level of education the respondent had completed. Survey respondents were asked to indicate both Race (Asian, Black, Native American etc.,) and Ethnicity (Hispanic or Non-Hispanic). Home tenure information indicated whether the respondent's household was owned, rented, or it was a rent-free living arrangement. Respondents were asked to provide information related to the housing type, including Recreational Vehicles, Mobile homes, and traditional 'stick-built' homes. Duration on the Ridge was up to the respondent to interpret, where participants were asked if they had spent most or all of their lives in a Ridge Community.

Place Attachment

Place attachment literature has long been used in disaster research to measure QoL (Adams 2016; Nussbaum, Sen, and World Institute for Development Economics Research 1993; Anton and Lawrence 2016)**. T**o measure place attachment, we asked questions related to satisfaction with their current location. Specifically, respondents were asked about their ability to

handle another disaster, whether they thought of wildfires often, whether they felt supported, whether living with a yard was important to them, whether they felt that they belonged in their current community, whether living on the Ridge was part of their identity, and whether they wanted to stay where they were. Respondents indicated their 2018 and current quality of life, each on a 5-point Likert scale with 1 corresponding to lower satisfaction and 5 with high satisfaction. Households that agreed (4) or strongly agreed (5) on the Likert scale were coded as "1" and entered as a binary variable in the regression, with the remainder coded as zero.

Location and Displacement

While Johnston et al. (2016) and Geobel et al. (2015) use 50km to distinguish between nearby and distant, Clark et al. (2014) rely on a 30km boundary (Johnston et al. 2021; Goebel et al. 2015; W. A. V. Clark, van Ham, and Coulter 2014). Geodesic distance was available from the raw survey data in the form of ZIP code centroids. However, respondents were also asked to indicate the name of their city or town, allowing us to distinguish among Ridge Communities (Paradise, Magalia and the nearby Ridge Communities of Pulga and Concow), locally displaced households within Butte County (Chico, Oroville, Durham, Gridley) and all else "Outside Butte County." Households from Ridge Communities were coded as 1, those beyond Butte County were coded as 2, and locally displaced (outside of Ridge Communities but within Butte County) were coded as 3.

Analytic Strategy

To test research hypotheses and examine the relationship among Quality of Life, location, and sociodemographic variables, binary logistic regressions were employed, with QoL as the outcome variable, and location and demographics and explanatory variables. Regressions have been used to estimate post fire migration intent and satisfaction in QoL contexts. This technique is well suited for this analysis because it quantifies the strength of the association between a set of independent explanatory

variables and a binary dependent variable. When considering this relationship between change in satisfaction and location, it can help clarify the extent to which location and other variables play a role. A description of the dependent and the independent variables follows. All statistical modeling was performed using SPSS version 29.

Results

Descriptive Statistics

Of the 684 households that participated in the Ridge Recovery Survey and provided demographic data, 611 (89.3%) answered QoL related questions. Table 1 contains descriptive statistics of the sample. Demographically, respondents were predominately white, (78.3%), homeowners (78.5%), and over the age of 50 (70.2%). These demographics are consistent with the 2018 American Community Survey data for the town of Paradise, which was older and whiter than the Butte County average.

	Total Households (n=684) *N* (%)	Households with reported QoL Rating (n=611) *N* (%)	Households without a reported Qol Rating (n=73) *N* (%)
Sex			
Female	390 (56.93%)	387 (63.34%)	3 (4.11%)
Male	206 (30.07%)	204 (33.39%)	2 (2.74%)
Missing	89 (12.99%)	20 (3.27%)	68 (93.15%)
Age (yrs)			
18-35	48 (7.0%)	48 (7.9%)	0 (0.0%)
36-49	73 (10.7%)	73 (11.9%)	0 (0.0%)
50-64	177 (25.9%)	176 (28.8%)	1 (1.4%)
65-79	257 (37.6%)	255 (41.7%)	2 (2.7%)
80 or older	46 (6.7%)	44 (7.2%)	2 (2.7%)
Missing	83 (12.1%)	15 (2.5%)	68 (93.2%)
Race			
White	536 (78.25%)	531 (86.91%)	5 (6.85%)
Hispanic or Latino	10 (1.46%)	10 (1.64%)	0 (0.00%)
American Indian or Alaska Native	2 (0.29%)	2 (0.33%)	0 (0.00%)
Native Hawaiian or Pacific Islander	1 (0.15%)	1 (0.16%)	0 (0.00%)
Mixed or Multiple	46 (6.72%)	46 (7.53%)	0 (0.00%)
Missing	90 (13.14%)	21 (3.44%)	69 (93.2%)

Educational level			
Some School; No Diploma or GED	6 (0.88%)	6 (0.98%)	0 (0.00%)
High School Diploma / GED	40 (5.85%)	39 (6.38%)	1 (1.37%)
Some College	163 (23.83%)	161 (26.35%)	2 (2.74%)
Associate's or other Technical Degree	112 (16.37%)	110 (18.00%)	2 (2.74%)
Bachelor's Degree	163 (23.83%)	163 (26.68%)	0 (0.00%)
Graduate Degree	118 (17.25%)	118 (19.31%)	0 (0.00%)
Missing	82 (11.99%)	14 92.29%)	68 (93.15%)
Housing status			
Own your residence	538 (78.54%)	517 (84.62%)	21 (28.77%)
Rent your residence	53 (7.74%)	52 (8.51%)	1 (1.37%)
Live with friends or family (rent free)	32 (4.67%)	31 (5.07%)	1 (1.37%)
Other	13 (1.90%)	10 (1.64%)	3 (4.11%)
Missing	49 (7.15%)	1 (0.16%)	47 (64.38%)

Table 4.1: Descriptive Summary Statistics of Total Household With Reported Needs and Households with Reported Needs. Discrepancies between reported demographics and population sizes ("Missing") are due to not all survey respondents answering both QoL and demographics questions.

Logistic Regression Model

Table 4.2 indicates the parameter estimates and overall results of the binary logistic regression model predicting effects of geographic group (within Camp Fire footprint, beyond the footprint but within Butte County, and beyond Butte County), sociodemographic characteristics, and protective factors on positive change in quality of life of respondents (n = 509). This set of predictors explained 38.5% of the variance (Nagelkerke) in the outcome. The model correctly classified 92.8 percent of cases. The final model was statistically significant, predicting the dependent variable over and above the intercept-only model, c^2 (12) = 93.03, $p < 0.001$.

Parameter Estimates	*B*	Std. Error	Wald	Exp. (*B*)
Current Residence within Fire Footprint	2.793	0.537	27.01	16.33***
Current Residence outside of Butte County	1.644	0.667	6.07	5.18*
Senior	1.596	0.438	13.30	4.93***
Lost home from Camp fire	-0.553	0.462	1.431	0.575
Lived in Ridge Community for most/all adult life	-1.006	0.443	5.165	0.366*
Homeowner	-0.698	0.519	1.811	0.497
Wish they were in safer location	-2.114	0.775	7.446	0.121**
Feel wildfires pose a risk	-0.433	0.401	1.166	0.649
Having a yard is important to me	-1.246	0.519	5.761	0.288†
Living on the ridge is part of my identity	-0.392	0.451	0.759	0.675

I feel a sense of belonging in my community	0.814	0.444	3.354	2.256†
I want to live where I am now for the rest of my life	1.436	0.439	10.700	4.205***

†p<0.1, *p<0.05, **p<0.01, ***p<0.001

Table 4.2. Estimates of Logistic Regression Model Predicting Positive Quality of Life change, Controlling for Locally Displaced Households

Of the geographic variables, current residence in the Camp Fire footprint and locally displaced households were highly significant in predicting positive QoL change ($p < 0.001$). Households located in fire-affected areas were 16.33 times more likely than locally displaced households to report a positive change in quality of life. Households displaced outside of Butte County ($p = 0.014$) were 5.18 times more likely to report a positive quality of life change.

Of the sociodemographic variables, age and duration living on the Ridge were statistically significant predictors of a positive change in quality of life. Among respondents aged 65 or over the odds of reporting higher QoL was 4.93 greater than among those aged < 65. Secondly, for respondents who spent most or all of their lives on the Ridge, there was a decrease in the likelihood of positive quality of life change by 64% Wald c^2 (1) = 5.17, $p = 0.023$). That is, the odds of respondents who spent most or all of their lives on the Ridge being positive were lower than the odds for respondents who were less connected to Paradise, Magalia, or other fire-affected communities.

During model testing, many identity variables were found to be significant predictors for positive quality of life change. Households that wanted to live in a safer location were less likely to report positive quality of life changes (OR=0.121, Wald c^2 (1) = 7.45, $p = 0.006$). Put differently, if households felt unsafe in their current living arrangement, then they were 88% less likely to report an increase in their quality of life. Likewise, respondents who agreed that living in a house with a yard was important to them were also less likely to experience an increase in

quality of life (OR=0.288, Wald c^2 (1) = 5.76, p = 0.016). Put differently, households that strongly valued having a yard, (i.e. Strongly Agreed / Agreed with the phrase "Having a yard is important to me") were 72% less likely to report increased quality of life. Many properties within Ridge Communities were larger than suburban or urban parcels within Chico or Oroville, meaning that displaced households, or households that moved from a house into an apartment may have missed access to a relatively larger or more forested yard. Two significant variables that contributed to positive change in QoL were households that felt a sense of belonging in their community, and households that wanted to remain in place for the rest of their lives. Households that felt a strong sense of belonging were 2.3 times more likely to report positive QoL (Wald c^2 (1) = 3.35, p = 0.067). Respondents that wanted to live in their current location for the remainder of their life were 4.2 times more likely to experience a positive QoL change (Wald c^2 (1) = 10.07, p = 0.001).

Discussion

Studies on post-wildfire change in quality of life are limited, though our findings suggest that this is a fruitful direction for future research as shifts in post-disaster QoL may be influenced by displacement. In exploring change in quality-of-life after the 2018 Camp Fire, we found key differences related to current location, place attachment and identity, and advanced age. These findings raise questions about post-wildfire recovery and the broader recovery of households affected by wildfires, especially households that may be displaced locally following a wildfire. In the case of the Camp Fire, households that were displaced to Chico, Oroville, or elsewhere in Butte County were much less likely to report a positive change in QoL, even compared to households living in the fire footprint, where nearly 19,000 structures were destroyed. This is important because locally displaced residents are not expected to face the same degree of losses related to social ties and place attachment as residents that relocate further from their impacted

communities (Hori and Schafer 2010; Sanders, Bowie, and Bowie 2003; Mortensen et al. 2009). Thus, I would not expect respondents residing in nearby communities untouched by wildfires to be less likely to report positive QoL compared to those who live in Ridge Communities amidst potentially stressful memories or households that relocate further away outside of Butte County. The post-disaster relocation literature consistently stresses the negative impacts of displacement (Barile et al 2021; Fussell and Lowe 2014; Hori and Schafer 2010; Sanders et al. 2003; Uscher-Pines 2009), and my findings show that households remaining in Ridge Communities were 16 times more likely to report an increase in their QoL than locally displaced households (Barile, Binder, and Baker 2020; Sanders, Bowie, and Bowie 2003; Uscher-Pines 2009; Fussell and Lowe 2014; Hori and Schafer 2010).

These findings highlight the importance of post-wildfire location on a household's quality of life. I found mixed support for our first hypothesis, which posited that factors shown to influence disaster recovery, including age, (Scannell et al. 2016; Kamo, Henderson, and Roberto 2011) sex/gender, (Zabaniotou, Pritsa, and Kyriakou 2021; Spence, Lachlan, and Burke 2007) race (Graif 2016; Davies et al. 2018), and socio-economic status (Rovai 1994; Sullivan and Sagala 2020b; 2020b; Tobin et al. 2006; Davis 1998) would negatively influence QoL. Of these, being over the age of 65 was associated with a positive change in QoL, while other demographic variables were not significant predictors of change in QoL.

I found mixed support for my second hypothesis, which predicted that QoL will differ between households that remain or rebuilt within a Ridge Community, households that were locally displaced within Butte County, and households that moved outside of California. Despite living within the Camp Fire footprint, households that remained or rebuilt in a Ridge Community were much more likely to report a positive QoL relative to displaced households. A notable

distinction is that households outside of Butte County were 5 times as likely to report a positive change in QoL compared to locally displaced households, a finding that runs counter to my expectations. These results support the hypothesis that insecurity and wildfire risk were associated with decreases in QoL. The ongoing perceptions and fears related to future potential disasters are real and pose a challenge for government and private agencies. Understanding those who are feeling insecure and identifying their specific needs is a requirement for providing appropriate services during the post-wildfire recover period.

Many post-disaster QoL studies measure residents' attachment to impacted communities, while others link relocation and displacement with negative mental and physical health outcomes (Barile, Binder, and Baker 2020; Papanikolaou, Adamis, and Kyriopoulos 2012; Fussell and Lowe 2014). Studies have shown that wildfire survivors tend to rebuild (Nawrotzki et al. 2014; Tinoco 2023) for many reasons, including their attachment to a place, which can encompass environmental factors (Anton and Lawrence 2014; 2016), established community or social groups (Graif 2016; Lewicka 2011), and familial ties to a place (Blondin 2021). The desire to remain and/or rebuild after a disaster, as well as other facets of place identity are important aspects for understanding QoL. In the context of this study, households that were displaced locally may have retained attachments, despite being relatively much closer to Ridge Communities than households that moved outside of Butte County. While place attachment may explain the proportionately higher positive QoL among households living on the Ridge, it may also explain the more moderate positive impact on QoL for households that moved out of the county.

The disproportionate gap between change in QoL amongst households in Ridge Communities compared to locally displaced households highlights the importance of place

attachment and identity in post-disaster communities. While prior wildfire research (e.g. Anton and Lawrence 2016; Bonaiuto et al 2016; Greer et al 2020) explores facets of place attachment, the role of community and other bonds to a specific location may operate as protective factors against the challenges associated with rebuilding after a disaster. Living through a disaster and returning to a disaster-affected landscape can cause negative effects on QoL increasing risk perceptions and contributing to the decision to relocate (Bonaiuto et al. 2016). Questions about wildfire risk, including wanting to live in a safer location, were associated with a negative change in QoL. Respondents who agreed or strongly agreed that they wanted to be in a safer location were 88% less likely to report a positive QoL change. While other direct questions, such as feeling that wildfires posed a risk, were not statistically significant, many households may have felt that there was simply nothing left to burn or may have felt secure in their move elsewhere. Descriptive visuals such as Figure 4.5 (below) can provide important context to visualize the more quantitative aspects by showing the areas where respondents with positive, neutral, and negative changes in their QoL.

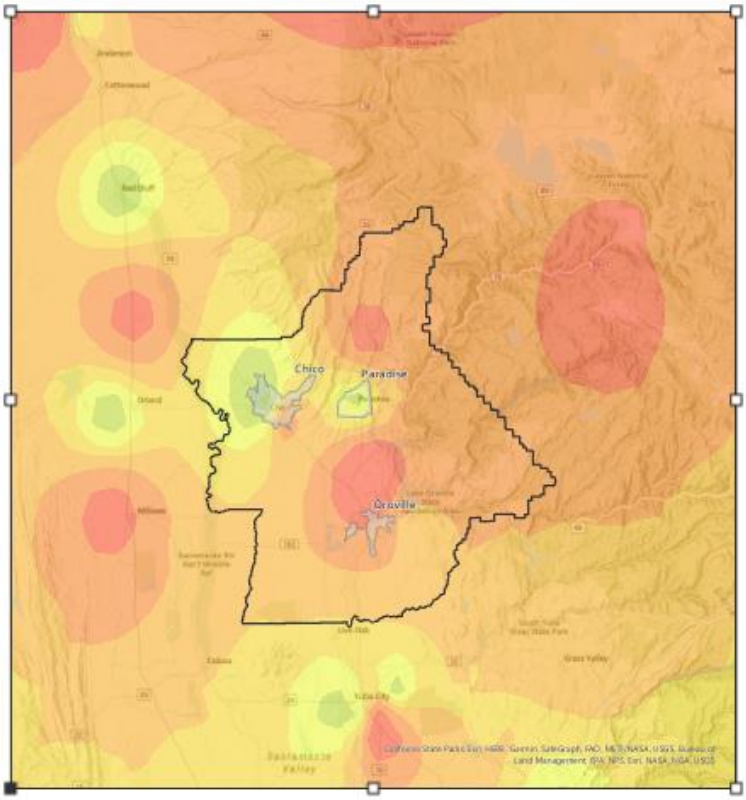

Figure 4.5: Descriptive Visualization of QoL Variation of Respondent Households

Limitations and Future Research:

This study relies on a retrospective self-reported evaluation of Quality of Life, which is difficult to measure despite being widely used in prior disaster studies (Nussbaum, Sen, and World Institute for Development Economics Research 1993; Shalaby et al. 2024; Blome and Augustin 2015). Respondents were predominately older White homeowners, which should be considered given the breadth of disaster research highlighting how strongly demographic characteristics influence disaster experiences and disaster recovery trajectories (c.f. Davies et al 2018; Do et al 2019 ; Cutter et al 2014; Uscher pines 2009) (Davies et al. 2018; Cutter, Schumann, and Emrich 2014; Uscher-Pines 2009; Do 2019). The overrepresentation of homeowners has been noted by Chase and Hanson's (2021) exploration of Camp Fire displacement, and our methods reflect a similar property bias. These differences indicate a

potential for reduced generalizability of our findings, but do not invalidate the research question. Prior work on displacement and place attachment (c.f. Greer et al 2020) have sought to address the property bias by limiting the scope of their study to property owner, citing Brown‘s (2004) finding that renters experience place attachment differently (Greer et al. 2020). Given that this study more broadly explores quality of life and has a larger proportion of renters than do Greer et al, (7.7% vs 3.4%) we did not exclude renters, or indeed any households from our analysis on the basis of sociodemographic characteristics. The present study contributes to the disaster literature by evaluating the disproportionately low QoL of the locally displaced, who are not in the position to rebuild. Our findings fill this gap—in the attachment and displacement literatures which overlook locally displaced households in favor of residents which re-settle within the immediately affected community.

Location turned out to be a significant predictor of QoL, and I found that locally displaced people were much less likely to report and increase in QoL. Age was a significant predictor of a positive change in QoL, as were a sense of belonging and wanting to remain in their current location. Living in a Ridge Community for most or all of a respondent's life was associated with a decrease in the likelihood of a positive QoL change, as was wishing that they lived in a safer location. This paper succeeds in highlighting the role of post-disaster location on quality of life, although future research can explore the exact mechanisms which inform how QoL changes over time. Descriptive visualizations of qualitative results, such as Figure 4.5 above, can help highlight relative “highs” and “lows” and illustrate the uneven regional impacts of disaster QoL. Increased attention on locally displaced households is important because after the acute phase of the disaster has ended, there is often little to no long-term resources available.

Conclusion

This research focuses change in QoL, finding that locally displaced households were much less likely to report a positive change in QoL compared to both the households that remained near the Camp Fire footprint and those households that moved outside of Butte County. The high QoL levels reported by households in Ridge Communities follow results of previous disaster studies which explore place attachment. However, locally displaced households did not reflect the same level of satisfaction and instead indicated their willingness to return to the disaster area at a higher rate than those that moved out of Butte County (an average distance of 15 miles or greater). I posit that these locally displaced households fall in a knowledge gap between the displacement and migration literatures, with locally displaced households as a high-risk group among wildfire-affected households. The combination of low QoL and a low sense of risk was unexpected given the prevailing theories of contemporary disaster scholars. Clarifying the factors that influence whether a household wishes to return or relocate after a disaster is a key component of disaster recovery, and can help communities, professionals, and scholars to align safety and satisfaction for displaced households.

In this paper, I investigate the factors and impact that displacement location had on the different levels of quality of life following the 2018 Camp Fire. To the best of my knowledge, there has been little geographical research that studies the persistent impacts of disasters on locally displaced populations. To date, most scholarship in this space has focused either on returning households, or, for households that had relocated, why they had selected their destination. In theorizing the 'missing middle' of disaster displacement, this paper fills an important gap by linking local displacement to a high willingness to return, but a lack of resources to have agency.

Data Availability

The data cannot be made publicly available upon publication because they contain sensitive personal information.

Ethical Approval

All protocols of the Ridge Recovery Survey were reviewed and approved by The University of California, Davis Institutional Review Board before any recruitment or data collection.

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CHAPTER 5. CONCLUSIONS AND FUTURE RESEARCH

This dissertation research explored relationships between post-wildfire needs, Quality of Life, and sociodemographic factors. Utilizing a mixed methods research design, this research effort integrated findings from across the broad literature on disaster recovery to better understand how wildfires impact households. Chapters 2 and 3 used data from the "***W***ildfires and ***H***ealth: ***A***ssessing the ***T***oll in ***No***rthern ***Ca***lifornia Study" to examine and identify how respondent households' needs were impacted by the 2017 and 2018 California wildfires. Chapter 4 drew on original survey data collected from the "Ridge Recovery Survey IRB (1958929-1)" to understand the social and geographic factors that influenced change in Quality of Life for respondents affected by the 2018 Camp Fire. The findings from these surveys inform the findings of my dissertation and provide information that is useful to county and state health departments, disaster preparedness and response agencies, and non-profit organizations to prepare for and respond to future wildfires.

My dissertation research also provides valuable insights into the long-term impacts of wildfires, such as who is most affected by them and how fire impacts are felt over time and across different communities. This research addresses a significant gap in the literature on wildfire recovery that focuses on the economic and physical impacts of wildfires but pays less attention to where survivors go after a wildfire and the longer-term impacts wild-fire motivated migration. Moreover, prior work has not fully explored the intersectionality of social statuses (e.g. race, class, and gender) and how they too are linked to post-wildfire needs. Research that takes a broader view, that considers the regional impacts of disasters beyond simple economic impacts is needed. By applying concepts from the broader literature on "Social Vulnerability" and "Quality of Life," my dissertation uses insights from the broader array of disaster scholarship and explores environmental and social interactions to understand post-fire contexts better. For example, utilizing qualitative methods to define vulnerability as I do, represents progress in wildfire risk research, as the majority of previous work has focused on quantitative methods.

My research specifically contributes to the fields of disaster impacts and wildfire recovery in several ways. First, this study investigated (1) post-wildfire needs and (2) how they differed across wildfire seasons; (3) how socioeconomic factors affected need duration; and (4) change in Quality of Life to assess wildfire impacts. This research utilizes open and close-ended qualitative data to test other pertinent factors in the location and distribution of wildfire impacts in the form of post-fire needs, need duration, and change in Quality of Life. In addition to coding the open-ended needs of 3,038 households to identify household needs at two-time points following the California wildfires, this scholarship reflects on the factors that can enhance recovery and the broader factors that contribute to persistent housing and information needs. As

such, this dissertation contributes to the broader mixed-methods research on wildfires by exploring the multifaceted dimensions of wildfire impacts and the moderating effects of class, race, and gender but also place on household Quality of Life. The mixed-method approach of the research provides new data and analyses to better understand the complex relationships shaping place attachment, displacement, and Quality of Life.

Specifically, Chapter 2 deploys a mixed methodology to answer t two key questions: 1) What was your household's greatest need one week after the wildfires*?* And 2) What is your household's greatest need currently? Of the 4,095 households that participated, 74% (n=3,038) answered one or both of the open-ended questions, and had their responses coded into four major thematic needs categories: Physical, Health, Air, and Information[1]. Cross-tabulation statistics were used to describe the relationship between reported post-wildfire needs and wildfire season. We set the 2017 and 2018 wildfire seasons as the rows and the reported needs by major themes across the immediate and time of survey time categories. Hypotheses drawn from the wildfire recovery literature (Davies et al. 2018; G. Simon 2017) state that wildfire impacts vary by race, class, and other socio-economic factors. My findings substantiate variation across wildfire seasons but note that differences across wildfire seasons were not as pronounced as might be expected. Implications of this research demonstrate the potential of confounding factors that might influence household-level needs being met or persisting over time such as age, housing tenure, and insurance coverage.

Chapter 3 uses ordinal regression to identify key associations between post-wildfire needs and socio-demographic factors. A series of ordinal logistic regression models were performed to investigate how well respondent sociodemographic variables (age, sex, race, length

[1] Qualitative data collection strategies, including the codebook are discussed in Appendix A.

of residence, employment, and education) and household characteristics (home tenure, household size) predicted duration of post-wildfire needs (i.e., adequate clothing, cellular phone service, electricity, enough money to cover living expenses, food, internet access, safe drinking water, shelter, and transportation). The model included nine predictors and allowed for simultaneous entry of all independent variables. The primary hypotheses held that many of the commonly used variables associated with "Social Vulnerability Indices" would predict post-wildfire with greater concentrations of needs among elderly, minority, uneducated, and female-headed households. Results confirm these trends and demonstrate the importance of including and expanding measures that represent social vulnerability to include need types such as information and adequate transportation.

In Chapter 4, I again used logistic regressions to test my research hypotheses and examine the relationship between changes in informant assessments of Quality of Life (QoL) and location and sociodemographic variables. This technique has been used to estimate post-fire migration intent and satisfaction in QoL contexts. Binary regression is well suited for this analysis because it quantifies the strength of the association between a set of independent explanatory variables and a binary dependent variable. Considering this relationship between change in satisfaction and location can help clarify the extent to which location and other variables play a role in QoL. My findings indicate that locally displaced households are much less likely to report a positive Quality of Life changes compared to households still living within the Camp Fire footprint and households that moved outside of Butte County. One implication of my findings is that the local displacement of people due to wildfire (i.e., for my research, those currently living 10-30 miles from the final fire perimeter) necessitates further research.

In pursuing these issues, I hope to add to our understanding of how wildfires impact at the household level, especially "vulnerable households," and how recovery is multifaceted and influenced by racial minority status, poverty and socioeconomic status, age, and/or gender status. There is an important gap in the attachment and displacement literature that overlooks locally displaced households in favor of residents that re-settle within the immediately affected community or seek to understand the priorities that drive more distant (>30 mi / 50km) relocation (Johnston et al. 2021). Increased attention on locally displaced households is important because after the acute phase of the disaster has ended, there can be little to no long-term resources available. Few studies have theorized or empirically examined how post-wildfire needs might interact with other sociodemographic factors to predict longer-term impacts to health, stable housing, and overall assessments of Quality of Life. This is an important contribution to the disaster literature, particularly longitudinal studies, of recovery as these remain an emergent area of research (Norris 2006).

Broader Impacts

This dissertation has several broader impacts. In it, I have identified persistent, widespread needs that extend beyond a single county or community, highlighting barriers to recovery. Additional systematic research into the long-term needs and impacts that can follow wildfires is required, work that will require particular attention to vulnerable populations, which this dissertation identifies. Incorporating monitoring and evaluation efforts following disasters such as wildfires in order to more closely understand how impacts vary should be a high priority across local, state, and federal disaster response agencies. Doing so may require workforce development in several areas, and our data spotlight the need for immediate and long-term mental health and housing support services. A comprehensive approach to preparedness and recovery could help match heavily impacted households not only with available shelter, but also

available mental health resources. Symptoms of mental health problems may not manifest until long after the disaster event, potentially years later, underscoring the need for longitudinal study. This dissertation reflects the needs of participating households and further work is required to better understand how these needs change over time and how to assess and address the needs reported above.

Limitations

There are several limitations to this dissertation. First, the lack of continuous longitudinal data makes it difficult to argue causality since retrospective reporting of needs shortly after wildfires the present data can only measure existing relationships, especially with measurements of Quality of Life (see Blome and Augustin 2015). The qualitative data used above does not resolve the issue of whether households that left portions of the survey blank had needs or had their needs met. However, the primary aim of this research, through empirical analyses, is to show the variety of post-wildfire needs across diverse populations, to test the distribution of needs and relative need impact vis-à-vis need duration. Findings demonstrate that households affected by 2018 wildfires were relatively more affected by wildfires, and that age, race, and education influenced how long a household went without particular needs. Some respondents listed a variety of needs rather than individual "greatest" needs, and all listed needs were included. Our findings represent responses from 50 California counties but make no claims to broader representativeness of participant households to the broader population at the county or state level. Respondents were predominately older White homeowners, which should be considered given the breadth of disaster research highlighting the demographic characteristics influence disaster experiences and disaster recovery trajectories (Davies et al. 2018; Cutter, Schumann, and Emrich 2014; Uscher-Pines 2009; Do 2019). The overrepresentation of

homeowners has been noted by Chase and Hanson's (2021) exploration of Camp Fire displacement, and our methods reflect a similar property bias (Chase and Hansen 2021b).

Future Research

I have contributed to wildfire research on post-fire needs and will continue to investigate the factors influencing displacement and return intent following the 2018 Camp Fire. To the best of my knowledge, there has been little geographical research that studies the persistent impacts of disasters on locally displaced populations. To date, most scholarship in this space has focused either on returning households or, for households that had relocated, why they had selected their destination. In theorizing the 'missing middle of disaster displacement', my future work will fill an important gap by contextualizing the factors that influence local displacement.

My research findings will be disseminated through state and national conferences for academics, activists, and peer-reviewed Academic journal articles. Researchers in Geography, public health, and other environmental studies that intersect with hazard and disaster research can benefit from the empirical and theoretical contributions presented in my dissertation. Relatedly, I anticipate the findings will be useful to long-term recovery organizations and other aid and recovery organizations to address the variety of needs which emerge following a wildfire. Moreover, my findings may assist government leaders and agencies in developing local, state, and federal government guidelines and implementing monitoring and evaluation efforts to ensure that wildfire recovery efforts can reach vulnerable populations.

In my future research, I will continue to investigate the variety of wildfire impacts at multiple levels of analyses. After developing my dissertation into a series of articles, I plan to explore socio-environmental aspects of wildfire recovery through continued attention to how households have been affected by the Camp Fire over the long-term. By understanding the mechanisms that contribute to post-

wildfire resilience, I hope to add to this ongoing research that assesses recovery programs and outcomes to identify best practices that reduce needs and contribute to household and survivor resilience.

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Appendix

Chapter 2 Supplemental Materials

Macro Categories	Definition	What it IS	What it ISN'T
Physical	non-medical and non-air related physical and material needs of respondents	housing, utilities, food, money	information, medical care
Health	mental health and physical health-related needs and impacts indicated by respondents	medical care, asthma, therapy, anxiety	food, water, money, information about health impacts from smoke
Air	air-related needs of respondents	air quality, smoke, air filters, masks, air purifiers, clean air for breathing	information about air
Information	any informational needs of respondents	status of fire, status of home, evacuation/warning systems, insurance information, information about health impacts, informational resources, how to help, communication from state or family members, etc.	medical care, money

Appendix Figure 1: Codebook Major Categories

Chapter 3 Supplemental Materials

Interactive web map of Post-wildfire needs:
https://environmentalhealth.ucdavis.edu/research/california-wildfires/statewide-health-survey/data-map

Alternative formatting of Table 3.2

(3.2a, 2.2b and 3.2c (below).

	Electricity	Internet	Cell service
Age 65+	0.77*	0.78†	0.93
Male	1.03	0.86	1.17
HH Size	0.94†	1.00	0.97
Evacuated	5.53**	8.28***	4.41***
Homeowner	1.30*	1.28*	1.20
White	0.98	0.91	0.94
Education (Above BA)	0.71***	0.64***	0.67***

Notes: † $p< 0.1$, * $p<0.05$, ** $p<0.01$, *** $p<0.001$

Table 2a Exponentiated Estimates Of Ordinal Regression Models Predicting Longer (Weeks – Months) Need Duration

	Food	Water	Shelter
Age 65+	0.81	0.85	0.83
Male	1.50*	0.93	1.58*
HH Size	0.94	0.99	1.08
Evacuated	10.77***	10.28***	25.69***
Homeowner	0.67*	1.30†	0.74†
White	1.35	0.73*	1.01
Education (Above BA)	0.50***	0.73*	0.80

Notes: † $p< 0.1$, * $p<0.05$, ** $p<0.01$, *** $p<0.001$

Table 2b Exponentiated Estimates Of Ordinal Regression Models Predicting Longer (Weeks – Months) Need Duration

	Clothing	Transport	Finances
Age 65+	1.47†	0.96	1.08
Male	0.98	1.64*	0.95
HH Size	1.04	1.08	1.18***
Evacuated	58.73***	7.12***	12.26***
Homeowner	0.84	0.63*	0.34***
White	1.59**	1.02	1.07
Education (Above BA)	0.54***	0.48***	0.41***

Notes: † $p< 0.1$, * $p<0.05$, ** $p<0.01$, *** $p<0.001$

Table 2c Exponentiated Estimates Of Ordinal Regression Models Predicting Longer (Weeks – Months) Need Duration