Risk Disclosure and Home Prices: Evidence from California Wildfire Hazard Zones

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ABSTRACT *Damages from wildfires have increased dramatically in recent years. This study uses a boundary discontinuity design to estimate the effect of wildfire-hazard disclosure on house prices. Using the universe of single-family sales transactions from Zillow's Transaction and Assessment Database in California from 2015 through 2022, we find that, on average, homes facing disclosure requirements sold for approximately 4.3% less than nearby homes that did not. Price impacts are higher in recent years, after several damaging wildfires. Our findings highlight the use of disclosure regulations to ensure that disaster risks are reflected in housing markets.* (JEL Q51, Q54)

1. Introduction

The growing exposure of people and property to natural hazards such as floods and wildfires is a significant contributor to the rising costs of disasters in the United States (Higuera et al. 2023). Homes in the wildland-urban interface (WUI), the transition zone between natural and developed lands where the built environment intermingles with forested areas, account for most of the properties lost in wildfires (Kramer et al. 2019). By some accounts, the WUI is the fastest growing land use type in the conterminous United States (Radeloff et al. 2018), and more than 600,000 new homes are expected to be built in high-fire-hazard areas in California alone by 2050 (Mann et al. 2014).

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Whether people consider disaster risks when choosing where to live and whether such risks are capitalized into home prices are open questions. One of the challenges to addressing these questions in an empirical setting is causal identification. Disasters such as floods and wildfire risks are often highly correlated with natural amenities: proximity to rivers and oceans in the case of floods, and forested landscapes, access to public lands, and views in the case of fire. Thus, distinguishing the effect of risks from amenities can be difficult. Furthermore, whether home buyers fully understand risks and how they vary across properties and the extent to which they incorporate risks in their decision-making is unclear.

Tackling the issue of correlated amenities and missing or incomplete risk information is more straightforward for floods than for wildfires because the federal government officially designates high-flood-risk areas as special flood hazards areas (SFHAs), commonly referred to as the 100-year floodplain. When a home is in an SFHA, the homeowner is required to have flood insurance when they have a federally backed mortgage on the property, and the SFHA designation must be disclosed on sale of the property. This provides a spatial delineation of risks. Some studies have combined this spatial distinction with the timing of major flood events in a differences-in-differences hedonic regression (Bin and Polasky 2004; Kousky 2010; Atreya, Ferreira, and Kriesel 2013; Atreya and Ferreira 2015; Beltran, Maddison, and Elliott 2019). Others have used a boundary discontinuity design, comparing home sales near and on either side of the SFHA boundary to isolate the effect of flood risks on home prices (Bakkensen and Ma 2020).

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The wildfire setting has some important differences from the flood setting. Insurance is generally provided through standard homeowner insurance policies, not a wildfire-specific policy, and there is not a federally mapped high-fire-hazard zone. It is thus unclear the extent to which homebuyers understand the risks when purchasing a home in wildfire-prone areas. Perhaps for these reasons, the literature on hedonic pricing of wildfire risks is sparse.

In California, wildfire risks may be better understood among homebuyers than in other states, at least in some locations. California law requires that sellers of properties in certain designated wildfire-hazard areas disclose this information to buyers. These disclosure requirements are determined based on properties' locations with respect to mapped wildfire-hazard categories and the jurisdiction responsible for wildfire management. Where the state of California is responsible for wildfire management, so-called state responsibility areas (SRAs), disclosure is required anywhere the state classifies as a fire-hazard severity zone (FHSZ).[1] In areas where local jurisdictions are responsible for managing wildfires, local responsibility areas (LRAs), disclosure is required only in very high FHSZs. In this study, we refer to these two types of areas where disclosure is required as "regulated" and identify the geographic boundaries between regulated areas and unregulated areas throughout the state. We focus on the extent to which wildfire-risk disclosure affects home prices, which provides some evidence on how wildfire risk may affect homebuyers' decisions.

We use a boundary discontinuity design (BDD) (e.g., Black 1999; Turner, Haughwout, and Van Der Klaauw 2014; Bakkensen and Ma 2020), comparing sales of homes that are nearby but on either side of a regulated area boundary. The primary identifying assumption under this research design is that, although disclosure requirements change abruptly at the boundary, unobserved variables that may be correlated with wildfire hazard vary continuously across it, at least within some distance band close to the boundary. Using the fact that disclosure requirements are also determined by wildfire management responsibility—that is, whether a property is in an SRA or an LRA—we compare nearby properties with similar levels of fire hazard but different disclosure requirements. Specifically, in our main results, we compare prices of nearby homes in high FHSZs that do and do not face wildfire-hazard disclosure requirements.[2] In this way, our empirical methods should isolate the effect of risk disclosure on home prices.

Using data from Zillow's Transaction and Assessment Database (ZTRAX) on home sales in California from 2015 through 2022, a period of unprecedented wildfire activity and damages, we find that, on average, high FHSZ homes within 300 m of the regulated area boundary that faced disclosure requirements sold for approximately 4.3% less than homes within 300 m that did not face these requirements. Consistent with expectations, homes in moderate FHSZs also sold for less if they were subject to disclosure requirements (the discount is 2.6%). We investigate geographic heterogeneity in our results by estimating separate regressions for northern and southern California. The estimated impacts are stronger in southern California. When we estimate separate effects by year, we find that the magnitude of the price discount increases in the later years of our sample, 2020 and 2021, which followed several years of large and damaging fires.

This study contributes to a literature that attempts to uncover household risk preferences with respect to natural hazards and the effect that these hazards have on home prices. In this literature, two primary empirical approaches have been used. First, many studies in the flood context (e.g., Bin and Polasky 2004; Kousky 2010; Bakkensen, Ding, and Ma 2019; Gibson and Mullins 2020), have used difference-in-differences approaches that make use of hazard events

[1] California divides FHSZ in the state into moderate, high, and very high categories. We discuss these zones in greater detail in Section 2.

[2] Although we limit our main analysis to high FHSZs to control for unobserved wildfire hazard correlates, our results are robust to limiting the sample to moderate FHSZs, where there is also variation in regulation.

for identification. A common finding is that prices in high-hazard areas decline relative to low-hazard areas after nearby hazard events, but these declines are short-lived, usually lasting no longer than two to three years. In one of the few studies applying the difference-in-differences approach to wildfires, McCoy and Walsh (2018) use data from Colorado and find a price discount for properties in high-fire-risk areas after a fire, and the discount is larger and more immediate for properties that have a view of a burn scar from a recent fire. Huang and Skidmore (2024 [this issue]) study the effects of smoke on home prices and find that smoke induced by upwind fires decreases home values for up to three years.

A second somewhat less common approach in the literature has been to use policy-based information treatments. Studies adopting this approach have often analyzed changes in house prices using difference-in-differences strategies centered on adoption or revisions to disclosure policies or hazard maps. Pope (2008) finds that after the implementation of a flood-risk disclosure law in North Carolina in 1996, the prices of homes in SFHAs declined by approximately 4% relative to homes outside SFHAs. Donovan, Champ, and Butry (2007) find that after the online publication of wildfire-risk ratings in Colorado Springs, Colorado, wildfire risk, which had previously been positively correlated with home price, became negatively correlated.

A few studies using policy-based information treatments have also used BDDs. Bakkensen and Ma (2020) use SFHA boundaries to identify flood risk preferences from home prices. They find that home prices are approximately 6% lower just inside the flood zone, where buyers tend to receive more information about flood risks, even though the risk varies continuously across and near the flood zone boundary. Finally, in the study most closely related to this one, Garnache (2023) analyzes how revisions to California's FHSZ maps affect house prices. Focusing on seven counties in southern California, Garnache (2023) compares changes in home prices just outside a new boundary to changes in home prices just inside and finds that newly regulated homes drop in price by between 3% and 6%.

Hedonic studies in other contexts have estimated the impact of information and disclosure programs on property sales prices and rents. Most notably, several studies have found that energy and "green" property certifications, which typically provide a label or score to indicate energy efficiency and other hard-to-observe environmental features of properties, tend to increase prices and rents. These results have been found for residential (Brounen and Kok 2011; Walls et al. 2017) and commercial properties (Eichholtz, Kok, and Quigley 2013; Brolinson, Palmer, and Walls 2023).

This article makes several key contributions to the relatively small literature estimating the capitalization of wildfire hazard into home prices. First, we make use of very recent data, from 2015 through 2022, a period during which wildfire damage in California rose dramatically. Second, our dataset includes transactions from across California, rather than small geographic areas common in many hedonic analyses. This facilitates use of the BDD approach and allows us to consider spatial heterogeneity across regions of the state. Third, although our main results use a pooled cross-section time series dataset with seven years of data, we also estimate the model on separate single-year cross sections. This addresses the critique that due to changes in population and preferences, samples using multiple years may mix different hedonic equilibria, obscuring the interpretation of the estimates as a welfare measure (Kuminoff and Pope 2014; Banzhaf 2021). Further, by estimating our model separately by year, we can consider how preferences to avoid wildfire hazard may have changed over the study period. Finally, our empirical strategy, using regulated boundaries in areas classified with the same level of fire hazard, achieves the goals of isolating the impacts of risk-disclosure requirements and reducing omitted variables bias from unobserved amenities that are correlated with wildfire hazard.

2. Wildfire-Hazard-Disclosure Laws in California

California law requires sellers of properties in designated wildfire-hazard areas to disclose this information to buyers in a natural-hazard-disclosure (NHD) statement, which is used for disclosure of a variety of state and federally designated hazards (Troy and Romm 2007).[3] The NHD statement, which warns property buyers about hazards as well as the potential for challenges in obtaining insurance and developing the property, is mandated to be disclosed prior to escrow, at which point buyers have a three-day period during which they are allowed to back out of the purchase.

For wildfires, disclosure requirements are determined based on the degree of wildfire hazard (i.e., the FHSZ) and the jurisdiction responsible for wildfire management ("responsibility areas"). In California, jurisdictional responsibility for wildfire management is divided across federal responsibility areas, SRAs, and LRAs, areas where the federal, state, or local governments, respectively, have financial responsibility for managing wildfires. These areas roughly correspond to federal lands, unincorporated nonfederal lands, and lands under the jurisdiction of a local fire department.[4]

The fire-hazard component of disclosure requirements is based on FHSZ maps. In SRAs, moderate, high, and very high FHSZs are designated by CAL FIRE based on fire history, vegetation, and modeled predictions of fire behavior. In LRAs, CAL FIRE makes recommendations regarding the boundaries of FHSZs; however, local communities make the final decision regarding whether these are adopted. Most communities across California have done so.[5] During the period of our data, disclosure regulations and building codes applied to only very high FHSZs in LRAs. Other FHSZ classifications were not formally adopted in LRAs, but CAL FIRE maintains data on modeled fire hazard levels in these areas. As a result, LRAs and SRAs now comprise three FHSZ classifications. Table 1 shows the combination of responsibility areas and FHSZs where disclosure is and is not required.

Table 1
Responsibility Area and Fire-Hazard-Severity Zone Categories Where Disclosure Laws Apply under California AB 1195

Responsibility Area	Fire-Hazard-Severity Zone			
	None	Moderate	High	Very High
Local	No	No	No	Yes
State	No	Yes	Yes	Yes
Federal	No	No	No	No

Note: "Yes" indicates disclosure laws apply. "No" indicates disclosure laws do not apply.

Building codes requiring fire-resistant building materials as well as maintaining areas clear of vegetation (defensible space) around homes were implemented in California beginning in the 1990s and were substantially strengthened in 2008 with passage of the chapter 7A building codes, which included requirements for house siding, eaves, vents, doors, windows, and decks in addition to requiring fire-resistant roofing materials for new construction.[6] Like the disclosure requirements, building codes applied to all FHSZ categories in SRAs and to the very high FHSZ category in LRAs. In our main analysis,

[3] Almost all counties in California have prepared community wildfire preparedness plans (CWPPs), which are necessary for receiving some sources of federal wildfire mitigation funding (Jakes et al. 2012; FEMA 2020). These plans are another potential source of information about wildfire risk; although they include some risk mapping, they are mainly focused on communicating ways that households can reduce flammable materials and structure ignitability. Homebuyers are not required by law to be informed of a CWPP upon purchase of a home.

[4] Federal responsibility areas do not precisely correspond to federal lands because under a policy known as the "balance of acres" arrangement, state and federal agencies have traded fire responsibilities in some areas to maximize efficiency (Starrs et al. 2018). Such swaps are especially common in areas with a high degree of checkerboarding due to nineteenth- and twentieth-century land disposal policies.

[5] Following a map revision process that began in 2007, eventually more than 92% of communities CAL FIRE identified as containing very high FHSZs either adopted or believed they had adopted the very high FHSZ maps (Miller, Field, and Mach 2020) Most communities adopted the very high FHSZs by 2009; however, some communities in southern California adopted hazard zones as late as 2012.

[6] For a more detailed review of changes over time in California building codes related to wildfire hazard, see Baylis and Boomhower (2022).

we focus attention on sales of properties built before 2008 to focus on disclosure impacts to prices and reduce effects of building codes.

3. Empirical Strategy

A basic model of the effect of wildfire hazard on home prices is given by

$$\ln(P_{i,t}) = \alpha + \beta X_{i,t} + \gamma Z_{i,t} + \delta W_{i,t} + \nu_t + \epsilon_{i,t}, \qquad [1]$$

where the dependent variable $\ln(P_{i,t})$ is the log of housing price for property i sold at time t. $X_{i,t}$ represents the property's structural characteristics; $Z_{i,t}$ represents neighborhood characteristics attached to the property at time t, where we have separated out wildfire risk $W_{i,t}$, our neighborhood characteristic of interest; ν_t represents time period fixed effects (e.g., year and month of sale); and $\epsilon_{i,t}$ denotes an idiosyncratic term that is unobserved by the researcher.

Recovering implicit prices of wildfire risk requires that buyers are informed of and attentive to the wildfire risks they face. It is unclear whether this full information requirement can be satisfied for homes in wildfire hazard areas since there are no federally mapped wildfire zones and there is no separate wildfire insurance policy requirement. Thus, unknowing buyers might have been willing to pay less for a property with a high wildfire hazard had they known about the exposure risk; ignoring imperfect information over risks would attenuate willingness to pay to avoid those risks. Our focus on the price capitalization of disclosure helps us understand the extent of the information problem in hedonic valuation of wildfire risks.

We exploit spatial variation, where disclosure laws in California enforce provision of information about wildfire hazard. Specifically, we define a binary treatment variable $Regulated_{i,t}$ equal to one if the property is in an SRA or an LRA with a very high FHSZ designation and zero otherwise. When California's chapter 7A building codes were passed in 2008, the wildfire-hazard-disclosure requirement coincided with additional construction requirements for newly built homes. Therefore, we focus on sales of properties built before 2008, when building codes for new properties in regulated areas were much less stringent; we argue that differences in price for regulated and unregulated homes built in this period are likely to be driven by differences in disclosure requirements.

In addition, we face the prevalent problem of omitted variable bias. Although we have collected data on a host of neighborhood amenities (e.g., proximity to protect lands and school quality), it is impossible to collect all relevant neighborhood information that covaries with wildfire hazard. This is particularly true because the same attributes that drive wildfire hazard (e.g., proximity to forests or other wildlands) are also valued as an amenity by many homebuyers.

We attempt to alleviate the omitted variables problem with various strategies. First, we include fixed effects at high spatial resolution and allow for county-specific time trends (Kuminoff, Parmeter, and Pope 2010). Second, we focus on a sample of property sales near the disclosure regulatory boundary and compare properties on either side of the same boundary segment, similar to a regression discontinuity design (Imbens and Lemieux 2008). The identifying assumption in this design is that, although disclosure requirements vary discontinuously at the regulated-unregulated boundary, unobserved attributes that affect home price do not; if amenities and other attributes do not change discretely at the regulatory boundary, any change in price at the boundary should be attributed to disclosure of wildfire risks.

Regulated areas are defined in part as a function of wildfire hazard (see Section 2). We are concerned that in places where regulated and unregulated status differs because of differences in designated wildfire hazard severity, there may be differences in unobserved amenities across the boundary in addition to differences in disclosure requirements. Therefore, we restrict the sample to transactions in only high FHSZs and near boundaries between SRAs and LRAs. This allows us to better control for unobserved variation in amenities that are correlated with disclosure. Although this comes at the expense of reducing variation in wildfire risk, we retain variation in wildfire-risk regulation. We modify our empirical specification to include these additional fixed effects and sample controls:

$$\ln(P_{i,t}) = \alpha + \beta X_{i,t} + \gamma Z_{i,t} + \delta Regulated_{i,t} + \nu_{c(i),t} + \nu_{b(i)} + \nu_{g(i)} + \epsilon_{i,t}$$
$$\forall i \text{ s.t. } BoundaryDist_i < |\text{B km}|, FHSZ_i = \text{high}, BoundaryType_{b(i)} = \text{high FHSZ LRA / high FHSZ SRA}, \quad [2]$$

where $\nu_{c(i),t}$ represents county-by-year fixed effects, $\nu_{b(i)}$ represents fixed effects for the boundary segment nearest to each transacted property, and $\nu_{g(i)}$ represents fixed effects at the 250 km^2 grid cell level (discussed in greater detail in Section 4). We limit the sample to high FHSZ properties within *B* km of boundaries between high FHSZ LRAs (unregulated) and high FHSZ SRAs (regulated). Our sample limitation, in conjunction with the boundary and grid cell fixed effects, allows us to identify effects of hazard disclosure on property values by comparing the sales of properties on either side of a regulated boundary.

A potential problem created by using the LRA-SRA boundary for identification is that they frequently coincide with boundaries between incorporated and unincorporated areas, which may differ with respect to taxes, regulations, and public good provision. Fortunately, there exist unincorporated LRAs; therefore, it is possible to separate the effect of being in an incorporated area from the effect of wildfire-hazard disclosure.

Our empirical strategy importantly assumes that homebuyers in areas where disclosure is not regulated are mostly unaware of wildfire risk, or at least are less aware of wildfire risk than homebuyers in areas where disclosure is regulated. This is similar to assumptions in studies of flood risk and home certification schemes for energy efficiency (i.e., that disclosure through flood maps or green labels provides information that homebuyers would otherwise not have). If this assumption is violated in our setting, our estimates of wildfire-risk disclosure will be biased toward zero. We evaluate the effectiveness of our strategy when we present our findings.

4. Data

This study uses data on home sales prices provided by ZTRAX, which include comprehensive transactions records and assessors' data. Transaction records provide information about property sale dates and prices; they can be linked in ZTRAX to the assessors' data to provide information on the characteristics of each property. Property characteristics in the assessors' data include lot size, year of construction for buildings on the property, square footage, number of bedrooms, number of bathrooms, and an array of other building and property characteristics.[7]

From ZTRAX, we assembled a dataset describing property sales in California from 2015 to March 2022.[8] We focused on these years because during this time California experienced a dramatic increase in wildfire activity and damage from wildfires; as of January 2022, 14 of the most destructive wildfires in California state history had occurred since 2015 (California Department of Forestry and Fire Protection 2022b). Further, we restricted our dataset to arm's-length purchases of single-family residential homes.[9] We also dropped transactions that included the exchange of multiple distinct properties. After these sample restrictions, we were left with an initial dataset containing 1.56 million observations.

For each transacted property in the dataset, we used CAL FIRE spatial data to identify the location relative to responsibility areas and fire hazard zones and to measure distance

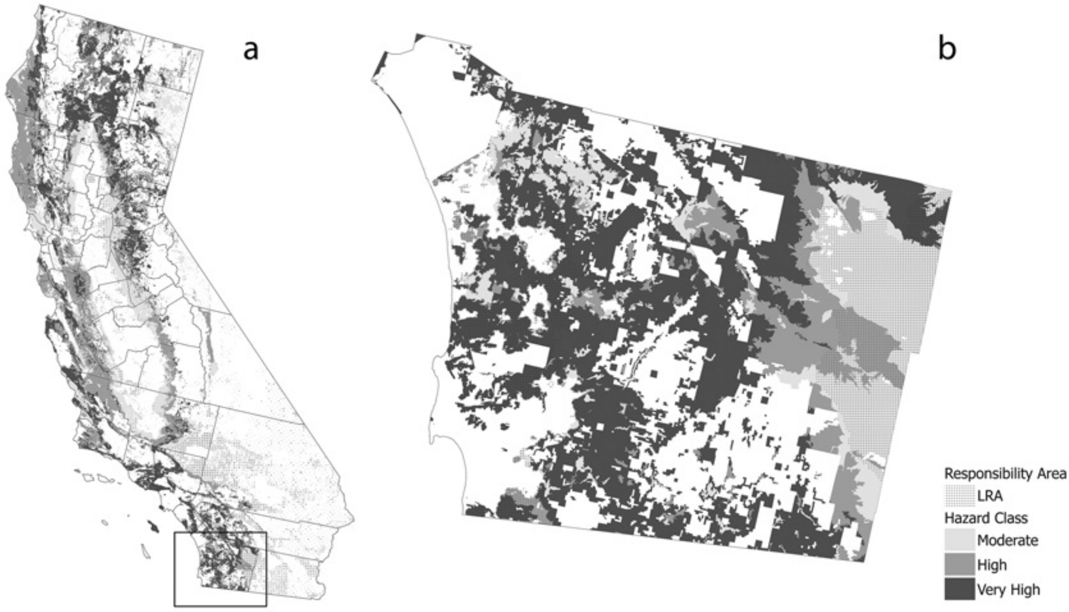
[7] In some cases, assessors' data include records for more than one building associated with a single property. For each transaction in our dataset, we measured property characteristics based on those associated with the largest building (with respect to square feet) on the property.

[8] Our dataset includes all California counties except San Francisco, which is excluded because it is large but contains insignificant high-fire-hazard areas.

[9] We include properties with land use classified single family residential, rural residence, and inferred single family residential. To restrict attention to arm's-length transactions, we drop transactions with sales prices below $10,000.

Figure 1

Fire-Hazard-Severity Zones in State and Local Responsibility Areas: (a) California; (b) San Diego County



Note: Shaded areas without a stipple pattern are fire-hazard-severity zones (FHSZ) within state responsibility areas. Nonshaded areas include areas not classified as FHSZs and federal responsibility areas.

from the boundary between regulated areas (where disclosure laws apply) and unregulated areas (where they do not).[10] A map of FHSZs in SRA and LRA areas is shown in Figure 1a. A more detailed view of FHSZs in San Diego County is shown in Figure 1b. As the state map shows, SRAs cover a larger land area. However, among properties in FHSZs, nearly 70% of transaction observations in (352,000 out of 519,000) correspond to properties in LRAs.[11]

Following a procedure described by Bakkensen and Ma (2020), we divided boundaries between regulated and unregulated areas into discrete segments using the polygon to line tool in ArcGIS, and we measured the distance from each transacted property to its nearest boundary segment.[12] Our design makes use of boundary fixed effects to ensure that we are identifying differences in price between properties on either side of the same boundary segment. Therefore, it is important that boundary segments are neither too long (in which case boundary fixed effects would insufficiently account for differences across neighborhoods) nor too short (in which case boundary effects would eliminate too much variation from our sample).

Our boundary segments average 3.4 km, with an average of 1,183 transacted properties

[10] We define FHSZs and responsibility areas using a dataset assembled by CAL FIRE to provide accurate wall-to-wall descriptions of fire hazard in SRAs and LRAs. For SRAs, the dataset includes FHSZs as adopted by CAL FIRE in 2007. Local communities generally adopt only very high FHSZs, and statewide data on the precise boundaries of locally adopted very high FHSZs are unavailable. Therefore, for LRAs the dataset includes boundaries of very high FHSZs recommended for adoption by CAL FIRE. For other FHSZs in LRAs, fire hazard classifications are based on initial draft maps provided by CAL FIRE.

[11] Federal responsibility areas are another category, and these encompass a large area of California. However, residential properties in these mostly federal lands make up only 0.2% of transactions (1,450) in the sample; we drop these from the dataset.

[12] In addition to dropping properties in the FRA from the dataset, we measure distances from regulated SRA areas to unregulated LRA areas and ignore unregulated FRA areas. This is because SRAs are frequently near boundaries with unregulated and relatively unpopulated FRAs due to checkerboarded federal landholdings in California (see Leonard, Plantinga, and Wibbenmeyer 2021).

nearest to each one. We judge this to be a reasonable length. Nevertheless, boundary segments necessarily vary in length, and some very long boundary segments resulted from using the ArcGIS tool. In addition to boundary segment fixed effects, we divided California into a 250 km^2 hexagonal grid and included fixed effects for each cell. For properties along long boundary segments, these cell fixed effects account for differences in home prices across cells that may vary in unobserved neighborhood characteristics that affect home prices.[13]

As discussed in Section 3, we were concerned that where boundaries between regulated and unregulated areas exist due to differences in fire hazard, differences in amenities across these areas may confound identification of the effects of disclosure. Therefore, in our primary regressions we restricted our attention only to properties that are closest to boundaries between high FHSZ LRAs and SRAs. These properties face significant wildfire hazards; however, they face different disclosure requirements depending on whether they are in the LRA or the SRA. With the sample restricted to properties in high FHSZ areas, our primary final dataset contains 164,019 observations over the 2015–2022 period. In robustness checks, we estimated effects of disclosure requirements for properties in moderate FHSZs.

In addition to the property and structural characteristics obtained from ZTRAX, we assembled property- and neighborhood-level covariate variables from a variety of sources. We measured wildfire hazard at the property level based on wildfire hazard potential (WHP), an ordinal measure created by the U.S. Forest Service to measure the potential for a site to experience a difficult-to-contain wildfire. We used data on historical fire perimeters from the USGS Monitoring Trends in Burn Severity project to identify transactions for properties that had been in a fire perimeter within five years before the year of sale.[14] Using the USGS Protected Area Database, we measured the distance of each property to the nearest area classified under GAP status 1 or 2, a possible source of amenity values for homeowners.[15] To separate effects of location in incorporated areas (which frequently coincide with the boundary of unregulated LRAs) from exposure to disclosure requirements, we gathered data on the extents of California incorporated areas from the California Department of Forestry and Fire Protection (2022a). We used summary file 1 data from the 2010 U.S. Census to measure the share of white residents in each property's block group. Finally, we measured the quality of the school district using data from the California Department of Education on the percentage of students in each property's district who met or exceeded math and language arts testing standards.

Summary statistics for our property characteristics, including transaction value, are shown in Table 2. The average price of properties in our sample is $625,000. As expected, fire hazard, measured by WHP, is higher among regulated than unregulated properties. A total of 2% of properties in our overall sample, and 6% of properties in regulated areas, had been within a fire perimeter in the five years prior to the observed sale. Regulated and unregulated properties are similar with respect to the number of bathrooms and bedrooms; however, regulated properties tend to have greater floor space, smaller lots, and were built more recently on average. School district quality is higher among regulated properties. Regulated areas contain a higher proportion of white residents, and they are closer to protected areas. This is because these properties are often located in rural SRAs, which is underscored by the fact that only 47% of regulated properties are in incorporated areas compared with 84% of unregulated properties.

[13] For reference, counties in California are approximately 7,300 km^2 on average. Each county contains an average of approximately 29 cells.

[14] McCoy and Walsh (2018) find evidence that proximity to (and views of) burn scars matter for house prices. Our use of a BDD, comparing houses in very close proximity, eliminates the need to control for this factor. For the same reason that amenities should be similar for houses on either side of the boundary, proximity to burn scars should be as well.

[15] Protected areas with GAP status 1 or 2 are permanently protected and have a management plan to maintain the lands in a natural state. These areas, which include national parks and wilderness areas, are distinguished from areas with lower GAP status, which may be protected from land cover conversion but subject to extractive uses such as logging or mining.

Table 2
Summary Statistics

Attribute	Full Sample Mean	Full Sample SD	Regulated Mean	Regulated SD	Not Regulated Mean	Not Regulated SD
Wildfire hazard						
Ln(1 + WHP)	1.69	2.74	4.13	3.37	1.18	2.28
Previous fire	0.02	0.14	0.09	0.29	0.01	0.08
Property characteristics						
Price	625,444	846,988	746,907	1,006,942	599,987	807,154
Bedrooms	3.362	0.895	3.28	0.99	3.38	0.87
Bathrooms	2.327	0.85	2.5	1.03	2.29	
Ln(lot size)	−1.543	0.96	−0.82	1.4	−1.69	0.76
Year built	1980.67	24.91	1984.9	22.27	1979.79	25.34
Sq. ft.	1,973.19	7,739.74	2,245.02	1,213.98	1,916.21	8,492.98
Neighborhood characteristics						
% meeting standard language arts	52.15	13.75	54.4	13.98	51.67	13.66
% meeting standard math	39.22	15.44	41.34	16.3	38.77	15.21
Share white residents	0.66	0.19	0.8	0.13	0.64	0.18
Distance to protected areas (m)	17,126.2	14,398.22	11,679.37	9,222.43	18,267.76	15,013.67
Incorporated	0.77	0.42	0.37	0.48	0.86	0.35
Observations	1,556,426		271,413		1,295,013	

Note: The table presents the mean and standard deviations of various house characteristics for the full sample by regulatory status. The period in this sample is 2015–2020. WHP = wildlife-hazard potential.

5. Results

Naive Model Results

We begin by using data on property-level WHP to explore correlations between log WHP and log housing prices in our sample under different sets of controls. This naive specification demonstrates our concerns about correlated risks and amenities. Evidence that homeowners are willing to pay to avoid wildfire risk is weak. In the specification with tract-level fixed effects, we find that wildfire risk is positively correlated with housing prices, as shown in Table 3, column (3), consistent with Wibbenmeyer and Robertson (2022) and viewshed analyses in McCoy and Walsh (2018). This counterintuitive result is likely driven by omitted variables bias. The problem is compounded if we assume that buyers are cognizant of the risks when they are not.

Main Results

Considering the estimates in the previous section, we turn to identifying the effects of wildfire-hazard disclosure on home prices using the BDD described by equation [2]. We present results that do not limit the sample based on distance to the regulatory boundary in Table 4. The variable of interest is *Regulated*, which is an indicator for whether a property is in an area that requires wildfire-risk disclosure. All else equal, one would expect the coefficient to be negative. All specifications include the same set of house and neighborhood controls and fixed effects for year and month of sale at baseline.[16] Standard errors are two-way clustered at the county and year level for all specifications.

Column (1) begins with the sample of all house sales. Prices are generally higher in areas with disclosure requirements than in areas without. This is unsurprising because disclosure requirements apply in areas with high wildfire hazard, which also tend to be rich in amenities (e.g., proximity to protected areas). This is alleviated when we limit the sample to high FHSZs in column (2). There is still variation in disclosure regulation but

[16] Controls include number of bedrooms, number of bathrooms, log of lot size, age, indicators for the decade of construction, square feet, share white at the census block group level in 2010 decennial census, measures of school quality (percent meeting standardized testing standards for English/language arts and math), an indicator for location in the perimeter of any fire in the past five years, logged distance to a protected area, and an indicator for whether the area is incorporated.

Table 3

Price Regression Using Wildfire-Hazard Potential (WHP)

Log(Price)	Full	Add County-by-Year Fixed Effect	Add Tract Fixed Effect
Log(1 + WHP)	−0.00242	−0.00242	0.00232**
	(0.00187)	(0.00184)	(0.000960)
Observations	1,566,426	1,566,422	1,566,361
R-squared	0.695	0.697	0.780

Note: The table presents a regression of the log of housing price on house and neighborhood controls and the log of WHP, a measure of wildfire risk. Each column represents a separate regression. The baseline regression in the first column includes house and neighborhood controls and fixed effects for the year and month of sale. Subsequent columns progressively add spatial fixed effects (denoted in the column header). House and neighborhood controls include number of bedrooms, number of bathrooms, log of lot size, age, indicators for the decade of construction, square feet, share white at the census tract in 2010 decennial census, measures of school quality (test scores for English/language arts and math), an indicator for location within the perimeter of any fire in the past five years, logged distance to a protected area, and an indicator for whether the area is incorporated. Standard errors are two-way clustered at the county and year level and are in parentheses.

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Table 4

Price Regression using Regulatory Status

Log(Price)	Full	Limit to High-Fire-Hazard Severity Zones	Limit to Build before 2008	Add Fixed Effect County-by-Year	Add Fixed Effect Tract	Add Fixed Effect Grid
Regulated	0.00970	−0.0565*	−0.0606*	−0.0617*	−0.0328**	−0.0507**
	(0.0259)	(0.0260)	(0.0290)	(0.0287)	(0.0133)	(0.0147)
Observations	1,566,426	164,019	141,606	141,597	141,512	141,546
R-squared	0.695	0.701	0.724	0.726	0.798	0.780

Note: The table presents a regression of the log of housing price on house and neighborhood controls and an indicator for location in a regulated area. The first column begins with the sample of house sales in high-fire-hazard severity zones. Subsequent columns either make additional restrictions on the sample or progressively add spatial fixed effects (noted in the column header). All specifications include house and neighborhood controls (see Table 3 note) and fixed effects for the year and month of sale. Standard errors are two-way clustered at the county and year level and are in parentheses.

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

reduced unobserved variation in correlated positive amenities, though effects are not precisely estimated. In column (3), we focus on properties built before 2008, so that we remove any confounding effects from additional regulation that apply to houses built in 2008 or later. We progressively add fixed effects: column (4) removes correlated price changes due to county-specific trends by including county-by-year fixed effects, column (5) includes census tract fixed effects, and column (6) adds 250 km^2 grid cell fixed effects to limit the comparison to properties sold within a neighborhood to further control for correlated amenities. With these controls, we find that property sold in areas that require wildfire risk disclosure sell for 4.9% lower than areas that do not.[17]

[17]This figure is based on applying the Halvorsen-Palmquist correction to the coefficient in Table 3, column (6) (Halvorsen and Palmquist 198).

Next, we consider only houses sold in the vicinity of the regulatory boundary. We include boundary fixed effects to compare homes near the same boundary. Because boundaries can span long distances, we include 250 km^2 grid cell fixed effects to control for differences across neighborhoods. Appendix Figure A1 presents a binned scatter plot of logged price at various distances to the regulatory boundary, where the region to the left side of the vertical dashed line is unregulated and the region to the right is regulated. We fit a fourth-degree polynomial to visualize the trend in prices across the boundary. The figure indicates that prices fall by around 3% at the boundary. Moreover, the trend in prices suggests that the magnitude of the price decrease would increase if one expanded the sample around the regulatory boundary.

Table 5 presents the point estimates with the sample restricted to diminishing boundary

Table 5
Boundary Discontinuity Price Regression, High-Fire-Hazard Severity Zones

	Boundary Distance				
Log(Price)	10 km	8 km	4 km	2 km	1 km
Regulated	−0.0253*	−0.0267*	−0.0248	−0.0343*	−0.0402*
	(0.0121)	(0.0121)	(0.131)	(0.0151)	(0.0154)
Observations	139,195	138,052	125,789	98,035	72,967
R-squared	0.799	0.800	0.807	0.815	0.821
	Boundary Distance				
Log(Price)	0.75 km	0.5 km	0.4 km	0.3 km	0.2 km
Regulated	−0.402**	−0.0417**	−0.0455**	−0.0426**	−0.0511**
	(0.0153)	(0.0144)	(0.0160)	(0.0170)	(0.0187)
Observations	64,165	54,033	49,269	43,483	35,039
R-squared	0.821	0.822	0.823	0.825	0.827

Note: The table presents a regression of the log of housing price on an indicator for location in a regulated area. All specifications include house and neighborhood controls (see Table 3 note), county-by-year fixed effects, month of sale fixed effects, and grid fixed effects. We narrow the bandwidth around the wildfire regulatory boundary from 10 km on either side of the boundary to 200 m. Standard errors are two-way clustered at the county and year level and are in parentheses.

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

distances, or bandwidths, around the boundary. At 10 km on either side of the regulatory boundary, we find that disclosure regulation reduces housing prices by 2.5% ($p < 0.01$). As we narrow the boundary, the estimated magnitude of the discount increases (in absolute value). At a bandwidth of 300 m (our preferred boundary sample), we find that properties in areas that require disclosure sell for a discount of about 4.2% ($p < 0.01$). The magnitude of the effect is comparable to existing work using disclosure laws to value wildfire hazard (Troy and Romm 2007; Garnache 2023); it is smaller than the effect estimated in McCoy and Walsh (2018) after a major wildfire event. As mentioned, if homebuyers understand wildfire risks without disclosure, our estimate is biased toward zero. Our finding of a statistically significant negative effect of approximately 4% within 300 m of the regulation boundary suggests that disclosure is indeed filling an information gap, which is reflected in differences in house prices.

We investigate the extent to which the price discount that we measure is driven by changes in correlated attributes at the regulatory boundary. We regress a house attribute on an indicator for location in a regulated area, controlling for boundary, grid, county-by-year, and month fixed effects, as well as location in an incorporated area, and present the coefficient on *Regulated* in Table 6. The results give an adjusted average difference in observed characteristics between the regulated and unregulated sides of the boundary. We estimate these regressions for each attribute using different bandwidths so that each cell in Table 6 presents the coefficient and standard error from a separate regression.

Restricting the sample to a narrow bandwidth around the regulatory boundary does not eliminate differences in observed attributes between regulated and unregulated areas; except for distance to protected areas, which is marginally significantly different between regulated and unregulated areas, estimated differences would likely bias our coefficient of interest toward zero. Wildfire hazard, as measured by WHP, is higher in regulated versus unregulated areas, even after restricting the sample to areas classified as high FHSZ. However, as shown in Table 3, WHP is positively correlated with price, other things being equal; therefore, we would expect that higher WHP in regulated areas would positively bias our estimates. Nevertheless, in a neighborhood around the boundary between regulated and unregulated areas, we estimate negative effects of disclosure requirements on home prices. A similar argument applies for lot size, which we would also expect to positively impact home prices and language arts

Table 6
Variation in Observed Variables across the Boundary

	Fire-Hazard-Severity Zones, Built before 2008	4 km	1 km	500 m	200 m
Log(1 + WHP)	1.28***	1.19***	1.14***	0.84***	0.48***
	(0.14)	(0.14)	(0.09)	(0.12)	(0.16)
Bedrooms	0.03	0.02	0.03	−0.03	−0.12
	(0.06)	(0.06)	(0.06)	(0.08)	(0.11)
Bathrooms	0.25***	0.24***	0.19***	0.10	0.05
	(0.06)	(0.07)	(0.07)	(0.08)	(0.09)
Ln(lot size)	0.88***	0.79***	0.63***	0.51***	0.39***
	(0.15)	(0.15)	(0.12)	(0.10)	(0.09)
Age	−3.42	−3.37	−3.55*	−2.46	−0.31
	(2.21)	(2.31)	(1.93)	(2.12)	(1.74)
Year built	3.42	3.37	3.55*	2.46	0.31
	(2.21)	(2.31)	(1.93)	(2.12)	(1.74)
Log(sq. ft.)	0.13***	0.12***	0.10**	0.05	0.00
	(0.03)	(0.04)	(0.04)	(0.05)	(0.06)
Share white residents	0.03***	0.02***	0.01	0.01	0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
% meeting standard language arts	2.68***	2.39***	1.15**	1.00**	0.91***
	(0.96)	(0.84)	(0.55)	(0.44)	(0.36)
% meeting standard math	2.60***	2.25***	0.79**	0.63*	0.56
	(1.03)	(0.89)	(0.35)	(0.32)	(0.35)
Previous fire	0.01	0.01	−0.00	−0.01	−0.01
	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)
Ln(distance to protected areas)	0.04	0.04	0.09*	0.07***	0.06*
	(0.06)	(0.06)	(0.05)	(0.03)	(0.04)
Observations	71,406	65,864	45,996	37,204	25,317

Note: The table presents results from regressions of a house attribute on an indicator for location within a regulated area. Coefficients for *Regulated* are presented, and all other coefficients are omitted; each cell presents the coefficient and standard error for a separate regression. The variables *WHP, sq. ft., lot size*, and *distance to protected areas* are logged. All regressions include boundary, grid, county-by-year, and month of sale fixed effects, and a control for location in an incorporated area. Standard errors are two-way clustered at the county and year level and are in parentheses. WHP = wildlife hazard potential.
* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

test scores. In addition, while we find differences in WHP at the boundary, we do not detect significant differences in the likelihood of being affected by a wildfire event in the past five years (*Within fire*). This helps limit the price effects being driven by other differences associated with disastrous events (e.g., a salience or recency bias). Homes in regulated areas are farther from protected areas, after controlling for other home attributes, which is contrary to expectations given that regulated high FHSZ areas are within typically more rural SRAs.

Robustness

We assess the robustness of our estimated effects. Our main estimates focus on high FHSZs to limit variation in unobserved heterogeneity while retaining variation in disclosure. We can similarly estimate our effects of interest while focusing on moderate FHSZs because properties in SRAs with moderate fire-hazard severity are required to disclose risks, whereas those in LRAs are not. Appendix Table A1 reestimates the boundary discontinuity regressions under different bandwidths for moderate FHSZs. The price discount associated with regulated disclosure ranges from 1% to 2.6% for bandwidths between 200 and 400 m, though estimates are not statistically significant.

In light of earlier evidence that regulated areas coincide with more rural locations, we reestimate our main boundary discontinuity regressions (with a 0.3 km bandwidth) by limiting the sample based on whether the property is located in an incorporated area. We present these results in Appendix Table A2 for both high and moderate FHSZs. We find that the price discount associated with disclosure is higher in magnitude when limiting to incorporated areas: prices fall by 9.2% ($p < 0.01$) and 3.7% (not statistically significant) for high and moderate FHSZs, respectively. Impacts for unincorporated areas are smaller in magnitude (around –2%), but effects are not statistically significant. If the price effects we found earlier were driven by regulated areas coinciding with rural areas, limiting the sample based on incorporation status should attenuate the magnitude of the price effects for all samples.

Our strategy to identify housing price impacts of wildfire risk is based on cross-sectional variation in information disclosure. This strategy lends itself well to investigating the price impacts separately by year, which allows us to recover willingness-to-pay measures that do not require the hedonic equilibrium to be stable over time. Because our sample spans more than six years, changes in population and preferences (for wildfire risk and other amenities) may mix different hedonic equilibria, which obscures the interpretation of the estimates as a welfare measure (Kuminoff and Pope 2014; Banzhaf 2021). We reestimate our main results for each year from 2015 to 2021; results are shown in Appendix Table A3 and plotted in Appendix Figure A2. Although not all estimates are statistically significant, estimates are generally more precise once we allow for larger bandwidths of 0.4 km or 0.5 km, also shown in Appendix Figure A2. Overall, there appears to be an increase in the magnitude of effects of regulated status on home prices over the study period, though differences between coefficients are likely not statistically significant. This downward trend would be consistent with increasing salience of wildfire risk during this period.

Heterogeneity

We explore geographic heterogeneity in willingness to pay to avoid wildfire risks by estimating our model separately for southern California and northern California.[18] Results are shown in Appendix Table A4. In southern California, regulated status has strong negative effects on house prices at all bandwidths. At the 300 m bandwidth, a 6% reduction in house prices occurs in regulated areas, larger than the effect we find for the state as a whole. All the coefficients for northern California are smaller (in absolute value) than those for southern California, and they are not significantly different from zero. In part, this may be due to the smaller sample size. But it also may be due to heterogeneity in the high-hazard zones in northern California, which cover geographic areas from the wine country counties near the coast to the high Sierras. Southern California high-fire-hazard areas, by contrast, are more homogeneous, mostly in the coastal ranges and not inland (which is primarily desert).

6. Discussion

In this article, we use information on home sales in California to estimate the effect of wildfire disclosure on house prices. We address two empirical challenges that arise when attempting to analyze disaster risk impacts in housing markets: (1) risks are positively correlated with amenities, and (2) homeowners may be uninformed when making home purchase decisions. We do this by leveraging differences in wildfire-risk-disclosure requirements established by the state and by using a BDD to compare houses with similar spatial amenities. Specifically, we use data on home sales in areas the state has designated as high-fire-hazard zones but only near the boundary between areas where disclosure is required and areas where it is not.

We find that homes where wildfire-hazard disclosure is required sell for 4.3% less, on average, than those just across the boundary, where disclosure is not required. The median value of homes in regulated areas near the regulatory boundary is $557,000; thus, our results suggest an approximately $21,500 reduction in willingness to pay for high-hazard homes because of risk disclosure.

[18] We define northern and southern California based on the distinction used by the American Automobile Association. The counties in each region are listed in the footnote to Appendix Table A4.

The key identifying assumption in our BDD strategy is that unobserved variables do not vary discontinuously at the regulatory boundary, which is defined jointly by the boundaries between SRAs and LRAs and by California FHSZ boundaries. Unlike previous work, we focus specifically on boundaries between SRA (regulated) and LRA (unregulated) in high FHSZs. We limit the sample to high FHSZs to allay concerns about correlation between different fire risk levels and unobserved amenities. To address remaining differences between SRA and LRA areas in high FHSZs, notably rurality and incorporation status, we adopt two strategies. First, we control for a broad suite of observable property- and neighborhood-specific variables. Second, we collect data on incorporated status, control for effects of incorporated status on price, and in robustness tests, estimate effects of disclosure separately for incorporated and unincorporated areas. Although it remains possible that some of our observed effects are driven by unobservable variables, most of the observed variables that appear to differ across the boundary would likely bias our estimated effects upward, toward zero.

The magnitude of our estimates, and how they vary across years and in California, give us some confidence that they reflect homebuyers' attitudes about wildfire hazard and not other factors. They also suggest that disclosure of risks is filling an information gap in the housing market. Our estimates are consistent with those in the (limited) existing literature. Troy and Romm (2007) use the passage of California Assembly Bill 1195 in 1997, which consolidated wildfire-hazard-disclosure requirements in the state, and found that homes in areas requiring disclosure sell for 5% less if they were near a recent wildfire perimeter than if they were not. Garnache (2023) uses changes in California FHSZ maps and a repeat sales approach and finds that properties in southern California with newly imposed disclosure requirements experience price declines of 3%–6%.

Our analysis uses data from across California for a recent seven-year period, 2015–2021, which allows us to examine temporal and spatial variation in our estimates. We find that the estimated effects increase in magnitude (in absolute value) over the study period, a time during which wildfire frequency and severity were rising. However, we find sizable and statistically significant impacts in southern California, which appear to be driving our estimates for the state as a whole.

Our results have several important policy implications. First, they indicate that availability of information regarding risk may be a factor in determining demand for homes in high-hazard locations. This is consistent with findings for disclosure of flood risks (Pope 2008). Second, as wildfire activity and development in high-fire-hazard areas continue to increase across the western United States (Mann et al. 2014; Abatzoglou and Williams 2016; Radeloff et al. 2018), disclosure requirements could play a role in mitigating further increases in exposure to risk. Third, we document heterogeneity in price discounts over time, revealing that concern about wildfire hazard among homeowners may be increasing. Rising insurance premiums in high-fire-hazard areas could be contributing to this concern; thus, an important question for future research is how these changes will shape the future of development and exposure to risk in these areas.

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