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Comments

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High spatial and temporal resolution census data reveal communities at risk along the wildland-urban interface (WUI) in California, USA

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Introduction

Wildland-urban interfaces (WUIs) are transitional zones that are ecologically sensitive to wildfire and have experienced increasing pressure from human activities over the past decade (Radeloff et al., 2018). In California, such pressures are largely driven by the increase in human populations and high real estate development in response to the housing crisis. Understanding which regions of California's WUI have experienced significant population increases over the past decade can effectively identify communities that are exposed to a greater risk of wildfire, especially when investigated at a fine spatial scale and using the most recent demographic data. Understand this information is also a key step to better prepare vulnerable communities for future wildfire seasons.

We addressed three questions regarding the change of population at the census tract level along California's WUI during the past decade, including 1) How did the populations change along California's WUI? 2) Which communities/counties were greatly affected by such change? 3) What are the possible drivers of the change? We answered these questions by analyzing the monotonic trend of population changes across counties and comparing observed population shifts with potential socio-economic drivers, such as house ownership, house affordability, and wildfire hazard potential.

Data and Method

We adopted the 2010 boundaries of WUI in California from University of Wisconsin-Madison SILVIS Lab (Radeloff et al., 2018). The yearly population count data at census tract level for California were obtained from the American Community Survey by U.S. Census Bureau from 2010 to 2019. We also utilized three explanatory variables to understand the drivers of population change, including 1) percent housing units owned by occupants from 2019 American Community Survey, 2) Esri's House Affordability Index (HAI) (Esri, 2022), and the 3) USGS Wildfire Hazard Potential (WHP) map (Dillon et al., 2015).

A monotonic trend of population was derived for each census tract inside California's WUI from 2010 to 2019 using Mann-Kendall (M-K) test (Hamed, 2009). This method does not assume the input data are normally distributed and works for count data with sparse observations (i.e., yearly population count). We reported z-scores and p-values to measure the consistency of the monotonic trend. Recent studies showed that the z-score from M-K test can also reflect the magnitude of change (Wang et al., 2020).

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Lastly, we focused on the tracts inside WUI with significant increasing trends ($p < 0.05$, referred as high-growth counties hereafter). We calculated Pearson and Spearman correlations between the proportion of population living in the high-growth tracts and three explanatory variables.

Results

Spatial distribution of significant population change

Nearly one-third of census tracts (29.2%) inside California's WUI are high-growth tracts (Figure 1), affecting 12.7% of total population of California in 2019. For comparison, proportions of California's WUI tracts that experienced a significant population decrease or no significant change were 9% and 61.8%.

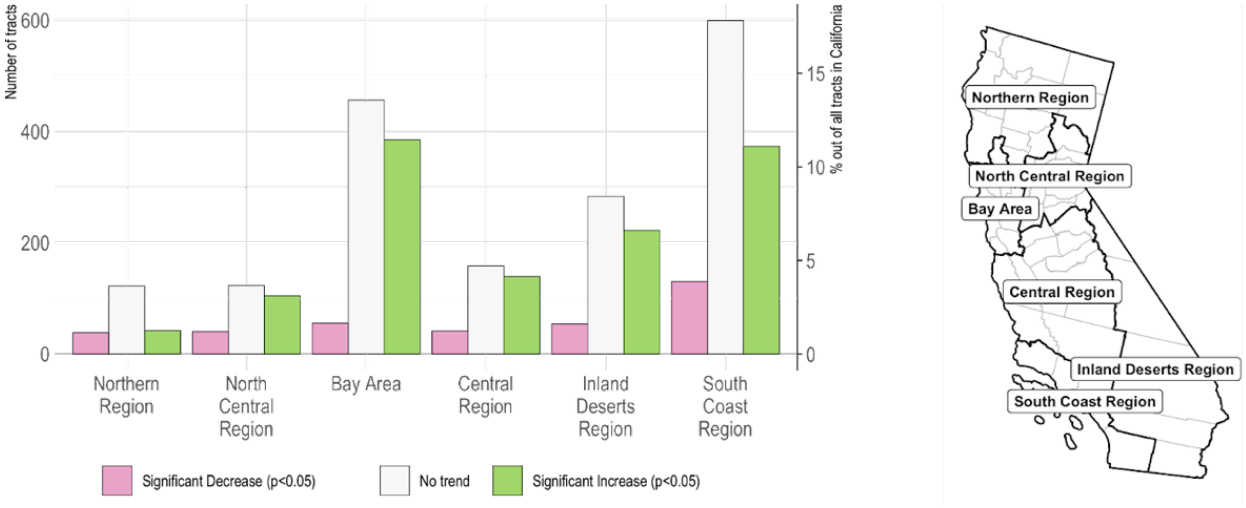

Figure 1. Monotonic population trends from 2010 to 2019 of census tracts inside Wildland-Urban Interface (WUI) of California.

Southern California and the Bay Area account for 76% of all high-growth tracts in California. However, the two regions showed different patterns in terms of degree of change and the impact on total population. Bay Area counties showed a greater degree of population increase (Figure 2a). All but one (Riverside) of the counties with a median z-score in the top tertile (z-score > 2.6) are located in the Bay Area (Figure 2c). Furthermore, these changes affected a greater proportion of county population in the Bay Area. Nearly every county in the Bay Area except San Francisco had above 15.3% of the county population living in high-growth tracts (Figure 2a). In contrast, four out of six Southern California counties had <15.3% of their opulation living in such tracts.

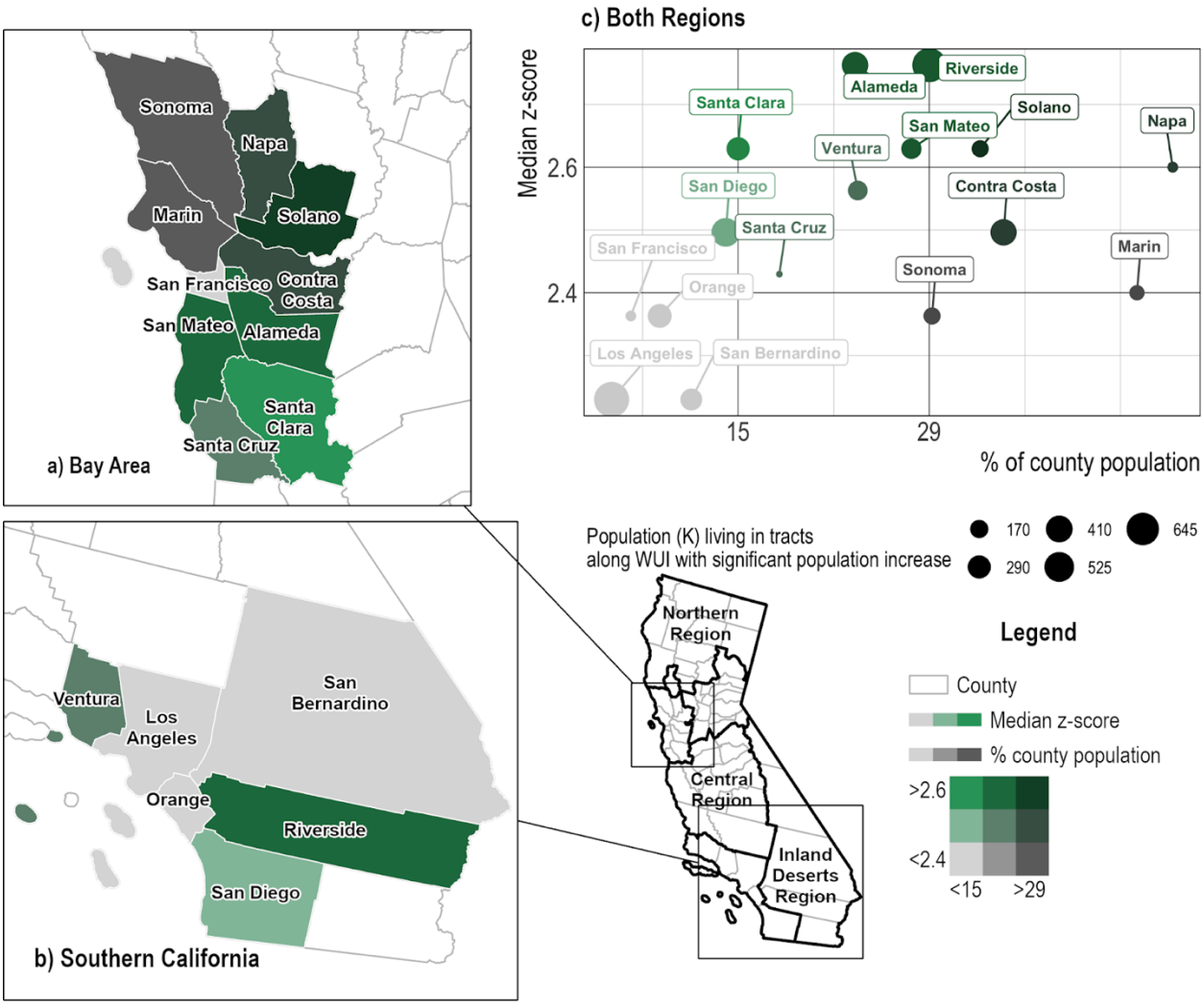

Figure 2. Degree of increase (median z-score) and percent of county population affected by the increase along WUI in Southern California and the Bay Area.

The population increase within WUI zones encompassed more residents in Southern California (1,886,078). Only 6.1% of Los Angeles County's population live in high-growth tracts, accounting for approximately 765,000 residents. This is almost twice as many as the top county (Alameda) in the Bay Area (Figure 3). Among all 16 counties in both regions, Riverside is the only county where a high degree of population change (z-score > 2.6) encompassed a large number of residents (717,000) that represent a high proportion of county population (29.2%).

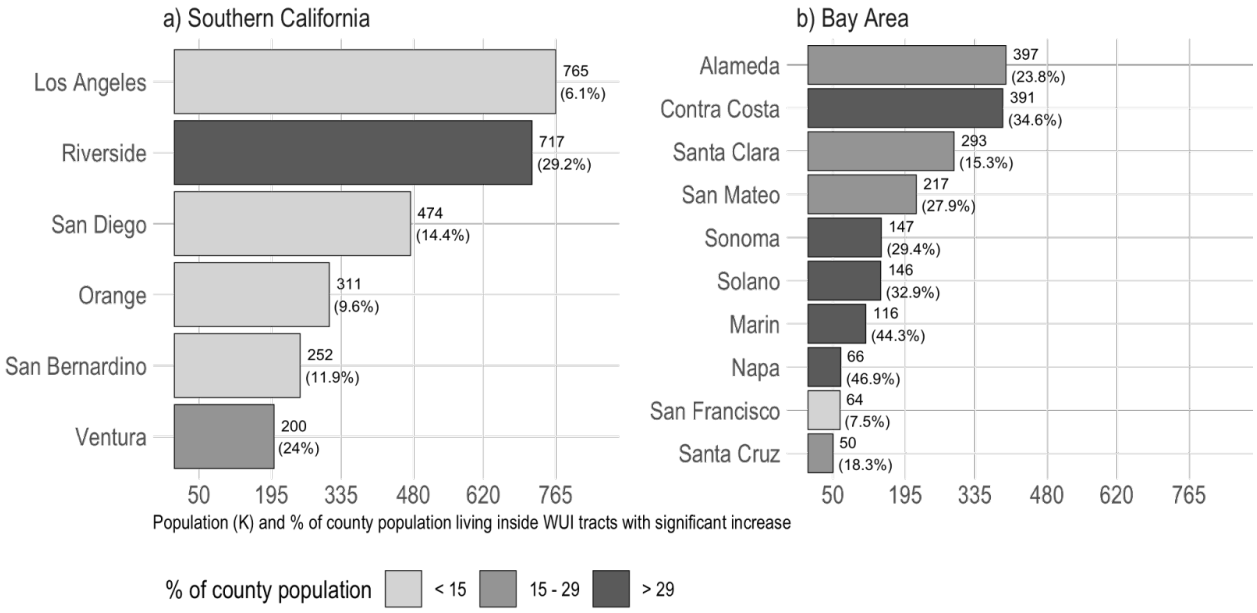

Figure 3. Number of residents and percent of county population living in WUI tracts with significant population change for Southern California and Bay Area counties.

Possible drivers of population increase along WUI

House affordability has been frequently cited as a key driver of the sprawling towards WUI in California. Both Spearman and Pearson's correlation coefficients (Figure 4a-b) demonstrated that counties with a higher proportion of residents living in high-growth tracts are positively correlated with increased housing affordability ($\boldsymbol{\rho} = 0.56$, $R = 0.61$) and house ownership ($\boldsymbol{\rho} = 0.63$, $R = 0.50$). However, there is no significant relationship between the wildfire hazard and the proportion of residents living in high-growth tracts (Figure 4c), indicating that the sprawling is curbed under a tolerable level of wildfire risk. Yet the positive slope in the linear regression suggested that the wildfire risk is a weaker deterring factor of sprawling in Sonoma, Riverside, and Ventura. Outliers of these patterns include Napa, Marin, and Solano Counties, driven by the sparse population distribution and large parcel size associated with the wine industry.

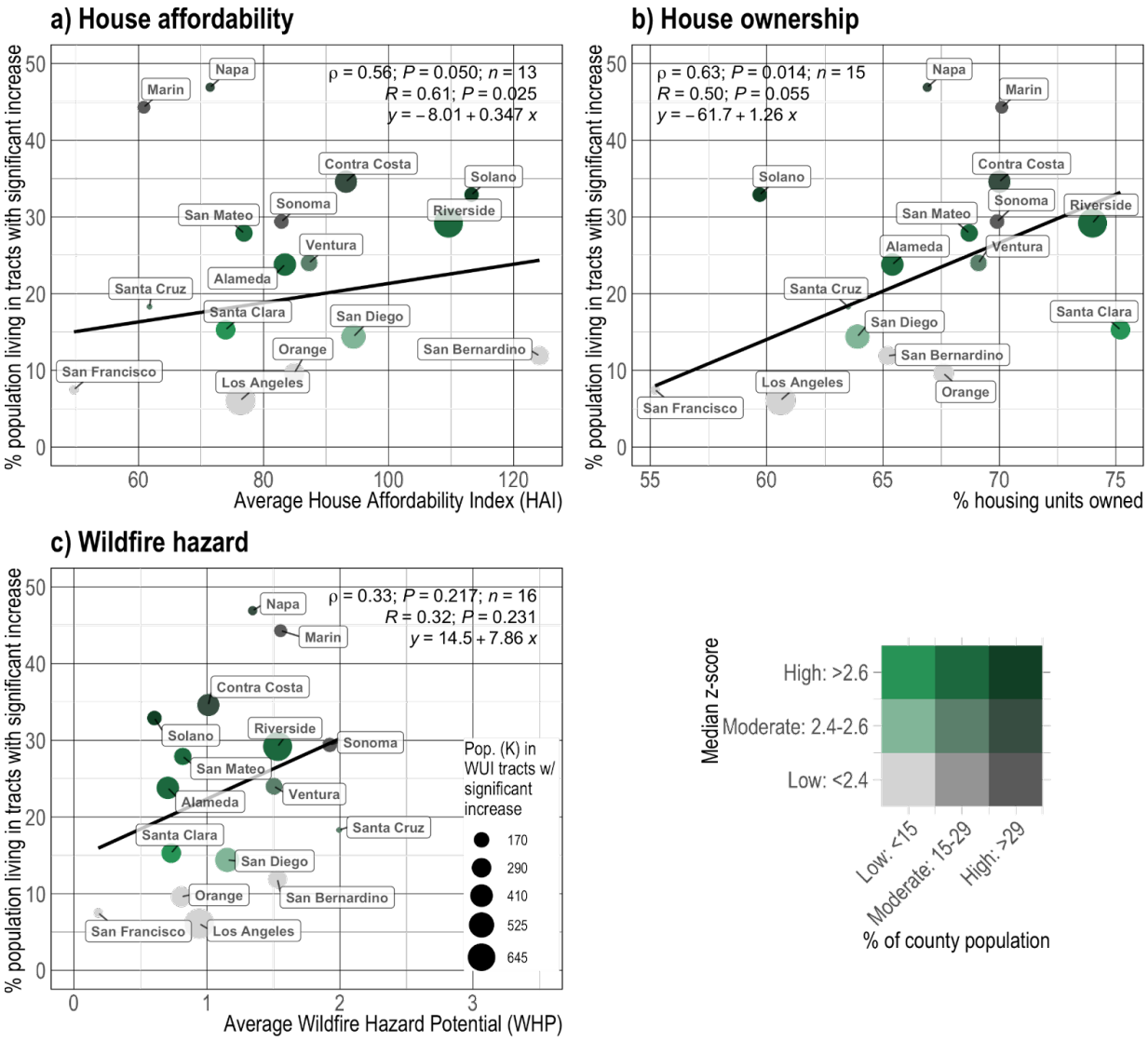

Figure 4. Potential factors contributing to the distribution of the proportion of population living in WUI tracts with significant population change in Southern California and Bay Area counties.

Discussion and Conclusions

Our analysis confirmed that California's WUI has experienced a significant population increase during the past decade, particularly in Southern California and the Bay Area. Bay area counties exhibited the largest overall increase in population and a higher proportion of the population located within WUI tracts. However, the population increase within WUI zones encompassed considerably more residents in Southern California due to its larger population size. Among all California counties, Riverside County is the most prominent example of increasing risk along the WUI due its population increase coupled with the high proportion of population and large number of residents affected.

Our preliminary analysis found that the population increase is driven by the house affordability in WUI, where homes can be built at a lower price at the cost of elevated wildfire risk.

California's zoning laws before 2021, as well as local resistance to development, also contributed to sprawl by restricting apartment complex construction in single-family zoning areas (Rothwell, 2019). Furthermore, the car-centered lifestyle of California also makes long commutes tolerable. As these socio-economic hurdles are likely to stay, the provision of more homes is often met by construction in the WUI. Coupled with climate change, this growth may significantly increase the chance of wildfire occurrence due to an increased level of human activities near fuels (Williams et al., 2019), exposing these already-vulnerable communities to more risk (Balch et al., 2017). Our results are a call-to-action for lawmakers, community leaders, and the general public to be aware of the elevated level of risk in future planning.

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