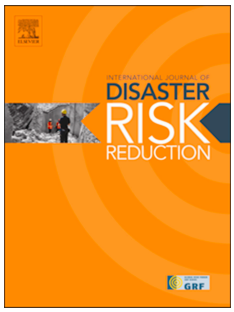


Housing and Economic Recovery as Interdependent Pathways in the Wake of Wildfires

Nicole Lambrou, Crystal Kolden, Anastasia Loukaitou-Sideris, Xijing Li

PII: S2212-4209(25)00644-2

DOI: https://doi.org/10.1016/j.ijdrr.2025.105820

Reference: IJDRR 105820

To appear in: *International Journal of Disaster Risk Reduction*

Received Date: 13 April 2025

Revised Date: 23 June 2025

Accepted Date: 13 September 2025

Please cite this article as: N. Lambrou, C. Kolden, A. Loukaitou-Sideris, X. Li, Housing and Economic Recovery as Interdependent Pathways in the Wake of Wildfires, *International Journal of Disaster Risk Reduction*, https://doi.org/10.1016/j.ijdrr.2025.105820.

Housing and Economic Recovery as Interdependent Pathways in the Wake of Wildfires

Author Team:

* Nicole Lambrou, PhD (corresponding author)
nlambrou@cpp.edu
Assistant Professor, Department of Urban and Regional Planning
College of Environmental Design
Cal Poly Pomona
3801 W Temple Ave, Pomona, CA 91768

Crystal Kolden, PhD
ckolden@ucmerced.edu
Director, UC Merced Fire Resilience Center
Associate Professor of Fire Science
University of California, Merced
5200 N Lake Rd, Merced, CA 95343
(209) 228-4400

Anastasia Loukaitou-Sideris, PhD
sideris@ucla.edu
Distinguished Professor of Urban Planning, University of California, Los Angeles
Interim Dean, Luskin School of Public Affairs, University of California, Los Angeles
UCLA Public Affairs, Box 951656
Los Angeles, CA 90095-1656
(310) 206-9679

Xijing Li, PhD
sideris@ucla.edu
Distinguished Professor of Urban Planning, University of California, Los Angeles
Interim Dean, Luskin School of Public Affairs, University of California, Los Angeles
UCLA Public Affairs, Box 951656
Los Angeles, CA 90095-1656
(310) 206-9679

Housing and Economic Recovery as Interdependent Pathways in the Wake of Wildfires

Introduction

The escalation of wildfires in the American West has resulted in significant changes to both the physical environments and socio-economic structures of impacted communities. In California, wildfires have worsened existing shortages in affordable housing and have undermined economic stability and community resilience. This study examines post-wildfire recovery in two California communities and draws attention to the interrelated concerns of housing and economic recovery. While prior research has emphasized that recovery must extend beyond physical rebuilding (Alexandre, 2013; Tierney, 2014), these case studies highlight how mismatches between local economic capacity and housing demand can fundamentally shape recovery trajectories. We present an integrated housing-economic approach to advance a more precise framework for understanding how employment structures, investor activity, and shifting demographics intersect with the rebuilding process. This methodology offers insights into the interplay between local economies—whether reliant on agriculture, tourism, or varied urban services—and the dynamics of housing recovery processes.

Conventional models for assessing vulnerability in post-disaster landscapes have been criticized for their reliance on census tract–level and other spatially aggregated socio-demographic data (Peacock et al., 2014), such as median household income, percentage of households in poverty, or proportion of elderly residents, which frequently obscure the distinct experiences of renters and seasonal workers, among other populations disproportionately affected by escalating housing

costs and precarious employment following a wildfire. While SoVI can help target recovery funding, it often fails to reflect the complex, place-specific nature of resilience (Lambrou et. al., 2023).

Analyzing recovery pathways that communities undergo after a disaster, as we do here, sheds light on the need to align recovery programs with local economic conditions and the needs of at-risk populations (Berke & Campanella, 2006; Smith & Wenger, 2007). Rural communities, especially those reliant on agriculture, face distinct and prolonged recovery challenges (Schnugg, 2014). Conversely, urban areas face increasing housing affordability challenges as surging property values and speculative investments lead to further displacement of low-income people (Tierney, 2019).

Following wildfires, recovery efforts often prioritize housin reconstruction of housing; however, rebuilding physical structures alone does not guarantee the restoration of a community (Comerio, 1998; Vale, 2014). While new homes may replace those lost, the residents who once lived in them, particularly renters, low-income workers, or elderly populations, may be permanently displaced due to limited resources or the absence of local jobs and services. Wildfires trigger simultaneous shocks to housing and local economies, leading to displacement and prolonged instability. Unlike conventional boom-bust cycles driven by market forces, these disasters abruptly erase both residences and job bases, undermining the conditions necessary for return and recovery. Industries that support neighborhoods vanish—not due to market competition or mismanagement—but because a disaster has destroyed infrastructure, displaced consumers and workers, and erased the job base that would otherwise anchor recovery. By examining data on

labor, housing, and vulnerability both pre- and post-wildfire disasters in two distinct communities in California, we aim to understand the interrelationship between housing and economic conditions and the impact on recovery pathways. We conclude with policy recommendations for integrating housing and economic strategies in recovery efforts, and emphasize the need for a holistic, inclusive approach to disaster recovery that accounts for the social, economic, and housing vulnerabilities exposed by wildfires.

Housing, Recovery, and Vulnerability After Wildfires

Social Vulnerability Indexes and Recovery

Social Vulnerability Indexes (SoVI) help identify communities in need of support during and after disasters. One concern about SoVIs is their level of sensitivity to the causes and effects of environmental and social change that are complicated and defy straight-forward assessments. Indexes are tools that quantify and simplify the complicated reality of a situation (Farell and Hart 1998). Since the 1990s, numerous indexes have been created to gauge susceptibility to environmental or societal change, such as assessments to quantify the vulnerability of social systems to climate change (Adger et al. 2004; Vincent 2004). The Centers for Disease Control and prevention (CDC) has developed a SoVI index that measures vulnerability by referring to 16 sociodemographic characteristics, while California's CalEnviroScreen tool combines 13 pollution characteristics with 8 sociodemographic variables to develop an index to assess community vulnerability and direct its funding accordingly.

The SoVI developed by Cutter et al. (2003) has become an important tool for evaluating community susceptibility in disaster settings, including wildfires. SoVI incorporates socioeconomic characteristics into its model, including income levels, education, age, race, and

housing conditions, to yield a composite score that reflects a community's vulnerability to catastrophic impacts. This tool has proven helpful to policymakers wishing to equitably distribute resources to socially disadvantaged groups (Cutter et al., 2003; Flanagan et al., 2018).

Although SoVI offers essential insights into vulnerability patterns, current research also highlights its limits, especially for wildfire recovery efforts in rural and socioeconomically varied regions (Peacock et al., 2014). Specifically, SoVI's reliance on higher-level geographic scales at the county or census-tract levels neglects vulnerabilities that often take place within these broader regions, such as those encountered by temporary or seasonal workers, who face increased risks during recovery (Mendez et al. 2020; Davies, Hughes, & Mitter, 2018).

SoVI does not reflect the housing-economic dynamics that often define wildfire recovery. Integrating this connection would yield a more nuanced comprehension of the impact of economic volatility on housing stability, especially for low-income renters and seasonal workers—often neglected by conventional vulnerability evaluations (Mendez, 2020).

Housing Vulnerability in the Post-Wildfire Context

Despite the presence of non-profit and voluntary organizations that often step in after a wildfire disaster to help impacted individuals and act a liaisons between them and state agencies, research indicates that barriers to recovery from wildfires persist and often result in displacement. Housing prices tend to increase in post-wildfire-affected places (McCoy and Walsh, 2018), and new development often increases at a more rapid rate than reconstruction (Alexandre et. al., 2014). Additional barriers to recovery include the presence of underinsured households, post-disaster price spikes, and required changes to the original structure because of new building

codes (Mockrin et. al., 2015). The loss of affordable housing for displaced tenants can also result in involuntary relocation, job loss, and fragmentation of social networks, all of which are essential for social resilience (Fothergill & Peek, 2004).

Post-disaster recovery is also impacted by the type and ownership of housing (Lu et. al., 2007). In the US, owner-occupied homes are prioritized when it comes to post-disaster financing, while financing repairs for rental units is more infrequent (Zhang and Peacocke, 2009). Access to housing recovery funding may be restricted by eligibility requirements, but also by federal program goals and decision-making processes (Smith, 2011). There are also notable distinctions between rural and urban areas in terms of post-wildfire recovery, because economies of scale for rebuilding are often lacking in rural locations, often resulting in higher rebuilding costs compared to areas with denser housing (Safapour et. al., 2021). Additionally, post-wildfire trends of housing recovery, redevelopment, or resettlement may be influenced by regional and national economic conditions (Davis et. al., 2014).

Traditionally, wildfires have created housing crises by removing significant portions of the housing stock and making existing affordability challenges that arise during rebuilding processes worse, especially for renters and low-income residents (Alexandre et al 2014, Lambrou et al 2023). Speculators may seek to acquire distressed or abandoned properties at reduced prices by hedging future gains (Mockrin et al., 2020). Such speculations, in turn, lead to less affordable options for primary housing, compounded by the rise in absentee ownership in wildfire-impacted communities that exacerbate shortages and lead to displacement (Weber et al., 2020; Peacock et al., 2014; Lambrou et al., 2025).

Housing and Economic Interdependency

Though the recovery of different parts of the built environment - schools, medical infrastructure, housing, among other - are often targeted through different policies and funding sources, recovery of a community as a whole requires a coordinated effort. In a comprehensive review of the literature, researchers identified key barriers to effective post-disaster recovery; infrastructure and housing reconstruction were cited as the most significant obstacles, with economic factors like employment and small business activity also cited as critical issues (Rouhanizadeh et. al., 2020). Wildfire-induced disturbances are unique in that they concurrently devastate residential and economic infrastructures. Thus, simply rebuilding homes is inadequate for reinstating the affected community's socio-economic structure. Wildfire-induced disturbances concurrently devastate residential and economic infrastructures, posing distinct recovery challenges.

Housing affordability and availability are especially important in areas with economies dependent on singular sectors, such as agriculture or tourism, where seasonal labor constitutes a substantial segment of the workforce. For example, in more rural wildfire-prone areas like California’s wine country, local economies are influenced by agricultural output as well as the accessibility of affordable housing for the workforce that supports these sectors (Weber, Moore, & Toman, 2020). Wildfire-driven housing shortages displace low-income and seasonal workers, limiting labor availability in sectors like agriculture and hospitality and delaying economic recovery (Peacock et al., 2014; Keenan & Chakrabarti, 2021).

Investigating the impact of fires on local labor markets, Coulombe and Rao (2023) find that heightened fire exposure results in diminished employment growth in both the short and medium

term, with medium-term impacts especially associated with migratory trends. The concept of *hysteresis* in labor economics (Blanchard and Summers, 1986) further points out that temporary economic disruptions can produce long-term effects on employment because of skill degradation and disenchantment among unemployed populations.

Methods

For this study we selected two recent California wildfires: the Camp Fire of 2018 that affected the Town of Paradise and several unincorporated communities in Butte County, and the Tubbs Fire of 2017 that affected Santa Rosa in Sonoma County. These fires struck communities with mid- to low-level vulnerability indexes prior to the events, which experienced shifts in vulnerability and housing in/stability in different ways post-fire. We chose these fires because they represent two different wildfire-impacted settings within California: a rural, resource-limited community and a suburban/urban core with more robust regional economic connections. Both fires are among the most destructive in state history but followed vastly different paths to recovery. Through comparison of these two cases, both associated with significant structural loss but with distinct underlying economic bases, we are better able to disentangle the relationship between local economic structure and housing market dynamics and the type of post-disaster resilience that emerges.

Between 2021 and 2023, we conducted 34 semi-structured interviews and 9 focus groups across the two study sites. In Butte County, this included 25 interviews and 7 focus groups; in Sonoma County, 9 interviews and 2 focus groups. Participants included local government officials, planners, nonprofit and community leaders, housing advocates, and residents affected by wildfire

recovery. Interviews and focus groups explored perceptions of housing recovery, displacement, governance, and barriers to rebuilding. All sessions were transcribed and thematically coded using Atlas.ti software, following an inductive approach to identify key patterns and recurring themes. Qualitative insights from this analysis are integrated throughout the paper to contextualize and interpret quantitative findings.

For each fire, we analyzed certain sociodemographic characteristics, housing and economic data, and vulnerability scores before and after the fire, and conducted interviews and focus groups with local agencies and community stakeholders from each area affected by the two fires (Table 1).

Table 1. Data Sources and Corresponding Variables Referenced in this Study

We analyzed a range of sociodemographic characteristics, including age distribution, income levels, poverty rates, homeownership rates, and educational attainment (Table 2). These variables were selected to capture key dimensions of social vulnerability and economic stability relevant to post-disaster recovery.

Table 2. Paradise and Santa Rosa Characteristics Pre- and Five Years Post-Wildfire Event

Housing

We examined California Department of Forestry and Fire Protection Damage Inspection (DINS) data, summarizing structure loss resulting from each fire. We also determined primary and secondary homeowner counts before and after the fires to understand shifts in residence patterns. Property owners were categorized as primary homeowners if the tax mailing address matched the

property's physical (situs) address, suggesting owner-occupancy; and as secondary homeowners (or absentee owners) if the two addresses differed. While this proxy allows us to estimate changes in ownership and occupancy status, it does not directly identify renters, who are often absent from parcel-level datasets. Therefore, although increases in absentee or secondary homeownership post-fire suggest a potential rise in investor ownership or rental conversions, we cannot quantify renter displacement from parcel data alone. To address this limitation, we rely on qualitative sources—including stakeholder interviews, focus groups, and local recovery reports—to understand how renters experienced post-disaster recovery, including barriers to return, changes in rental availability, and affordability challenges. This mixed-methods approach allows us to highlight differential impacts across tenure types, despite data constraints.

Economy

To analyze changes in industry and firm characteristics in the study area before and after the two wildfires, while also maintaining a relatively high spatial resolution, we utilized the Origin-Destination Employment Statistics (LODES) data provided by the U.S. Census Bureau's Longitudinal Employer-Household Dynamics (LEHD) program (US Census Bureau, nd). LODES provides employment data at the census block level and includes information about the industry classification of workplaces, the number of jobs at each location, and characteristics of the employers, such as firm size and firm age. These data are particularly useful for examining neighborhood-level economic changes over time. We first generated 5-mile and 10-mile buffers around the wildfire-affected areas and used the "Select by Location" tool to identify all census blocks within these buffer zones (Figure S1). After selecting these blocks, we joined their attribute tables with the LODES data. This approach allowed us to calculate, for each block within the wildfire buffers, the employment data for each 2-digit North American Industry

Classification System's industry category, as well as annual private firm employment size and firm age information for every year from 2009 through 2022.

To understand the diversity of local businesses we looked at the Herfindahl-Hirschman Index (HHI), a measure that reflects the concentration level of industries within a given area. The index ranges from 0 to 1, with higher values indicating greater industrial concentration and lower values representing more land use diversity (Brezina et al, 2016). We calculated the HHI by using the share of employment in different industries relative to total employment.

Social Vulnerability Index

We referred to the SoVI from the Centers for Disease Control and Prevention (CDC) / The Agency for Toxic Substances and Disease Registry (ATSDR) for the years 2016, 2018, 2022. SoVI values indicated measures of social vulnerability at the census tract level, as well as changes in social vulnerability, from 2016 or 2018 to 2022. Using ArcGIS, we rasterized the social vulnerability shapefiles for 2016, 2018, and 2022. The CalFire Fire Perimeter dataset allowed us to filter out data related to the Tubbs and Camp Fires, rezone social vulnerability using the fire polygons, and calculate the proportionate average of the change in social vulnerability for the areas involved in these two fires.

Wildfire Impacts

The wildfire impacts in Paradise and Santa Rosa illustrate contrasts in recovery and vulnerability. Paradise, a small rural town (population 26,800) located roughly 90 miles north of Sacramento, experienced the devastating 2018 Camp Fire that destroyed over 80% of its structures and displaced a population disproportionately characterized by low income and

advanced age, as documented in Chase and Hansen (2021) and confirmed by local assessor's property data (Butte County Assessor's Office, 2018). In contrast, Santa Rosa, in the North Bay region, about 60 miles from San Francisco, faced significant and different challenges during the 2017 Tubbs Fire, whose recovery efforts were marked by a quicker rebound, supported by stronger regional economic connections and resources.

Paradise, California (Camp Fire, 2018)

Prior to the Camp Fire, Paradise exhibited a significant concentration of older residents, as shown in demographic profiles summarized in Table 2 (US Census Bureau, 2017). Older adults often face mobility and health limitations that can impede evacuation and recovery, thereby increasing their vulnerability during disasters (Smith et al., 2016). With a median family income of $48,831—substantially below California's state average—and about 14% of residents below the poverty threshold, economic precarity shaped both the immediate and long-term recovery trajectories (ACS 2017 5-year estimates). The town's homeownership rate was relatively high at 70% prior to the Camp Fire, with average property values at $200,000 (Butte County Assessor's Office, 2018).

According to employment data from the Longitudinal Employer-Household Dynamics (LEHD) program (LODES, 2018-2022), the area's top three industries remained consistent following the wildfire. Between 2018 and 2022, accommodation and food services, education, and retail trade were the leading employment sectors in both Butte County and the Camp Fire-affected neighborhoods. Although healthcare ranked fourth in the Camp Fire area, the gap in total employment between healthcare and retail trade (the third-ranked industry) grew from 838 employees in the year prior to the wildfire to 1,408 employees in 2019, following the Camp Fire.

As reported in an interview with the Butte County Chamber of Commerce representative (interview by author, November 2023), the Camp Fire led to the displacement of a substantial portion of the population, eroding the customer base essential for the viability of many local businesses. As a result, small businesses, though not directly destroyed by the fire, were permanently closed, while significant delays disallowed restarting others (interview by author, November 2023). Lastly, the destruction of the local hospital, Adventist, a key employer in Paradise and an essential provider of healthcare who decided not to rebuild, introduced further economic and social disruption.

While the Camp Fire significantly altered Paradise's economic landscape and heightened its vulnerability, what gained the most attention was the destruction of 18,000 structures, including over 9,000 residences, commercial establishments, and critical infrastructure. This impact was especially severe for older and medically vulnerable residents, who depended on local care and faced growing challenges in remaining in or returning to Paradise (interviews by authors, 2023 and 2024).

Santa Rosa, California (Tubbs Fire, 2017)

Before the Tubbs Fire, Santa Rosa had a population of over 175,000 inhabitants, with a median family income of $65,000 and a poverty rate of nearly 11%. Despite the seeming low vulnerability, the city had a diverse housing profile, with 54% homeownership rate. A significant number of people worked in healthcare, tourism, and retail trade—industries with earnings frequently inadequate to cover the elevated cost of housing. With a median home value of

$500,000, Santa Rosa's housing market put considerable pressure on lower-income families, leading to persistent housing insecurity even before the fire.

The fire resulted in extensive property and commercial losses, significantly affecting the local economy. Following the fire, Sonoma County's retail industries, which previously ranked among the top three industries with the highest employment (LODES, 2017–2022), were replaced by other labor industries, and the same was true in the fire-affected area, which lies at the intersection of three counties (Figure S2). The fire destroyed hotels, vineyards, restaurants, and retail outlets that were critical to the local economy. The hospitality and tourism sectors, vital to Sonoma County, saw a temporary decline during the recovery period (LODES, 2017–2022). This resulted in major losses for local businesses dependent on tourism, a downturn that disproportionately impacted lower-wage workers, including undocumented vineyard laborers.

There was also a shift in the top three industries within the 10-mile buffer of the Tubbs Fire, following the event. Before the wildfire, the top three industries in the neighborhoods impacted by the fire mirrored those in Sonoma County: healthcare, accommodation, and retail trade. Post-fire, education replaced retail trade, surpassing it by about 200 employees by 2018; and employing 400 more people than retail trade in 2022, after disruptions from COVID-19. In contrast, Sonoma County as a whole did not experience a similar shift.

Recovery Pathways

Camp Fire (Town of Paradise, California)

The recovery strategy in Paradise after the devastating 2018 Camp Fire was multi-faceted, with primary efforts focused on rebuilding homes and infrastructure, while also supporting the town's economy. The extent of destruction was vast, with nearly the entire community impacted, necessitating a complex and coordinated recovery process involving local government, state resources, and federal aid. Rebuilding processes adhered to stricter fire safety codes to enhance resilience against future fires, including adopting newer building code standards and implementing additional planning to improve evacuation routes (Cova et al., 2017, Horney et al., 2018).

The loss of the Adventist hospital, a major employer in the area, and small businesses led to employment loss that yet to be mitigated (interview by author, 2023). Farmers and laborers, especially seasonal workers dependent on agricultural jobs, found few employment opportunities in the immediate aftermath of the fire, and recovery in the agricultural sector has been slow (interview by author, 2023). A layer of invisible vulnerabilities compounded these struggles, especially for renters, older adults, and those heavily dependent on the local economy (interview by author, 2024). Many residents relocated, even when their house was not destroyed, driven by their inability to rely on local employment options. The destruction of local healthcare and retail jobs further destabilized the community, reducing employment opportunities but also services supporting daily life. As a result, many older and lower-income residents were unable to return (Chase and Hansen, 2021), highlighting the gap between statistical recovery and the lived experiences of the Town of Paradise's most vulnerable populations.

Five years post-wildfire the housing rebuild rate was 35%, and during this timeframe there was an increasing number of speculators who purchased lots or properties at the same time that survivor rebuild rates began to decline (Lambrou et al. 2025; Butte County Assessors Data, 2018 and 2023). By 2022, there was an increase in absentee homeownership (Figure 2), which further complicated recovery for local leaders focused on community-oriented rebuilding. Rising property values, driven by absentee owners and investor purchases, created the illusion of decreased vulnerability in census data (Table 1).

LODES data shows that total employment in new firms (operating less than three years) in Camp Fire-affected neighborhoods experienced a generally upward trend prior to 2018, peaking in 2017 (see Figure S3). Following the wildfire, new firms in the area were significantly impacted and exhibited a slow recovery. One year after the wildfire, total employment in new firms had declined by 9%. The onset of the pandemic further compounded these challenges, leading to additional reductions in total employment. By 2022, employment levels remained 15% lower than those recorded before the wildfire, indicating a prolonged period of underperformance and slow recovery. The overall trend of total employment in Camp Fire-affected neighborhoods shows a steep decline beginning in 2018 and continuing through 2021 (Figure 3).

In contrast, statewide LEHD employment data indicate a milder decline in new firm employment beginning in 2019, with recovery commencing by 2020, reflecting broader economic resilience relative to Camp Fire-affected areas. Since 2015 total employment in new firms across the state remained relatively stable. Between 2018 and 2019 employment grew by 0.3%. While the COVID-19 pandemic briefly drove down employment levels among California's new firms,

statewide recovery was relatively quick. By 2022, total employment in new firms had increased by 4.4% relative to 2018. This rebound stands in sharp contrast to the persistent employment deficits observed in Paradise.

Tubbs Fire (Santa Rosa, California)

Following the Tubbs Fire, the housing market became even more inaccessible, which continuing its impact local businesses that rely on employees who could no longer afford to live in the area (interview by author 2024). Rising rents and housing prices, coupled with reduced housing availability, intensified pressure on the service and industrial sectors already struggling with employee retention. The CDC's SoVI shows a slight decrease in vulnerability five years post-wildfire for this community (Table 1), largely overlooking vulnerabilities, particularly those of undocumented laborers in the vineyards (interview by author 2024). Rising property values and a competitive rental market compounded these issues, and Santa Rosa also experienced an increase in absentee homeownership (Figure 2) five years post-wildfire. Nevertheless, the rebuilding of homes was comparatively stronger than in Paradise (Figure 1).

With already-mobilized community-based organizations that shifted towards recovery support, Santa Rosa's recovery strategy centered on a collaborative approach involving local government, private businesses, and nonprofit organizations, working to address both immediate and long-term recovery needs (interview by author 2024). Given the destruction of thousands of homes, Santa Rosa faced a massive rebuilding challenge compounded by an intensified housing crisis that strained an already limited housing supply. In response, the city instituted new housing development incentives that included affordable homes and modified zoning restrictions to allow for denser developments of smaller units that was codified into the county's Housing Element of

the General Plan. The city also formed committees to supervise housing, infrastructure, and economic recovery (interview by author 2023).

Santa Rosa's economic recovery prioritized restoring critical industries alongside housing efforts. Tourism, an essential component of Sonoma County's economy, was supported through marketing strategies designed to encourage visitor return. Wineries, hotels, and other hospitality establishments were targeted for recovery support. As a result, the tourism sector recovered within a year following the disaster (Sonoma County, 2018). Sonoma County *Economic Development Collaborative* further developed an action plan that included a goal to diversify business clusters (Sonoma County Economic Development Board, nd).

Data from LODES show that employment in new firms within neighborhoods affected by the Tubbs Fire fluctuated, but increased by 13.6% in 2017 relative to 2016, likely reflecting policy interventions supporting economic recovery. This rapid growth persisted, and by 2019, before the onset of the pandemic, new firm total employment had risen by 65.7% relative to pre-wildfire levels. Although the pandemic exerted downward pressures on employment, by 2022 total employment among new firms in this neighborhood remained 10% above pre-wildfire levels. This rate of increase far outpaced statewide figures, which saw only a 0.8% increase in new firm total employment from 2016 to 2019, and a 4.8% increase from 2016 to 2022 (LODES, Figure S3). Neighborhoods impacted by the Tubbs Fire demonstrated total employment trends that generally matched that of the state, with a notable dip during the years following COVID-19, but showing steady recovery after 2021 (Figure 3).

Notwithstanding Sonoma County's strategic initiatives, the recovery process encountered persistent hurdles. Significant infrastructure damage, including roads, water systems, and utilities, slowed the restoration of essential services, further delaying Santa Rosa's recovery (interview by author 2023). The lack of affordable housing persisted, undermining the city's economic stability and hindering businesses' ability to attract and retain staff. This was a continual impediment to recovery, especially for service sectors dependent on stable, local labor force.

Nevertheless, Tubbs Fire-impacted neighborhoods showed greater industrial diversity, evidenced by the lower HHI values over time, while Camp Fire-impacted neighborhoods have higher HHI levels, indicating a more concentrated industrial structure (Figure S4). Following the fire and before the onset of COVID-19, the HHI in the Camp Fire area increased sharply, suggesting that employment became increasingly concentrated in one or two industries. This pattern underscores the growing disparity in industrial diversity between these two neighborhoods over time.

Figure 1. Camp and Tubbs Fire Rebuild Rates by 2022, Stratified by Housing Type (Source: Butte and Sonoma County Assessor's Office)

Figure 2. Camp and Tubbs Fire Primary Resident vs Non-resident Owner Rates in 2017 and 2022 (Source: Butte and Sonoma County Assessor's Office)

Figure 3. Total Employment in Camp and Tubbs Fire-Affected Neighborhoods, and California State 2011-2022 (Source: LODES)

Cross-Case Analysis of Recovery Strategies: Insights from an Integrated Housing-Economic Framework

The increasing prevalence and severity of wildfires prompt critical examination of recovery strategies, particularly given their focus on rebuilding physical infrastructure (Pyne, 2017; Alexander, 2013). Examining the long-term recovery paths of Santa Rosa and Paradise helps us

understand that community recovery depends on housing reconstruction as well as revitalizing local economies and addressing persistent socio-economic vulnerabilities (Chang, 2010; Comerio, 1998). Recognizing that the distinction between urban and rural is often contentious, the cases of Santa Rosa and Paradise nevertheless provide a comparative framework that highlights the ways in which urban and rural recovery pathways can diverge in ways that impact recovery rates.

Researchers argue that urban centers with diverse economies are more capable of sustaining recovery due to their capacity to attract investment, assist displaced inhabitants, and stabilize housing markets (Peacock et al., 2014; Chang, 2010). Urban recovery hinges on the integration of economic resilience measures with housing reconstruction, creating a feedback loop that sustains community recovery beyond the immediate post-disaster period.

In Santa Rosa, the city's diversified economy—including sectors like healthcare, retail, and technology—enabled a multi-pronged recovery approach, where both housing and employment were prioritized. By supporting local businesses and maintaining workforce stability, Santa Rosa's recovery approach exemplifies a model in which economic and housing recovery reinforce one another, reducing displacement risks; Paradise, in contrast, lacked the employment base to support population return. Comerio (1998) and later Davies et al. (2018) demonstrate that rural communities with constrained economic foundations experience extended recovery periods, given that remaining industry is unable to accommodate returning people or draw new economic prospects. In Paradise, these constraints resulted in a lower population resurgence, coupled with

an increase in new, largely absentee homeowners, who presumably do not rely on local industry for household income.

This observation aligns with the CDC's SoVI scores, which show a decline in vulnerability four or more years after the initial disaster event, as well as with sociodemographic characteristics that indicate a younger, more educated population with a higher median income in Paradise. Further, SoVI may inadequately represent the ongoing economic fragility of Paradise, where a limited economic base exacerbated housing precarity, leading to prolonged outmigration and delayed recovery. Conversely, in Santa Rosa SoVI fails to consider intra-urban disparities, where low-income renters and undocumented populations, face heightened displacement risks as post-disaster housing prices surge (Fussell et. al., 2017; Pais and Elliott, 2008). These findings highlight how traditional recovery models that prioritize physical rebuilding overlook underlying economic fragilities. Our research shows that recovery frameworks must account for the unique vulnerabilities arising from limited economic structures that cannot independently support housing demand.

A Transformative Recovery Framework

Drawing from the cases of Santa Rosa and Paradise, this research reveals the limitations of conventional recovery models that prioritize physical rebuilding over socio-economic revitalization. Resilience depends as much on economic and social systems as on physical reconstruction. A housing-economic framework could be integrated into recovery planning to ensure that post-disaster efforts foster sustainable growth, reduce vulnerability, and support economic and housing security.

Previous research emphasizes aligning recovery efforts with local economic and social contexts (Berke and Campanella, 2006). Here, we propose that economic diversification and housing security can collectively shape a community's long-term resilience trajectory, particularly in response to climate-induced disasters. Traditional recovery frameworks often emphasize a "return to normal," focusing on physical reconstruction and using metrics like SoVI to allocate resources (Yi and Yang, 2014). Recent works indicate that recovery must be a transformative process that tackles underlying vulnerabilities, enabling communities to reconstruct in manners that bolster their long-term resistance to future shocks (Vale, 2014; Fussell, 2015). But how this can be implemented in disaster recovery settings remains vague. This study presents an integrated housing-economic paradigm as one facet in a recovery strategy, urging policymakers to prioritize economic diversity and housing stability equally.

A transformative recovery plan needs to combine housing stability and economic resilience in a way that acknowledges the lived reality of vulnerable communities. As represented in Paradise and Santa Rosa, there are different obstacles for groups such as low-income renters, undocumented and seasonal laborers, and older people, all of whom have relatively little access to aid, insecure jobs, and are excluded from formal planning processes. Including social vulnerability explicitly in recovery processes entails moving beyond aggregated indicators for place-based actions. These could range from tenant stabilization laws to informal labor protections, and local retraining initiatives and affordability mandates linked to any rebuilding (Table 3).

Table 3. Policy Recommendations in Post-Wildfire Recovery

Policy Implications for Integrated Recovery Models

To overcome the shortcomings of conventional vulnerability assessments like SoVI, which rely on static indicators not accurately reflecting socioeconomic realities of communities in long-term disaster recovery, policymakers ought to establish a dynamic vulnerability approach that integrates the housing-economic nexus into recovery evaluations (e.g. by linking LODES employment data with housing permits and migration patterns). This framework would incorporate local economic indicators, housing market metrics, and workforce characteristics, enabling a more tailored response to each community's unique recovery needs.

Establishing "Resilience Zones" in the areas most impacted by disasters would further support tailored economic and housing recovery efforts. In urban contexts, these zones could include incentives for affordable housing and business stabilization, while in rural areas, funding could support infrastructure improvements and economic diversification. Consolidating resources and support inside Resilience Zones would provide interventions that cater to the distinct requirements of various communities, maximizing the impact of long-term recovery initiatives. Federal and state recovery agencies may collaborate with local governments to formulate criteria for these zones, informed by damage assessments, economic profiles, and housing requirements.

Disaster recovery funding should include specific allocations for economic diversification and workforce development programs that match housing reconstruction demands (e.g., construction, healthcare, clean energy). For urban communities such as Santa Rosa, this entails incentives to bolster industries that stabilize housing demand and offer long-term employment, such as healthcare, technology, and local small enterprises. Rural regions such as Paradise, often

characterized by constrained economic foundations, would further benefit from investments in vocational training and incentives to attract new businesses.

Recovery programs must equally cater to the requirements of tenants, seasonal laborers, and economically disadvantaged families. Enacting post-disaster rent control, offering property tax relief for primary homeowners, and enforcing affordable housing mandates for new developments would reduce outmigration in rural areas and alleviate displacement pressures in urban regions, enabling long-term recovery pathways. Tax relief and subsidies should address both immediate and prolonged impacts of a disaster to support reconstruction and either resettlement or community retention. During recovery, prioritizing affordable housing solutions is essential to mitigate escalating housing costs; having such housing plans in place prior to a disaster can help reach more equitable recovery goals.

Integrating local economic resilience into pre-disaster planning would enhance community stability prior to the occurrence of disasters, and potentially during recovery processes. Local and regional resilience plans must incorporate strategies for economic diversification, basic services planning, and business support programs to mitigate potential worker relocation and resource deficiencies. State agencies may require the integration of resilience planning into local General Plans and Hazard Mitigation Plans (Zhang et al, 2025), providing technical help and financing to strengthen resilience projects, especially in socioeconomically disadvantaged areas.

Conclusion

The cases of Santa Rosa and Paradise underscore the necessity for a more comprehensive and nuanced understanding of vulnerability that considers economic variety and labor market stability, especially in rural contexts where conventional vulnerability evaluations such as SoVI may be inadequate. These cases highlight how housing and economic precarity reinforce one another after disasters. Community resilience cannot be measured or achieved solely through physical reconstruction; it demands an intersectional analysis of housing stability and economic viability, recognizing that together they form the backbone of sustainable recovery (Comerio, 2014; Fussell, 2015). Resilience theory emphasizes that recovery must address the complexities of community identity, social networks, and localized economic interdependencies (Aldrich & Meyer, 2015; Peacock & Ragsdale, 2012). An integrated housing-economic framework extends this discourse by highlighting how disruptions to housing and employment jointly shape the possibilities for social and economic recovery.

References

Aldrich, D. P., & Meyer, M. A. (2015). Social capital and community resilience. *American behavioral scientist*, *59*(2), 254-269.

Alexander, D. (2013). *Principles of emergency planning and management*. Oxford University Press.

Alexander, D. E. (2013). *Resilience and disaster risk reduction: An etymological journey*. Natural Hazards and Earth System Sciences, 13(11), 2707-2716.

Alexandre P.M., Mockrin M.H., Stewart S.I., Hammer R.B., Radeloff V.C. (2014) Rebuilding and new housing development after wildfire. Int. J. Wildland Fire, 24 (1), pp. 138-149

Berke, P., & Campanella, T. J. (2006). Planning for postdisaster resiliency. *The Annals of the American Academy of Political and Social Science*, 604(1), 192-207.

Blanchard, O. J., & Summers, L. H. (1986). Hysteresis and the European Unemployment Problem. *NBER Macroeconomics Annual*.

Brezina, I., Pekár, J., Čičková, Z., & Reiff, M. (2016). Herfindahl–Hirschman index level of concentration values modification and analysis of their change. *Central European journal of operations research*, *24*, 49-72.

Chang, S. E. (2010). Urban disaster recovery: A measurement framework and its application to the 1995 Kobe earthquake. *Disasters*, 34(2), 303-327.

Chase, J., and P. Hansen. 2021. “Displacement after the Camp Fire: Where Are the Most Vulnerable?” Society & Natural Resources 34 (12): 1566–1583. doi:10.1080/08941920.2021.1977879

Coulombe, R. G., & Rao, A. (2023). Fires and Local Labor Markets. *arXiv preprint arXiv:2308.02739*.

Comerio, Mary C. (2014) "Disaster recovery and community renewal: Housing approaches." *Cityscape* 16.2: 51-68.

Comerio, M. C. (1998). *Disaster hits home: New policy for urban housing recovery*. University of California Press.

Cova, T. J., Dennison, P. E., & Kim, T. H. (2017). Setting wildfire evacuation trigger points using fire spread modeling and GIS. *Transactions in GIS*, 21(6), 1333-1353.

Cutter, S. L., Boruff, B. J., & Shirley, W. L. (2003). Social vulnerability to environmental hazards. *Social Science Quarterly*, 84(2), 242-261.

Davies, I., Hossain, R., & Meyer, M. (2018). Social vulnerability to natural hazards: Insights from wildfire recovery in rural California. *Journal of Natural Hazards*, 93(1), 123-140.

Davies, I., Hughes, M., & Mitter, A. (2018). Learning from disaster recovery: A case study of government-community partnerships. *International Journal of Disaster Risk Reduction*, 28, 64-71.

Davies, I., Newton, J., & Thompson, J. (2018). Resilience and disaster recovery: Using the community capitals framework. *Journal of Urban Planning and Development*, 144(2), 05018007.

Davis E.J., Moseley C., Nielsen-Pincus M., Jakes P.J. (2014) The community economic impacts of large wildfires: A case study from Trinity County, California Soc. Nat. Resour., 27 (9), pp. 983-993.

Farell , A. and Hart , M. 1998 . What does sustainability really mean? The search for useful indicators . Environment , 40 : 4 – 9 . 26 – 31 .

Flanagan, B. E., Gregory, E. W., Hallisey, E. J., Heitgerd, J. L., & Lewis, B. (2018). A social vulnerability index for disaster management. *Journal of Homeland Security and Emergency Management*, 15(1), 9-23.

Fothergill, A., & Peek, L. A. (2004). Poverty and disasters in the United States: A review of recent sociological findings. *Natural Hazards*, 32(1), 89-110.

Fussell, E. (2015). The long-term recovery of New Orleans's population after Hurricane Katrina. *American Behavioral Scientist*, 59(10), 1231-1245.

Fussell, E., Curran, S. R., Dunbar, M. D., Babb, M. A., Thompson, L., & Meijer-Irons, J. (2017). Weather-related hazards and population change: A study of hurricanes and tropical storms in the United States, 1980–2012. *The Annals of the American Academy of Political and Social Science*, *669*(1), 146-167.

Horney, J., Nguyen, M., Salvesen, D., Dwyer, C., & Cooper, J. (2018). Assessing the impact of post-disaster recovery planning on disaster resilience. *Journal of the American Planning Association*, 83(2), 98-109.

Keenan, J., & Chakrabarti, P. (2021). Post-disaster housing and the challenge of recovery in wildfire-prone areas. *Journal of Disaster Risk Studies*, 13(2), 150-165.

Lambrou, N., Kolden, C., Loukaitou-Sideris (2025). Disaster Recovery Gentrification in Post-Wildfire Landscape: The Case of Paradise, CA. *International Journal of Disaster Risk Reduction*, 118.

Lambrou, N., Kolden, C., Loukaitou-Sideris, A., Anjum, E., & Acey, C. (2023). Social drivers of vulnerability to wildfire disasters: A review of the literature. *Landscape and Urban Planning, 237*, 104797.

Lu, J-C., W. Peacock, Y. Zhang, N. Dash, (2007) A comparative study of single-family and multifamily housing recovery following 1992 Hurricane Andrew in Miami-Dade County, Florida, in: Proceedings of the Hazards and Disasters Researchers Meeting, Boulder, CO, pp. 22–26.

Méndez, M., Flores-Haro, G., & Zucker, L. (2020). The (in)visible victims of disaster: Understanding the vulnerability of undocumented Latino/a and Indigenous immigrants. *Geoforum, 116,* 50–62.

Mockrin, M. H., Stewart, S. I., Radeloff, V. C., Hammer, R. B., & Alexandre, P. M. (2020). Recovery and adaptation after wildfire on the edge of the wildland–urban interface: Insights from communities in Colorado. *Society & Natural Resources*, 33(7), 923-940.

Olshansky, R. B., Hopkins, L. D., & Johnson, L. A. (2012). Disaster and recovery: Processes compressed in time. *Natural Hazards Review*, 13(3), 173-178.

Elliott James R., and Pais Jeremy. (2010). "When Nature Pushes Back: Environmental Impact and the Spatial Redistribution of Socially Vulnerable Populations." *Social Science Quarterly* 91(5):1187–202.

Peacock, W. G., Brody, S. D., & Highfield, W. E. (2014). Hurricane risk perceptions among Florida's single-family homeowners. *Landscape and Urban Planning*, 119, 13-26.

Peacock, W. G., Dash, N., & Zhang, Y. (2014). *Social vulnerability and hazards: Planning and policy implications*. CRC Press.

Pyne, S. J. (2017). *Fire in America: A cultural history of wildland and rural fire*. University of Washington Press.

Rouhanizadeh, B., Kermanshachi, S., and Napa, T.J. (2020). Exploratory analysis of barriers to effective post-disaster recovery. Int. J. Disaster Risk Reduc., 50, p. 101735

Safapour E., Kermanshachi S., Pamidimukkala A. (2021) Post-disaster recovery in urban and rural communities: Challenges and strategies. Int. J. Disaster Risk Reduct., 64

Schnugg, P. (2014). Community resilience and recovery: Local action for community resilience. *Community Development*, 45(1), 2-6.

Smith G.P. (2011). Planning for Post-Disaster Recovery: A Review of the United States Disaster Assistance Framework, Public Entity Risk Institute Fairfax, VA.

Smith, G. P., & Wenger, D. (2007). Sustainable disaster recovery: Operationalizing an existing agenda. *Handbook of Disaster Research*, 234-257.

Sonoma County Economic Development Board. (n.d.). Retrieved from https://sonomaedb.org/

Sonoma County, 2018. "Sonoma County Complex Fires: Housing and Fiscal Impact Report." Accessed on January 3, 2025. https://sonomaedc.org/Microsites/Economic%20Development%20Board/Documents/Archive/_Documents/Reports/_2018/Sonoma%20County%20Complex%20Fires%20Housing%20and%20Fiscal%20Impact%20Report%202018.pdf

Tierney, K. (2019). Disasters: A sociological approach. In *Handbook of Disaster Research* (pp. 43-58). Springer.

Tierney, K. (2014). *The Social Roots of Risk: Producing Disasters, Promoting Resilience.* Stanford University Press.

U.S. Census Bureau, Longitudinal Employer-Household Dynamics (LEHD) Program. Origin-Destination Employment Statistics (LODES). Available at: https://lehd.ces.census.gov/data/

Vale, L. J. (2014). The politics of resilient cities: whose resilience and whose city?. *Building Research & Information, 42*(2), 191-201.

Vale, L. J., & Campanella, T. J. (Eds.). (2005). *The resilient city: How modern cities recover from disaster*. Oxford University Press.

Weber, R., Moore, R., & Toman, E. (2020). Wildfire resilience and recovery in tourism-dependent communities: A framework for social science research. *Journal of Environmental Management*, 276, 111-222.

Yi, H. & Yang, J. 2014. Research trends of post disaster reconstruction: The past and the future. Habitat Int. 42, 21–29.

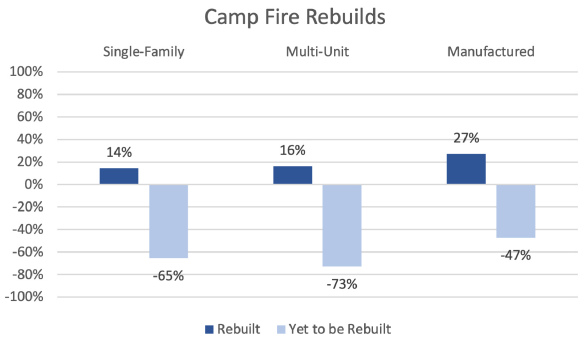
Zhang Y., Peacock W.G. (2009) Planning for housing recovery? Lessons learned from Hurricane Andrew J. Am. Plan. Assoc., 76 (1), pp. 5-24.

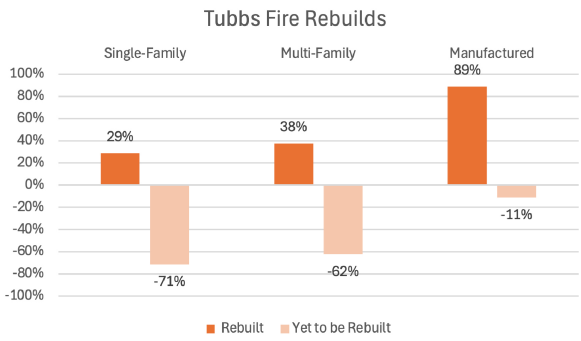
Zhang, C., Lambrou, N., Kolden, C., & Loukaitou-Sideris, A. (2025). Addressing Wildfire Resilience through Comprehensive County-Level Plan Effectiveness in California. *International Journal of Disaster Risk Reduction*, 105230.

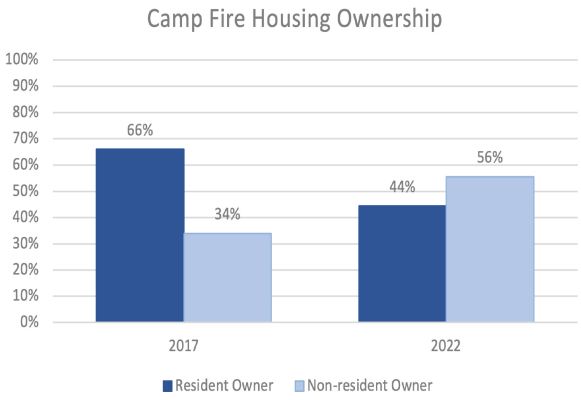
	Source	**Variables**
Sociodemographic Characteristics	UC Census Bureau American Community Service (ACS)	Varied, listed in Table 2
Housing Characteristics	County Assessor's Office	• Assessor's Parcel Numbers • Property Addresses • Ownership • Tax/mailing address
Damaged/Destroyed Housing	CalFire Damage Inspection (DINS)	Damage assessment of 25% or more
Fire Characteristics	CalFire California Fire Perimeters	Perimeters for Tubbs and Camp Fires
Employment and Economic Industries	US Census Bureau Origin-Destination Employment Statistics	• Industry classification of workplaces • Employment information of private businesses • Business size • Business age
Social Vulnerability Index	Center for Disease Control and Agency for Toxic Substances and Disease Registry Social Vulnerability Index	16 U.S. Census variables from the 5-year American Community Survey
Qualitative Data	Butte County Interviews: 25 Butte County Focus Groups: 7 Sonoma County Interviews: 9 Sonoma County Focus Groups: 2	Transcribed and coded based on prevalent themes using *Atlas.ti* software.

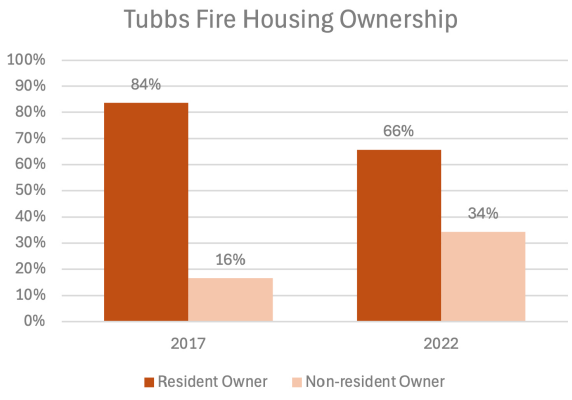
	Paradise (Camp Fire) 2017	Paradise (Camp Fire) 2022	Santa Rosa (Tubbs Fire) 2017	Santa Rosa (Tubbs Fire) 2022
Acres Burned *Source: CalFire Incident Archive*	153,336	-	36,810	-
Structures Burned *Source: CalFire Damage Inspection (DINS) Database*	18,904	-	5,636	-
Population (Pre-Fire) *Source: US Census Bureau*	26,437	6,666	174,244	177,185
Median Age *Source: American Community Survey 5-Year Estimates*	49.2	57.9	38.5	40.9
Median Household Income *Source: US Census Bureau*	$48,831	$54,842	$75,356	$95,403
Primary Industries (Top 3, 10-mile buffer) *Source: LODES*	Healthcare, retail, education	Healthcare, retail, education	Healthcare, accommodation, retail	Healthcare, accommodation, education
New Firm Employment (Age < 3 years) *Source: LODES*	4,277	3,640	6,990	6,777
Total Employment *Source: LODES*	48,855	43,090	67,117	66,970
Herfindahl-Hirschman Index	0.111	0.103	0.092	0.090
Social Vulnerability Index *Source: CDC*	0.516 (2018 data, prior to 11/2018 Camp Fire)	0.415	0.225 (2016 SVI, prior to 10/2017 Tubbs Fire)	0.177

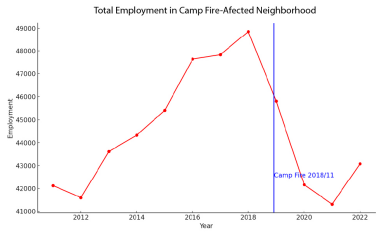
Population Group	Identified Recovery Challenges	Recommended Policies	Policy Mechanism Type
Renters	Displacement due to housing loss and rising rents; lack of formal support during recovery.	Post-disaster rent stabilization; inclusion of renters in relocation and recovery funding; new affordable rental construction.	Housing Policy, Disaster Relief
Older Adults	Limited mobility and access to healthcare; dependence on local services that may not return.	Rebuild local healthcare services; targeted relocation assistance; incentives for age-friendly housing.	Health & Social Infrastructure
Undocumented and Informal Workers	Job precarity; exclusion from federal recovery aid; housing insecurity.	Local recovery funds inclusive of immigration status; worker assistance programs; legal aid and tenant protections.	Labor Policy, Local Governance
Low-Income Households	Economic precarity; inability to rebuild; vulnerability to speculative displacement.	Subsidies for rebuilding and home repair; tax relief for primary homeowners; inclusionary zoning.	Housing & Economic Development
Small Business Owners	Loss of customer base and facilities; limited access to capital.	Bridge loans and grant programs; local procurement incentives; resilience planning support.	Economic Development

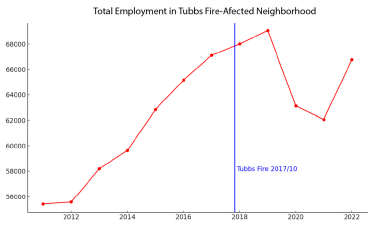


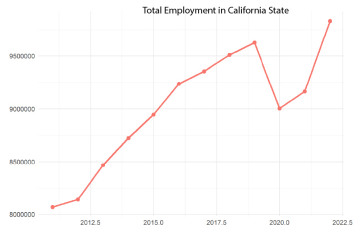












Housing and Economic Recovery as Interdependent Pathways in the Wake of Wildfires

Highlights

- Introduced an integrated housing-economic recovery framework that links post-wildfire housing stability to local employment conditions and economic diversity.

- Demonstrated how traditional vulnerability tools like SoVI overlook hidden and dynamic vulnerabilities, especially among renters, seasonal workers, and undocumented residents.

- Employed a mixed-methods approach combining quantitative data (DINS, assessor records, LODES, CDC SoVI) with qualitative interviews and spatial analysis to track recovery in Paradise and Santa Rosa.

- Found a marked rise in absentee homeownership post-fire, particularly in the Town of Paradise, which undermined local recovery and community cohesion.

- Identified the importance of economic revitalization in sustaining population return.

Declaration of interests

☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐ The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: