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A tale of two suburbias: Turning up the heat in Southern California's flammable wildland-urban interface

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ABSTRACT

As Southern California becomes hotter and dryer, wildfires are becoming more frequent and severe. At the same time, the suburbanization of poverty and immigration are making the region increasingly – albeit unevenly - diverse. This paper synthesizes insights from planning and ecology to address the following questions: how do burned areas differ from the rest of the region in terms of poverty, race, and housing values; how has this changed since 1980; and what are the implications for environmental justice? Typically, low-income urban communities of color are disproportionately vulnerable to climate impacts. However, this study finds that the wildland-adjacent neighborhoods most impacted by wildfire have remained predominantly white and affluent, even as Southern California has become increasingly diverse. Moreover, housing in burned areas is increasingly more expensive. These results indicate that home ownership in a fire-prone, wildland-adjacent neighborhood is a profitable investment for those who can afford it. This situation is likely creating perverse incentives for continued development of the wildland-urban interface, leading to both continued ecological disturbance and affluent residents continuing to subject themselves to more physical danger than they have acknowledged.

1. Introduction

Climate impacts are typically concentrated away from affluent privileged populations, leading to what Mike Davis has described as "green and gated oases" for "Earth's first-class passengers" (Davis, 2010, p. 38). On the international scale, the United States suffers less from climate change than the Global South (Roberts, 2009). However, climate hazards still pose a significant - albeit unequally distributed - threat to many Americans' lives, health, and homes. Prior research on climate hazards has found that they are typically concentrated in low-income, urban communities of color (Morello Frosch, Pastor, Sadd, & Shonkoff, 2009; Romero Lankao & Qin, 2011; Shepard & Corbin-Mark, 2009). Consequently, despite rising global temperature, affluent white American suburbanites have been slow to feel the heat.

However, these dynamics may be changing. As demonstrated by this study, there are at least some cases in which relatively privileged populations are disproportionately vulnerable to certain climate hazards. Based on the results of this analysis, wildfire in Southern California is one such case, with residents of affluent, wildland-adjacent suburbs at ever greater risk. By analyzing demographic data and the boundaries of wildfires from the 1980s to the 2000s, this paper addresses the following questions: how do the areas burned by wildfire compare with the rest of Southern California in terms of poverty, race, and median housing values; how has this changed over time; and what are the implications for environmental justice?

Quantitative spatial analysis is used to assess how the populations within and without areas burned by wildfires differ in terms of poverty and race. For each decade, the proportion of residents who are non-white, the proportion who are below the poverty line, and median housing value are estimated at the census tract level. Tracts that intersect with the boundary of any wildfire recorded by the State of California are classified as wildfire areas, while the remainder are classified as non-wildfire areas. The results of this analysis indicate that the wildland-adjacent neighborhoods most impacted by wildfire have remained predominantly white and affluent, even as the region has become increasingly diverse overall. Moreover, housing values in burned areas are increasingly higher than the rest of the region, creating perverse incentives for continued development of the increasingly flammable wildland-urban interface.

2. Environmental justice, climate hazards, and the wildland-urban interface

While environmental justice can be defined in terms of procedural

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fairness, public participation, and recognition of the needs of different communities, the most common definition is an equitable distribution of environmental impacts and amenities (Pellow, 2000; Schlosberg, 2003; Shrader-Frechette, 2002). Environmental *in*justice is predicated on the spatial separation of disadvantaged populations, which allows their communities to become sinks for environmental pollution while more privileged communities enjoy higher environmental quality and a spatial concentration of environmental amenities, such as access to open space. Climate injustice (on an intra-national scale) is similarly facilitated by spatial separation. Low-income minority communities tend to bear a disproportionate share of exposure to hazards such as flooding, while protective infrastructure is typically concentrated in more privileged areas (Shepard & Corbin-Mark, 2009). This injustice also extends to the positive elements of environmental goods and services, such as the positive impacts of open space and natural ecosystems on public health (Bernstein, 2014). In addition to greater physical vulnerability, marginalized populations have greater socio-economic vulnerability, defined as sensitivity to and inability to cope with disturbance, due to their lack of both financial and social capital (Romero Lankao & Qin, 2011). Consequently, it is typically the urban poor and communities of color who are the most vulnerable to climate change impacts (Morello Frosch et al., 2009; Shepard & Corbin-Mark, 2009).

One climate change impact of particular concern to Southern California is wildfire. In contrast to urban fires, wildfire burns wildlands and adjacent developed areas. While somewhat loosely defined, the term “wildland” generally signifies areas that have not been developed for human settlement or major agricultural or industrial activity. The wildland-urban interface (WUI) is defined by the National Wildfire Coordinating Group (NWCG) as “the zone of transition between unoccupied land and human development…where structures and other human development meet or intermingle with undeveloped wildland or vegetative fuels” (NWCG, 2017, p. 1). Due to its hybrid nature, the WUI cannot easily be classified as developed or undeveloped, urbanized or wild. Moreover, because private homes are in such close proximity to publicly managed open space, their mutual risk of wildfire is closely interlinked. Consequently, these areas challenge conventional binary understandings of urban vs. nonurban and public vs. private, necessitating their own distinct land classification (Simon, 2017). The WUI emerged as a formal land classification in 1987, when it appeared in the U.S. Forest Service's research budget as a designation for urban areas in need of greater fire protection due to their proximity to state, federal, and private forest lands (Simon, 2017; Sommers, 2008). The WUI became a major component for federal fire management when it appeared in the 2000 National Fire Plan (Simon, 2017; Sommers, 2008). However, the concept's roots can be traced back further, to Cold War-era civil defense concerns about the potential vulnerability of California's cities to ignition of nearby flammable wildlands during nuclear attacks (Sommers, 2008).

Southern California's WUI is concentrated along the coast in coastal sage scrub and chaparral ecosystems whose high vegetative fuel loads, Mediterranean climate, and proximity to ignition sources from urban areas and roads combine to produce periodic wildfires (Faivre, Jin, Goulden, & Randerson, 2016; Jin et al., 2014). Unsurprisingly, the boundaries of wildfires that burned since 1980 in Southern California have typically fallen within the boundaries of the WUI, as shown in Fig. 1 below. (However, it should also be noted that Southern California's WUI also includes wetlands and other non-flammable areas. In addition, some wildfires burned outside the WUI and much of the WUI was not burned by fire.)

The WUI can be alternatively conceptualized as the affluence-vulnerability interface (AVI) (Davis, 1995, 1998b;Simon, 2014, 2017; Simon & Dooling, 2013). Compared to the WUI model, the AVI model has the benefit of not only classifying these land areas, but also illuminating the social-ecological processes that produce them. When urbanization spreads until it pushes up against undevelopable foothills and canyons, it results in the production of risky yet profitable suburban housing (Simon, 2014, 2017; Simon & Dooling, 2013). The consequence is “natural” disasters produced by the wealthy building luxury homes adjacent to flammable chaparral ecosystems, only to be bailed out by state and federal authorities when those homes burn during the inevitable wildfires that follow (Davis, 1995, 1998b). These neighborhoods are not only at risk from wildfire; they actually increase the chances of one occurring. Their construction disturbs local ecosystems, introduces ignition sources (particularly near roads), and increases fuel loads through the addition of residential structures, fire-prone landscaping such as eucalyptus (perennially popular among Southern California's suburban developers and homeowners alike), and enhanced fire suppression activities that can promote additional fuel production (Faivre et al., 2016; Husari, Nichols, & Stephens, 2006; Simon, 2014, 2017; Simon & Dooling, 2013).

Moreover, home construction and post-fire reconstruction both result in wealth creation for the developers who build them, the homeowners who purchase them, and the local governments whose property tax base grows (Simon, 2017). There are many factors that determine housing values, including housing characteristics, location, job and transportation accessibility, and so forth, which are beyond the scope of the data presented here. However, the literature on the WUI suggests that homes in these areas are considered more desirable due to their proximity to undeveloped land. Wildland-adjacent homes offer recreational opportunities and an “outdoor” lifestyle, as well as views of natural landscapes, which have been the focus of real-estate promotion in Southern California since the 1920s (Davis, 1998a; Rodrigue, 1993). Southern California's WUI is concentrated along the coast (as shown in Fig. 1), giving many of these homes access to beaches, ocean views, and cooling ocean breezes. Due to this array of amenities, such homes command high prices (Simon, 2017). Moreover, insurance policies and state and federal subsidies and disaster recovery funds shield homeowners from paying the full price of protecting their risky investment from nearby natural hazards and help them build even bigger homes in the wake of disasters (Davis, 1995, 1998b; Simon, 2017). For example, once rebuilt after the 1991 Tunnel Fire, average home size and value in Oakland Hills, California actually increased (Simon, 2017). Consequently, the WUI becomes the interface between affluence and vulnerability, since residents' high physical vulnerability and low socio-economic vulnerability (i.e., their considerable financial and social capital, including access to local officials) together result in the transfer of public resources to already affluent residents (Simon, 2017).

The AVI stands in stark contrast to the usual conceptualization of vulnerability as being concentrated, both socially and spatially, among low-income urban communities of color forced to live in areas rendered “affordable” by the proximity of natural hazards (Romero Lankao & Qin, 2011. The AVI framework reflects the political ecology of California's WUI since the late-nineteenth century, as continued urbanization advanced into formerly undeveloped territory (Simon, 2014, 2017; Simon & Dooling, 2013). It has been supported by recent work demonstrating that while socio-economic vulnerability is concentrated among communities of color, physical vulnerability to wildfire remains concentrated in predominantly white, socially secure communities (Davies, Haugo, Robertson, & Levin, 2018). However, as this analysis will show, the AVI model has yet to account fully for two new sources of change over time: climate change and the suburbanization of poverty and immigration.

Wildfire in Southern California is projected to increase in frequency and severity under climate change (Baltar, Keeley, & Schoenberg, 2014; Bryant & Westerling, 2009; Faivre et al., 2016; Jin et al., 2014; Jin et al., 2015; Keeley & Syphard, 2016; Swetnam & Betancourt, 1990; Westerling, Hidalgo, Cayan, & Swetnam, 2006). This is predicted to occur in part as a function of greater interannual rainfall variability juxtaposing high fuel production in wet years with subsequent years of significant water deficit (Swetnam & Betancourt, 1990), and in part due to warming that extends the fire season significantly (Westerling et al., 2006).

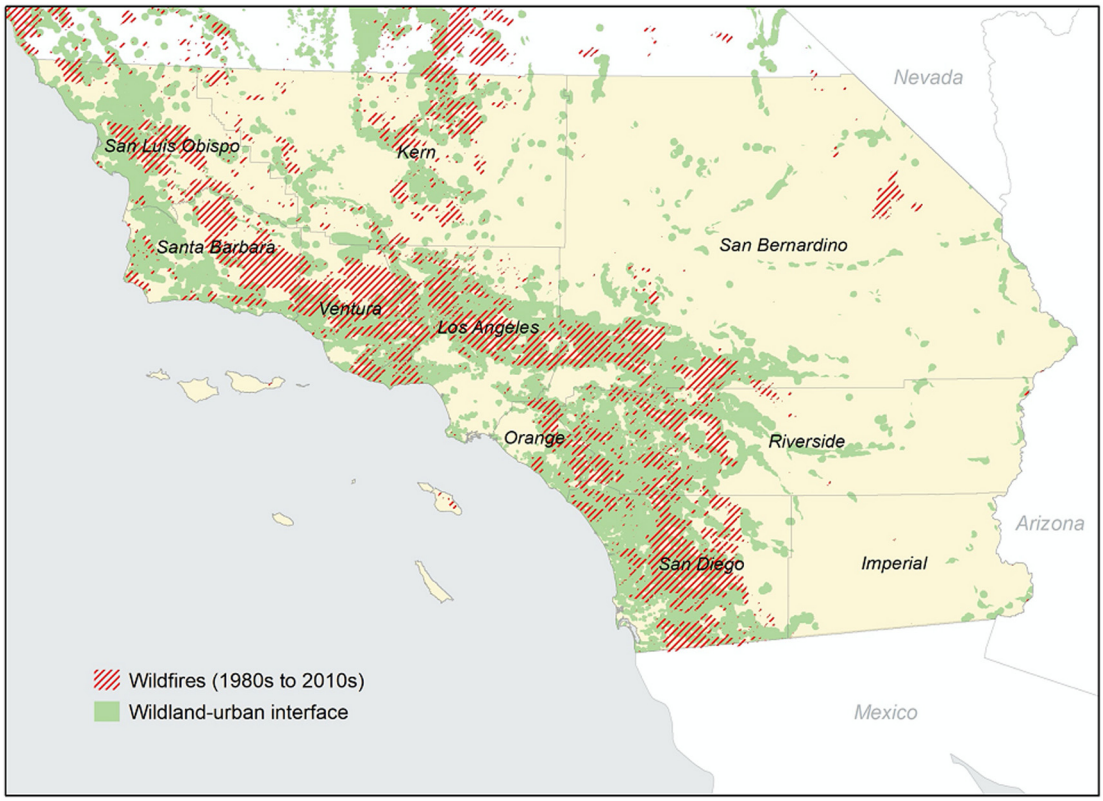

Fig. 1. Wildfires (1980–2016) versus WUI in Southern California's ten counties.
Data source: FRAP (2016); USFS (2006).

While climate change is altering the natural landscape, the suburbanization of poverty and immigration are altering the social landscape. For much of the twentieth century, suburban sprawl increased spatial segregation, concentrating low-income communities of color in central cities and dispersing the affluent to peripheral suburbs (Dreier, Mollenkopf, & Swanstrom, 2014; Jackson, 1985). Consequently, the poor and minorities were isolated in urban areas with lower environmental quality (Andrulis, 1997). Suburbanization therefore contributed to environmental injustice via the spatial separation of privileged and unprivileged populations. However, beginning in the late twentieth century, new immigration patterns and the suburbanization of poverty have begun to shift the demographics of the suburbs, particularly on the West Coast (Clark & Blue, 2004; Kneebone & Berube, 2014; UCI Community & Labor Project and the UCLA Labor Center, 2014). Since the late twentieth century, aging inner-ring suburbs have become more diverse as low-income people of color move out of central cities in search of affordable housing in older suburbs adjacent to urban cores (Clark & Blue, 2004; Hardwick, 2008; Kneebone & Berube, 2014; UCI Community & Labor Project and the UCLA Labor Center, 2014). Such patterns are particularly striking in predominantly suburban regions like Southern California.

However, these inner-ring suburbs are, by definition, distant from the flammable wildlands on the fringe of newer suburbs. Meanwhile, wildland-adjacent outer-ring suburbs have remained predominantly white and affluent as they continue to expand outwards into previously undeveloped areas. For example, suburban areas like Orange County (whose location is shown in Fig. 1) that were once predominantly white have become increasingly diverse, yet that diversity is unevenly distributed (UCI Community & Labor Project and the UCLA Labor Center, 2014). For instance, since the 1980s, older inner-ring suburbs have become home to large immigrant populations from Latin America and Southeast Asia, as well as significant concentrations of poverty (UCI Community & Labor Project and the UCLA Labor Center, 2014). These communities are geographically and demographically closer to Los Angeles' older urban areas to the north. In contrast, wildland-adjacent outer-ring suburbs have remained predominantly white and affluent as they continue to expand outwards into previously undeveloped areas (UCI Community & Labor Project and the UCLA Labor Center, 2014). AVI dynamics are likely intensifying as this divide grows, with wildland-adjacent neighborhoods become increasingly unaffordable as resources are transferred to already well-off homeowners, and low-income communities of color becoming increasingly concentrated in more affordable inner-ring suburbs.

3. Methods

This paper examines Southern California as a case study due to the region's increasingly frequent and severe wildfires (Baltar et al., 2014; Bryant & Westerling, 2009; Faivre et al., 2016; Jin et al., 2014, 2015; Keeley & Syphard, 2016; Swetnam & Betancourt, 1990; Westerling et al., 2006). In addition, human settlement continues to extend into the region's WUI, rendering an increasing area of developed land vulnerable to wildfires (Radeloff et al., 2005). Since the mid-twentieth century and continuing into the present, Southern California has experienced rapid urbanization driven by sprawling suburban housing development (Basolo, 2012). Consequently, much of Southern California is wildland or wildland-adjacent, with a large fraction of its landscape being WUI, as shown in Fig. 1. These characteristics make Southern California an ideal location to examine wildfire as an environmental justice issue in the context of climate change, suburbanization, and housing production.

In addition, as a case study, Southern California can provide insights of interest to comparable regions facing similar challenges. With its increasingly diverse suburban population, Southern California is prototypical of much of the western United States (Clark & Blue, 2004; Kneebone & Berube, 2014). In addition, its Mediterranean climate and

its expanding WUI make it similar to regions such as Mediterranean Europe, parts of South America, and Australia, which are also predicted to experience more wildfires under climate change (Flannigan, Krawchuk, de Groot, Wotton, & Gowman, 2009; Godoy et al., 2019; Molina-Terrén et al., 2019).

For the purpose of this analysis, Southern California is defined as the following ten counties, which collectively cover the southern portion of the state: Imperial, Kern, Los Angeles, Orange, Riverside, San Bernardino, San Diego, San Luis Obispo, Santa Barbara, and Ventura. Quantitative spatial analysis is used to assess how the populations within and outside areas burned by wildfires differ in terms of poverty and race. Four time periods are examined: the 1980s, 1990s, and 2000s. (As of this writing, wildfire data are available only through 2016.) The boundaries of wildfire-burned areas are defined as those mapped in each decade by the State of California's Fire and Resource Assessment Program, 2003 (FRAP), which is responsible for assessing the condition of the state's forests and rangelands (FRAP, 2016). (As shown in Fig. 1, wildfire-burned areas closely – but not perfectly - align with the boundaries of the WUI.) Data on poverty, race, and housing values (for owner-occupied units) are drawn from decennial census data compiled by the National Historical Geographic Information System (NHGIS), whose mission is to spatialize and standardize data from the U.S. Census for time series analysis (IPUMS NHGIS, 2016).

For each decade, the proportion of residents who are nonwhite, the proportion who are below the poverty line, and median housing value is estimated at the census tract level. (The nonwhite population is calculated by subtracting the population who self-identify as white from the total population. This approach effectively aggregates all nonwhite groups; however, the structure of the NHGIS data makes it necessary to avoid double-counting individuals who identified as, for example, both Hispanic/Latino and black.) Census tracts that intersect with the boundary of any fire occurring in that decade are classified as wildfire areas, while the remaining census tracts are classified as non-wildfire areas. Change over time is tracked using the proportion of residents who are below the poverty line, the proportion who are nonwhite, and the mean of tract-level median housing values in wildfire areas vs. non-wildfire areas, as well as for the region as a whole. In addition, each variable is compared between wildfire and non-wildfire areas using *t*-tests for independent samples with unequal variances, with the two-tailed *p*-value used to determine if the differences between these areas are statistically significant.

4. Findings

As illustrated in Fig. 2, Southern California's population has grown considerably, increasing by almost 50% between the 1980s (14,276,062) and the 2000s (20,637,512). Over the same time period, the number of people living in wildfire areas increased by 10% (from 1,968,557 to 2,167,521) and the total amount of land burned by wildfire more than doubled (increasing from approximately 4638 mile^2 to 9948 mile^2).

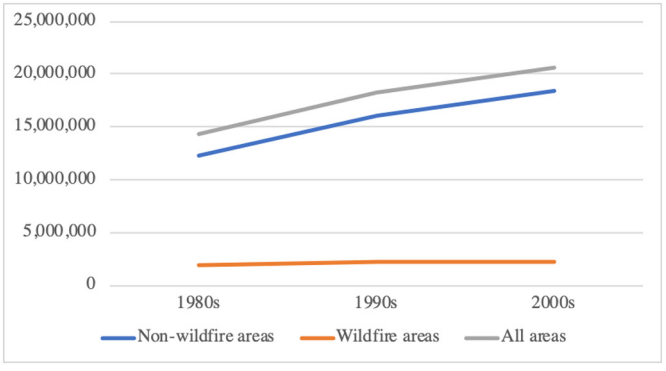

Fig. 2. Population of non-wildfire versus wildfire areas in Southern California.
Data source: FRAP (2016); IPUMS NHGIS (2016)

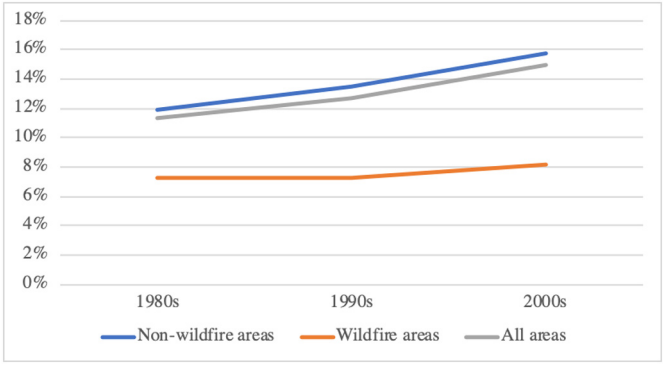

Fig. 3. Poverty rate (%) in non-wildfire versus wildfire areas (by census tract) in Southern California.
Data source: FRAP (2016); IPUMS NHGIS (2016).

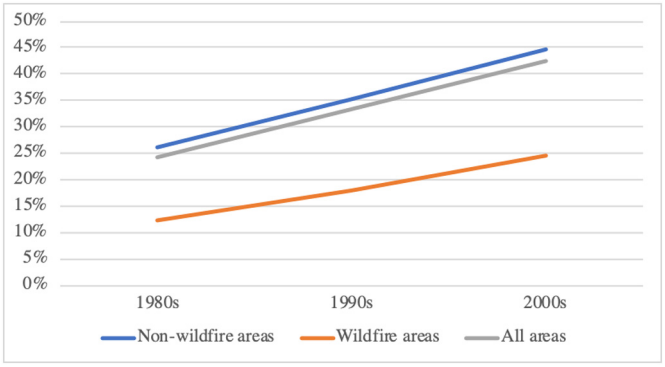

Fig. 4. Nonwhites as percentage of population in non-wildfire versus wildfire areas (by census tract) in Southern California.
Data source: FRAP (2016); IPUMS NHGIS (2016).

As shown in Figs. 3 and 4 below, since the 1980s, wildfire areas have had consistently lower poverty and fewer nonwhites than the rest of Southern California. Moreover, the populations of wildfire and non-wildfire areas have been diverging, with mean differences growing from the 1980s to the 2000s, as shown in Table 2. This pattern is also visible in the time-series maps in Fig. 6 below: from the 1980s forward, poverty and the proportion of nonwhite residents increased in inland areas, away from the boundaries of areas burned by wildfire. These two variables did have different dynamics over the several-decade time period, as shown in Table 1. Between the 1980s and the 2000s, the poverty rate in wildfire areas remained low and relatively constant (from 7.29% to 8.16%), while the nonwhite percentage grew from 12.33% to 24.39%. Non-wildfire areas showed more dramatic

Table 1
Non-wildfire areas versus wildfire areas (by census tract) in Southern California.
Data source: FRAP (2016); IPUMS NHGIS (2016).

		1980s	1990s	2000s
Below poverty line (%)	Non-wildfire areas	11.93%	13.48%	15.79%
	Wildfire areas	7.29%	7.25%	8.16%
	All areas	11.29%	12.72%	14.99%
Nonwhite (%)	Non-wildfire areas	26.20%	35.38%	44.57%
	Wildfire areas	12.33%	18.05%	24.39%
	All areas	24.29%	33.26%	42.45%
Median housing value	Non-wildfire areas	$87,351	$217,546	$220,108
	Wildfire areas	$91,162	$242,878	$282,438
	All areas	$87,802	$220,048	$226,564

Table 2
Two-sampled t-test for non-wildfire areas versus wildfire areas (by census tract) in Southern California.
Data source: FRAP (2016); IPUMS NHGIS (2016).

		1980s	1990s	2000s
Below poverty line (%)	Mean difference	0.045	0.056	0.077
	Standard error	0.005	0.006	0.006
	Test statistic	8.804	9.329	13.430
	p-value	0.000	0.000	0.000
Nonwhite (%)	Mean difference	0.134	0.174	0.210
	Standard error	0.014	0.014	0.011
	Test statistic	9.672	12.328	19.287
	p-value	0.000	0.000	0.000
Median housing value	Mean difference	-$3811	-$25,332	-$62,330
	Standard error	2632	6538	7388
	Test statistic	−1.448	−3.874	−8.437
	p-value	0.1478	0.0001	0.0000
Number of observations		2985	3239	4277

increases: the poverty rate grew from 11.93% to 15.79%, while the percentage of nonwhite residents grew from 26.20% to 44.57%. Overall, the difference between wildfire and non-wildfire areas in the proportions of residents who were below the poverty line or nonwhite was statistically significant in all decades, as shown in Table 2.

Housing values (for owner-occupied housing units) also differed between wildfire and non-wildfire areas, with the former being consistently more valuable across all three decades, as shown in Fig. 5. Moreover, mean differences increased from the 1980s to the 2000s (Table 2) and were statistically significant in the latter two decades. Moreover, the mean difference in housing values increased by over 1500% between the 1980s and 2000s. These results indicate that housing in wildfire areas is significantly and increasingly more expensive than housing in the rest of Southern California. While some of the difference is likely attributable to larger homes and lot sizes in the WUI, these numbers still indicate that housing development in wildfire areas is increasingly being tailored to buyers with deeper pockets.

5. Discussion

In short, home ownership in a fire-prone, wildland-adjacent neighborhood has become an increasingly valuable investment for those who can afford it. This situation is likely creating perverse incentives for continued development of the wildfire-prone WUI for high-end housing. Moreover, it is resulting in an ever-widening divide between an increasingly diverse region and predominantly white and affluent WUI neighborhoods. The results of this analysis are consistent with the AVI model (Davis, 1995, 1998b; Simon, 2014, 2017; Simon & Dooling, 2013). However, they also point to key ways in which this model must be expanded. As currently theorized, the AVI does not fully account for the change over time revealed by this analysis: inequality between wildfire and non-wildfire areas is not just present, it is intensifying over time. While past AVI-focused research has examined how histories of resource extraction, real estate development, and changes in property tax systems have produced unequal vulnerability (Simon, 2016), the AVI model must be expanded to include two new and increasingly influential temporal variables: climate change and the suburbanization of poverty and immigration.

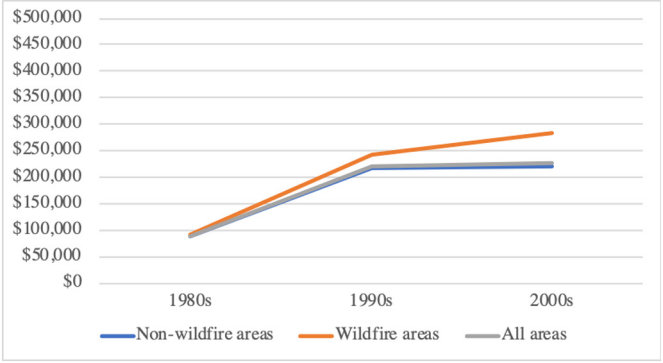

Fig. 5. Mean housing value in non-wildfire versus wildfire areas (by census tract) in Southern California.
Data source: FRAP (2016); IPUMS NHGIS (2016).

As wildfires increase in frequency and severity, the cycle of housing construction, destruction, and reconstruction that drives the AVI model also likely intensifies as public resources are increasingly transferred to affluent homeowners in wildfire areas. If this resource transfer results in homes becoming larger and more expensive as they are rebuilt (Simon, 2017), then the divide between the affluent inhabitants of wildfire areas and the rest of the region would be expected to continue to widen, consistent with increasing divide found in this study. The results also suggest that the suburbanization of poverty and immigration is likely accelerating AVI dynamics. The region's increasingly diverse inner-ring suburbs are, by definition, distant from the flammable wildlands on the fringe of newer suburbs. Meanwhile, wildland-adjacent outer-ring suburbs have remained predominantly white and affluent as they continue to expand outwards into previously undeveloped areas. These results suggest that wildland-adjacent neighborhoods are becoming increasingly unaffordable as resources are transferred to already well-off homeowners, and low-income communities of color are becoming increasingly concentrated in more affordable inner-ring suburbs.

6. Conclusions

In short, outer-ring wildland-adjacent suburbs are remaining relatively white and affluent, even as the Southern California region as a whole becomes more diverse. Despite their growing physical vulnerability, residents of wildfire areas are consistently and increasingly better off economically than the rest of Southern California, as evidenced by the growing divide in poverty rates between wildfire and non-wildfire areas found in this study. While the proportion of nonwhite residents is growing throughout the region, it has grown significantly higher in non-wildfire areas. Moreover, housing values are increasing faster in wildfire areas versus the rest of the region, creating a perverse incentive for more development in risky, wildfire-prone areas. The resulting clash between development pressures, ecological change, and growing inequality is likely to continue to intensify in future as climate change keeps turning up the heat while the suburbanization of poverty and immigration widens the gap between inner- and outer-ring suburbs.

It can be easy to dismiss the wealthy inhabitants of flammable wildland-adjacent neighborhoods as undeserving of sympathy. After all, their high levels of financial and social capital not only lower their socio-economic vulnerability to wildfires, but also compensate for their homes' physical vulnerability via insurance policies and greater access to the public officials who distribute disaster recovery resources (Davis, 1995, 1998b; Simon, 2014, 2017; Simon & Dooling, 2013). In other words, these homeowners are spending large amounts of money – both theirs and others' – to build their homes in risky, ecologically sensitive areas. However, the physical danger to these homeowners and their families is real, with wildfires routinely resulting in the deaths of local residents (Simon, 2017). These homeowners may be choosing to live where they do because they misjudge or are unaware of the actual level of physical risk, suggesting that outreach and education are needed to adequately inform the public of the potential consequences of fire. In addition, the wildlands next to these neighborhoods are not only home to many species threatened by human development, but also generate critical ecosystem services such as carbon sequestration and storm water management, which have broad benefits locally, regionally, and globally (Daily, 1997; Huntsinger & Oviedo, 2014). Moreover, wildland fires release a significant amount of carbon dioxide, methane, and

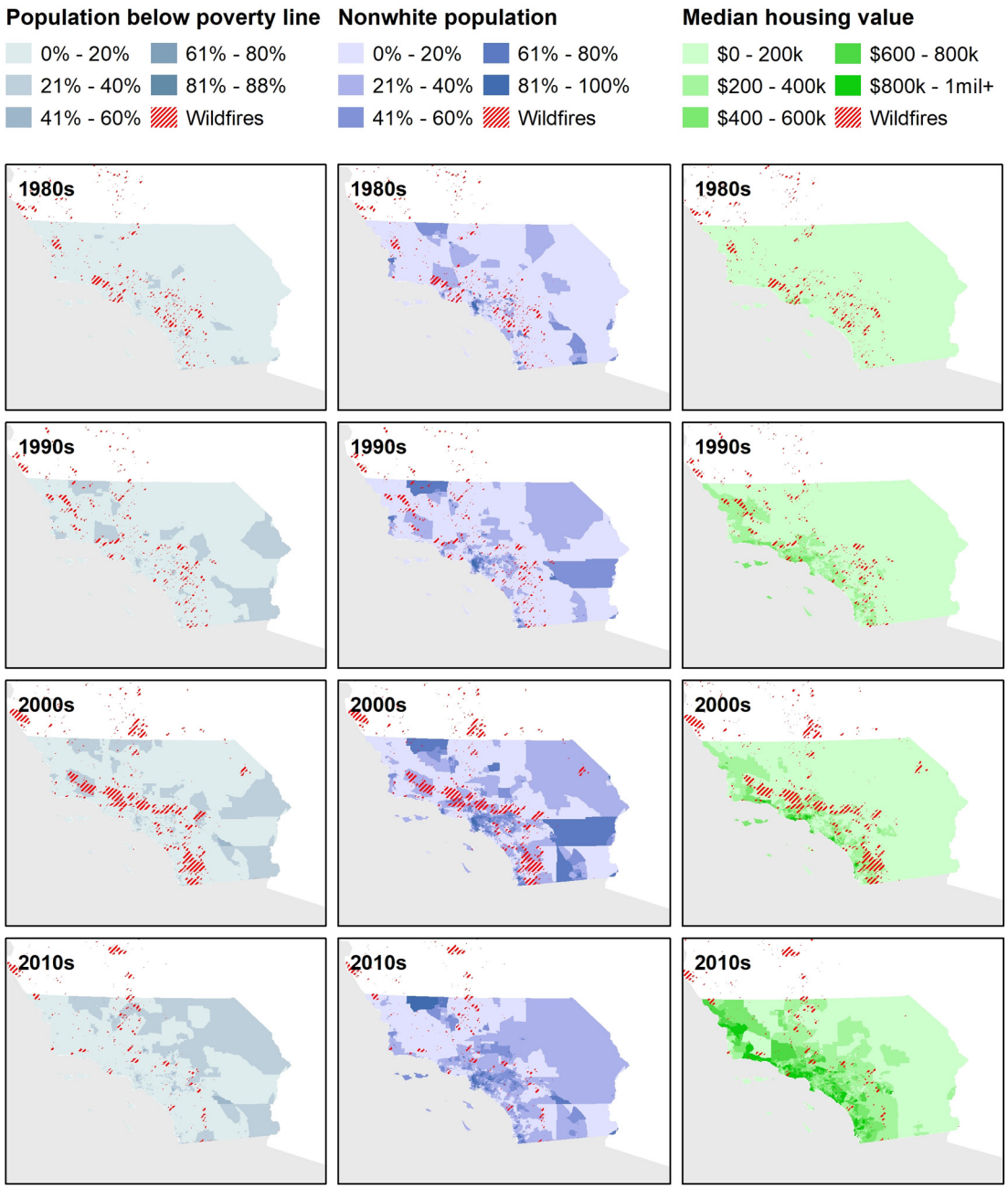

Fig. 6. Southern California's changing demographics.
Data source: FRAP (2016); IPUMS NHGIS (2016).

carbon monoxide as fuels combust, contributing to global climate change (Flannigan et al., 2009). In addition, as the boundaries of suburban sprawl push further and further outward, greenhouse gas emissions from vehicle miles traveled will increasingly contribute to rising temperatures under climate change (Basolo, 2012; Ewing, Bartholomew, Winkelman, Walters, & Chen, 2008), as will carbon emissions from the wildfires themselves (Flannigan et al., 2009), contributing to a vicious cycle. Consequently, some degree of public resources should be used to prevent human tragedy, ecological destruction, and continued damage to the planet's climate.

However, public investment in wildfire management in the WUI primarily benefits (and enriches) the affluent local homeowners whose property is protected. Meanwhile, low-income communities of color who live in inner-ring suburbs, far from the region's peripheral wildlands, will continue to have little access to these open spaces and the natural amenities they provide. As Southern California's population grows increasingly diverse, such an imbalance could imperil future political support for wildfire management in Southern California's wildlands, threatening the future of these ecosystems. Mandating affordable housing in the WUI through inclusionary policies or other mechanisms could ensure that more people have access to open space and its associated recreational amenities. However, in addition to potential drawbacks such as reduced employment accessibility and fewer transportation options, such policies would also expose more people to wildfire. Moreover, the long-term implications of this strategy are unclear. While relatively wealthy homeowners can afford insurance and the costs of rebuilding, the same may not be true of residents of subsidized affordable units, which may therefore end up not being rebuilt after fires, or at least not as quickly. Alternatively, more of the financial burden for fire prevention, response, and recovery could be shifted to

local homeowners to reduce the perverse incentives created by AVI dynamics that would otherwise continue raising home values in risky WUI neighborhoods. However, such cost-shifting strategies may merely give rise to new forms of inequality. For example, private companies have already begun providing "concierge-level" fire protection to owners of multimillion-dollar mansions in Southern California in exchange for premiums of at least $10,000 per year (Yoshino, 2007). At a time when public fire departments and other emergency responders are perpetually underfunded, privatized fire-fighting may be just another strategy for the wealthy to avoid paying their share of what ought to be a public service available to all.

Ultimately, continued housing development in the WUI – whether affordable or not – will put increasing numbers of people in danger from wildfires at the same time that climate change is making those fires more frequent and dangerous (Baltar et al., 2014; Bryant & Westerling, 2009; Faivre et al., 2016; Jin et al., 2014, 2015; Keeley & Syphard, 2016). Additional construction and traffic would also further disturb local ecosystems, raising the risk of wildfire even higher (Faivre et al., 2016; Husari et al., 2006; Simon, 2014, 2017; Simon & Dooling, 2013). Consequently, local communities and policymakers need to consider placing limits on future development to prevent such outcomes. Despite how politically incendiary such policies may be, they will likely be increasingly necessary as climate change and the suburbanization of poverty and immigration intensify AVI dynamics in the WUI. So long as home prices in wildfire areas continue to increase, they will continue to be built and rebuilt until planning and policy limits are set. Researchers can support efforts to set reasonable limits by synthesizing insights from ecology and planning to illuminate how combined environmental and demographic change are reshaping suburbia. Such analysis can inform planning and policy that ensure wildlands are protected in a socially equitable manner that ensures all Southern Californians' future enjoyment of this beautiful but flammable natural resource - preferably from a safe distance.

CRediT authorship contribution statement

Jessica Debats Garrison: Writing - original draft, Conceptualization, Formal analysis, Methodology, Visualization. **Travis E. Huxman**: Data curation, Writing - review & editing.

References

Andrulis, D. (1997). *The urban health penalty: New dimensions and directions in inner-city health care*. Washington, DC: American College of Physicians. Retrieved from http://www.acponline.org/ppvl/policies/e000246.html.

Baltar, M., Keeley, J. E., & Schoenberg, F. P. (2014). County-level analysis of the impact of temperature and population increases on California wildfire data. *Environmetrics, 25*(6), 397–405.

Basolo, V. (2012). Housing and urban sustainability: A Los Angeles case study. *Urban sustainability: A global perspective* (pp. 407–434). East Lansing: Michigan State University Press.

Bernstein, A. S. (2014). Biological diversity and public health. *Annual Review of Public Health, 35*, 153–167.

Bryant, B., & Westerling, A. (2009). *Potential effects of climate change on residential wildfire risk in California: Draft paper*. Sacramento, CA: California Energy Commission. Retrieved from http://www.energy.ca.gov/2009publications/CEC-500-2009-048/CEC-500-2009-048-D.PDF.

Clark, W. A. V., & Blue, S. A. (2004). Race, class, and segregation patterns in U.S. immigrant gateway cities. *Urban Affairs Review, 39*(6), 667–688.

Daily, G. C. (1997). *Nature's services: Societal dependence on natural ecosystems*. Washington DC: Island Press.

Davies, I. P., Haugo, R. D., Robertson, J. C., & Levin, P. S. (2018). The unequal vulnerability of communities of color to wildfire. *PLoS One, 13*(11), e0205825.

Davis, M. (1995). The case for letting Malibu burn. *Environmental History Review, 19*(2), 1–36.

Davis, M. (1998a). How Eden lost its garden. *Ecology of fear: Los Angeles and the imagination of disaster* (pp. 59–91). (1st ed.). New York: Metropolitan Books.

Davis, M. (1998b). The case for letting Malibu burn. *Ecology of fear: Los Angeles and the imagination of disaster* (pp. 93–148). (1st ed.). New York: Metropolitan Books.

Davis, M. (2010). Who will build the ark? *New Left Review, 61*, 29–46.

Dreier, P., Mollenkopf, J. H., & Swanstrom, T. (2014). *Place matters: Metropolitics for the twenty-first century*. University Press of Kansas.

Ewing, R., Bartholomew, K., Winkelman, S., Walters, J., & Chen, D. (2008). Executive summary. *Growing cooler: The evidence on urban development and climate change* (pp. 11–22). Washington, DC: Urban Land Institute.

Faivre, N. R., Jin, Y., Goulden, M. L., & Randerson, J. T. (2016). Spatial patterns and controls on burned area for two contrasting fire regimes in Southern California. *Ecosphere, 7*(5).

Fire and Resource Assessment Program (2003). Wildland urban Interface (WUI) fire threat. Retrieved from http://frap.fire.ca.gov/data/frapgisdata-sw-wui.

Fire and Resource Assessment Program (2016). Fire Perimeters Version 16_1. Retrieved from http://frap.fire.ca.gov/data/frapgisdata-sw-fireperimeters_download.

Flannigan, M. D., Krawchuk, M. A., de Groot, W. J., Wotton, B. M., & Gowman, L. M. (2009). Implications of changing climate for global wildland fire. *International Journal of Wildland Fire, 18*, 483–507.

Godoy, M., Martinuzzi, S., Kramer, H., Defossé, G., Argañaraz, J., & Radeloff, V. (2019). Rapid WUI growth in a natural-amenity rich region in central western Patagonia, Argentina. *International Journal of Wildland Fire, 28*(7), 473–484.

Hardwick, S. W. (2008). Toward a suburban immigrant nation. In A. Singer, S. W. Hardwick, & C. B. Brettell (Eds.). *Twenty-first century gateways: Immigrant incorporation in suburban America* (pp. 31–50). Washington, D.C: Brookings Institution Press.

Huntsinger, L., & Oviedo, J. L. (2014). Ecosystem services are social-ecological services in a traditional pastoral system: The case of California's Mediterranean rangelands. *Ecology and Society, 19*(1), https://doi.org/10.5751/ES-06143-190108.

Husari, S., Nichols, H., & Stephens, S. (2006). In N. Sugihara, J. Van Wagtendonk, K. Shaffer, J. Fites-Kaufman, & A. Thode (Eds.). *Fire in California's ecosystems*. (pp. 444–465). University of California Press J. Agee (Author).

IPUMS National Historical Geographic Information System (2016). National historical geographic information system: Version 2.0 [database]. Retrieved November 14, 2016, from https://www.nhgis.org.

Jackson, K. T. (1985). *Crabgrass frontier: The suburbanization of the United States*. New York: Oxford University Press.

Jin, Y., Goulden, M. L., Faivre, N., Veraverbeke, S., Sun, F., Hall, A., ... Randerson, J. T. (2015). Identification of two distinct fire regimes in Southern California: Implications for economic impact and future change. *Environmental Research Letters, 10*(9), 94005.

Jin, Y., Randerson, J. T., Faivre, N., Capps, S., Hall, A., & Goulden, M. L. (2014). Contrasting controls on wildland fires in Southern California during periods with and without Santa Ana winds. *Journal of Geophysical Research: Biogeosciences, 119*(3), 2013JG002541.

Keeley, J. E., & Syphard, A. D. (2016). Climate change and future fire regimes: Examples from California. *Geosciences, 6*(3), 37.

Kneebone, E., & Berube, A. (2014). *Confronting suburban poverty in America*. Reprint editionBrookings Institution Press.

Molina-Terrén, D. M., Xanthopoulos, G., Diakakis, M., Ribeiro, L., Caballero, D., Delogu, G. M., ... Cardil, A. (2019). Analysis of forest fire fatalities in Southern Europe: Spain, Portugal, Greece and Sardinia (Italy). *International Journal of Wildland Fire, 28*, 85–98.

Morello Frosch, R., Pastor, M., Sadd, J., & Shonkoff, S. (2009). *The climate gap: Inequalities in how climate change hurts Americans & how to close the gap*. PERE Publications. Retrieved from https://dornsife.usc.edu/pere/climategap/.

National Wildfire Coordinating Group (2017). Wildland urban Interface wildfire mitigation desk reference guide. Retrieved from https://www.nwcg.gov/sites/default/files/publications/pms051.pdf.

Pellow, D. N. (2000). Environmental inequality formation: Toward a theory of environmental injustice. *American Behavioral Scientist, 43*(4), 581–601.

Radeloff, V. C., Hammer, R. B., Stewart, S. I., Fried, J. S., Holcomb, S. S., & McKeefry, J. F. (2005). The wildland-urban interface in the United States. *Ecological Applications, 15*(3), 799–805.

Roberts, J. T. (2009). The international dimension of climate justice and the need for international adaptation funding. *Environmental Justice, 2*, 185–190.

Rodrigue, C. M. (1993). Home with a view: Chaparral fire hazard and the social geographies of risk and vulnerability. *The California Geographer, 33*, 29–42.

Romero Lankao, P., & Qin, H. (2011). Conceptualizing urban vulnerability to global climate and environmental change. *Current Opinion in Environmental Sustainability, 3*(3), 142–149.

Schlosberg, D. (2003). The justice of environmental justice: Reconciling equity, recognition, and participation in a political movement. In A. Light, & A. De-Shalit (Eds.). *Moral and political reasoning in environmental practice*. Cambridge, MA: MIT Press.

Shepard, P., & Corbin-Mark, C. (2009). Climate justice. *Environmental Justice, 2*(4), 163–166.

Shrader-Frechette, K. (2002). Distributive justice, participative justice, and the principle of prima facie political equality. *Environmental justice: Creating equality, reclaiming democracy*. Oxford: Oxford University Press.

Simon, G. (2014). Vulnerability-in-production: A spatial history of nature, affluence, and fire in Oakland, California. *Annals of the Association of American Geographers, 104*(6), 1199–1221.

Simon, G. (2016). Development, risk momentum and the ecology of vulnerability. In S. Dooling (Ed.). *Cities, nature and development: The politics and production of urban vulnerability*. Burlington, VT: Ashgate.

Simon, G. (2017). *Flame and fortune in the American West: Urban development, environmental change, and the great Oakland Hills fire*. Oakland, CA: University of California Press.

Simon, G., & Dooling, S. (2013). Flame and fortune in California: The material and political dimensions of vulnerability. *Global Environmental Change, 23*, 1410–1423.

Sommers, W. (2008). The emergence of the wildland-urban interface concept. *Forest History Today, Fall*, 12–18.

Swetnam, T. W., & Betancourt, J. L. (1990). Fire-southern oscillations relations in the southwestern United States. *Science, 249*, 1017–1020.

UCI Community & Labor Project and the UCLA Labor Center (2014, July). Orange County

on the cusp of change. Available at https://www.labor.ucla.edu/wp-content/uploads/downloads/2014/07/FINAL-OC-report-for-Web.pdf.
United States Forest Service (2006). Wildland urban intermix. Retrieved from https://www.fs.usda.gov/detail/r5/landmanagement/gis/?cid=fsbdev3_048299.
Westerling, A. L., Hidalgo, H. G., Cayan, D. R., & Swetnam, T. W. (2006). Warming and earlier spring increase western US forest wildfire activity. *Science, 313*, 940–943.
Yoshino, K. (2007, October 26). Another way the rich are different: "Concierge-level" fire protection. *Los Angeles Times*. Available at https://www.latimes.com/business/la-fi-richfire26oct26-story.html.