THE IMPACT OF CHANGING WILDFIRE RISK ON CALIFORNIA'S RESIDENTIAL INSURANCE MARKET

A Report for:

California's Fourth Climate Change Assessment

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Edmund G. Brown, Jr., *Governor*

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PREFACE

California's Climate Change Assessments provide a scientific foundation for understanding climate-related vulnerability at the local scale and informing resilience actions. These Assessments contribute to the advancement of science-based policies, plans, and programs to promote effective climate leadership in California. In 2006, California released its First Climate Change Assessment, which shed light on the impacts of climate change on specific sectors in California and was instrumental in supporting the passage of the landmark legislation Assembly Bill 32 (Núñez, Chapter 488, Statutes of 2006), California's Global Warming Solutions Act. The Second Assessment concluded that adaptation is a crucial complement to reducing greenhouse gas emissions (2009), given that some changes to the climate are ongoing and inevitable, motivating and informing California's first Climate Adaptation Strategy released the same year. In 2012, California's Third Climate Change Assessment made substantial progress in projecting local impacts of climate change, investigating consequences to human and natural systems, and exploring barriers to adaptation.

Under the leadership of Governor Edmund G. Brown, Jr., a trio of state agencies jointly managed and supported California's Fourth Climate Change Assessment: California's Natural Resources Agency (CNRA), the Governor's Office of Planning and Research (OPR), and the California Energy Commission (Energy Commission). The Climate Action Team Research Working Group, through which more than 20 state agencies coordinate climate-related research, served as the steering committee, providing input for a multisector call for proposals, participating in selection of research teams, and offering technical guidance throughout the process.

California's Fourth Climate Change Assessment (Fourth Assessment) advances actionable science that serves the growing needs of state and local-level decision-makers from a variety of sectors. It includes research to develop rigorous, comprehensive climate change scenarios at a scale suitable for illuminating regional vulnerabilities and localized adaptation strategies in California; datasets and tools that improve integration of observed and projected knowledge about climate change into decision-making; and recommendations and information to directly inform vulnerability assessments and adaptation strategies for California's energy sector, water resources and management, oceans and coasts, forests, wildfires, agriculture, biodiversity and habitat, and public health.

The Fourth Assessment includes 44 technical reports to advance the scientific foundation for understanding climate-related risks and resilience options, nine regional reports plus an oceans and coast report to outline climate risks and adaptation options, reports on tribal and indigenous issues as well as climate justice, and a comprehensive statewide summary report. All research contributing to the Fourth Assessment was peer-reviewed to ensure scientific rigor and relevance to practitioners and stakeholders.

For the full suite of Fourth Assessment research products, please visit www.climateassessment.ca.gov. This report advances the understanding of climate-related risks and resilience options by examining how wildfire risk is expected to change and the potential implications for the residential insurance market.

ABSTRACT

Wildfire currently poses considerable risk to many California homeowners and residents, and climate change and population growth are expected to make matters worse. Insurance provides resources to rebuild after disaster strikes and, if priced appropriately, provides signals about what areas to avoid and what mitigation measures to adopt. However, price increases that reflect rising risks can also cause financial hardship for families. Therefore, it is critical to understand how the insurance market is currently performing with regard to wildfire risk and how climate change may affect this performance. This study uses the outputs from detailed wildfire and population models and ZIP code–level data on insurance policies to examine how risk is expected to change and what the potential implications are for residential insurance markets. We focus on two study areas—one in the Sierra foothills east of Sacramento and one in the western portion of San Bernardino County. We find that the insurance market currently faces challenges in the high-risk portions of the study areas. Insurer-initiated policy nonrenewal rates are higher in those parts of the study area with the highest wildfire risk, as are the market shares of the state's residual insurance market and the more lightly regulated surplus lines market. As expected, premiums in the higher-risk areas are higher. Insurers interviewed for this study did not believe that the difference captures the full difference in risk. The California Department of Insurance, however, holds that insurers have not provided sufficient evidence that actual risk supports requested differentials between high- and low-risk properties. We provide estimates of how much climate change will affect premiums, the market share of the admitted insurers, and other market indicators. We find that an aggressive emission control strategy substantially reduces impacts after the middle of the 21st century. The study concludes by identifying insurance regulations (and public policies more generally) that will have an important impact on future market conditions.

Keywords: wildfire, homeowners insurance, climate change, regulation, California

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HIGHLIGHTS

- The average acres burned annually in the Sierra Foothills Study Area (SFSA) is projected to double by midcentury and, under a business-as-usual greenhouse gas (GHG) emission scenario, to double again by the end of the 21st century. An aggressive and successful GHG emission strategy stabilizes average annual acres burned in the second half of the century at midcentury levels.
- Based on the wildfire model used in this analysis, climate change is expected to have a minor impact on the average annual acres burned in the San Bernardino Study Area (SBSA). The wildfire model used in the analysis served as a common basis for all the studies that were part of California's Fourth Climate Change Assessment; however, wildfire models developed by other researchers do project that climate change will affect the SBSA. Further work in fire science is needed to reconcile these disparate findings.
- The insurance market currently faces challenges in those portions of the two study areas with high wildfire risk. The insurer-initiated policy nonrenewal rate is higher, as are the market shares of the state's residual insurance market (the FAIR Plan) and the more–lightly regulated surplus lines market. Although we did not find that take-up rate falls as structure risk increases when other factors are held constant, we did find evidence that homeowners in high-risk areas are purchasing less coverage relative to structure value and selecting higher deductibles than homeowners in low-risk ZIP codes.
- Premiums in the higher-risk areas are higher and have been growing more rapidly in recent years than those in lower-risk areas. Even so, insurers interviewed for this study believed that the difference between premiums for high- and low-risk structures still did not reflect the full difference in risk. The California Department of Insurance has approved substantial rate increases in high-risk areas; however, the department holds that insurers have not provided sufficient evidence to justify all requested differentials between high- and low-risk properties.
- In terms of financial performance, admitted insurers in the Homeowners Multiple Peril line broke even in terms of combined underwriting profit between 2001 and 2017. Results for the Fire line were better, with the combined ratio well below 100 percent over the same period. The industry was profitable when investment returns were considered; however, insurers' experience between 2001 and 2017 illustrates how a particularly bad wildfire season can wipe out many years of underwriting profits.
- Given current insurance regulations and the behavior of insurers and policyholders, our findings indicate that climate change could have a substantial impact on the residential insurance market in some parts of the SFSA. In the ZIP codes that currently face the highest fire risk, the market share of the admitted insurers is expected to drop by 5 percentage points on average by 2055, and the rate per $1,000 of coverage in the admitted market is projected to rise by 18 percent. The coverage-to-value ratio is expected to fall by 6.5 percentage points and the deductible to increase by $121.
- Successful efforts to reduce GHG emissions will not make a great deal of difference through midcentury because of the inertia of the climate system. However, reducing emissions will substantially reduce additional impacts between 2055 and 2095.

- Insurance regulations will have an important impact on how climate change will affect the residential insurance market. Insurance regulatory issues include the extent to which rates reflect the full difference in fire risk across structures, whether probabilistic models of wildfire risk are allowed in the rate-approval process, and whether the net reinsurance margin is allowed as an expense in rate filings. Although there is no indication that current FAIR Plan rates are artificially low, the extent to which rates offered by the FAIR Plan keep up with the increase in risk will also be an important factor in how insurance markets respond to climate-induced changes in wildfire risk.

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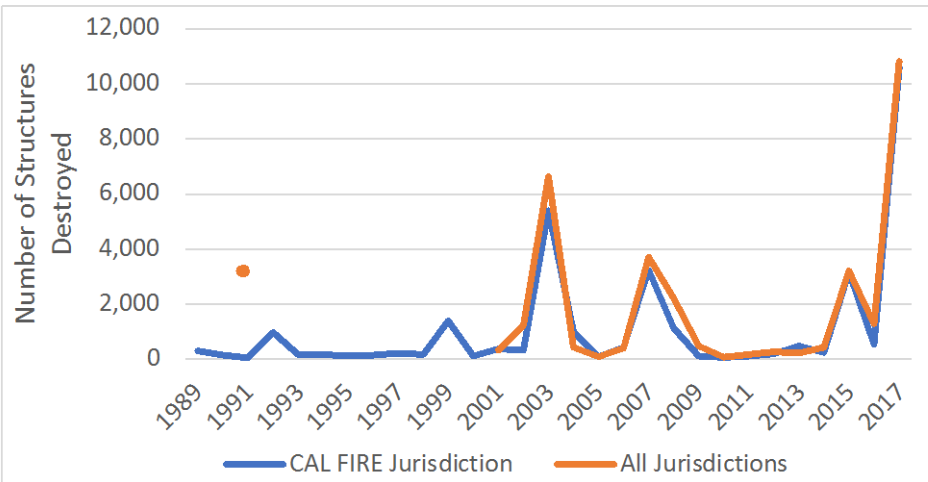
Chapter 1: Introduction

1.1 Context

Wildfire poses considerable risk to many Californians. A substantial number of acres burn in the state each year, and the number of structures destroyed by wildfire periodically spikes (Figure 1.1).[1] 2017 was a particularly bad year. Over 1.4 million acres burned in the state, and 10,800 residential and commercial structures were destroyed—the largest number of structures destroyed since recordkeeping started in 1989.[2] Climate change and population growth are expected to make matters worse, unless current behaviors and practices change.[3]



Sources: CAL FIRE, "Large Fire Reports," dataset, 2000–2017; CAL FIRE, "CAL FIRE Jurisdiction Fires, Acres, Dollar Damage, and Structures Destroyed," August 1, 2017.

Figure 1.1: Number of Structures Destroyed in California (CAL FIRE Jurisdictions and All Jurisdictions)

Insurance provides a way for homeowners to manage the risk of wildfires, supplying resources to rebuild after disaster strikes. If priced appropriately, insurance provides signals about which areas to avoid and which mitigation measures to adopt. However, price increases that reflect

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[1] The Oakland Hills Tunnel fire in 1991 destroyed 2,900 structures. It was not in California Department of Forestry and Fire Protection (CAL FIRE) jurisdiction, but is included in Figure 1.1 (the orange dot in 1991) to illustrate that large fires did occur in the 1990s, even though our data set of fires in all jurisdictions only goes back to 2001.

[2] CAL FIRE, 2018a.

[3] See Susanne Moser, Julia Ekstrom, and Guido Franco, *Our Changing Climate 2012: Vulnerability and Adaptation to the Increasing Risks from Climate Change in California*, Sacramento, Calif.: California Climate Change Center, 2012.

rising risks can also cause financial hardship for families. It is therefore critical to understand how the insurance market is currently performing with regard to wildfire risk. It is also important to understand how climate change might affect insurance markets and which changes in regulations, programs, and behaviors might influence market conditions.

1.2 Purpose of This Study

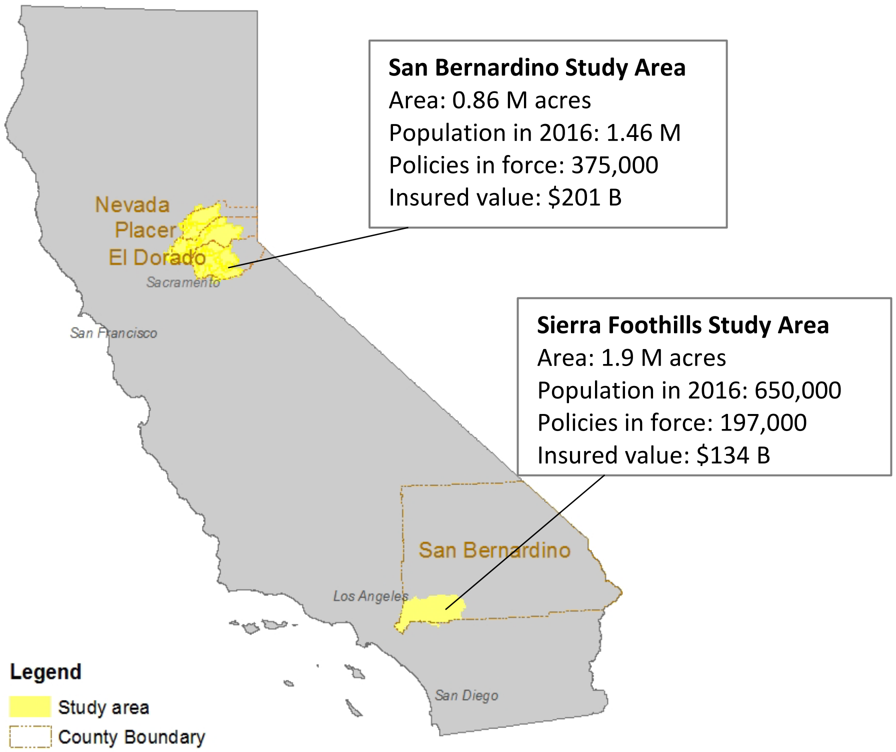
We selected two areas in the state for study and then addressed four main questions.

1. What is the current wildfire risk in the study areas and how might climate change affect it through the end of the century?
2. How well is the residential insurance market currently working in higher-risk fire areas?
3. How might climate-induced changes in wildfire risk affect the residential insurance market?
4. What factors can influence the effects of climate change on the residential insurance market?

1.3 Overview of Study Approach

We focused on two study areas within the state: the foothills of the Sierra Nevada mountains in Northern California and western San Bernardino County in Southern California. Focusing on two areas as opposed to the entire state allowed us to conduct a more detailed and context-specific analysis than would have been possible otherwise.

The Sierra Foothills Study Area (SFSA) covers 1.9 million acres of land between Sacramento and Lake Tahoe, spanning parts of three counties—Nevada, Placer, and El Dorado (Figure 1.2). The San Bernardino Study Area (SBSA) covers 0.86 million acres of land in the western, more populated portion of San Bernardino County. The SFSA was chosen because climate change is expected to have some of the most intense effects in the northern portion of the Sierra Nevada mountains and because the SFSA is experiencing rapid population growth. The SBSA was selected because there are many homes in the wildfire-prone areas of this study area; thus, it represents the type of exposure found in the densely populated southern portion of the state. Also, its population is expected to continue growing.



Source: Authors.
Note: M = million. B = billion.

Figure 1.2: The Sierra Foothills and San Bernardino Study Areas

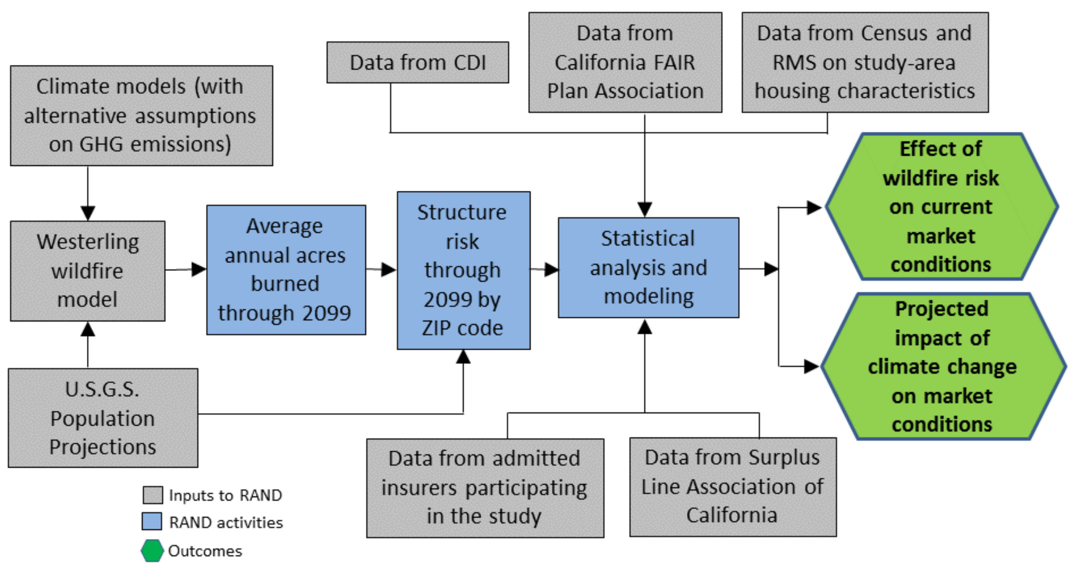
To answer the four research questions, we applied a combination of quantitative and qualitative approaches:

- wildfire scenario analysis to characterize changes in wildfire risk, both spatially and temporally (quantitative)
- regression analysis to investigate the impact of wildfire risk on insurance market indicators and to predict the effect of changing wildfire risk on future market conditions (quantitative)
- interviews with insurers, regulators, consumer advocates, and county staff on possible insurance industry developments and responses to changing wildfire risk (qualitative).

Figure 1.3 summarizes the components of the quantitative approaches. Our model analysis uses wildfire scenarios developed by Leroy Westerling at the University of California, Merced.[4] For consistency, the California Natural Resources Agency and the California Energy Commission asked the various research teams contributing to California's Fourth Climate Change Assessment (Fourth Assessment) to use this model in analyzing the wildfire-related impacts of

[4] Leroy Westerling, "Cal-Adapt: Wildfire Simulations for the Fourth California Climate Change Assessment: Projecting Changes in Extreme Wildfire Events with a Warming Climate," webpage, 2018.

climate change on the state. The Westerling wildfire model takes as inputs the predictions from an ensemble of climate models. These predictions are based on assumptions of future greenhouse gas (GHG) emissions and the size and spatial distribution of the population over time. The RAND project team was provided with the outputs from the wildfire model in terms of the acres burned annually through 2099 in 1/16th-degree grid cells (approximately 6 km x 6 km). We then used these outputs to calculate predicted average annual acres burned by decade through 2099 by grid cell in the study areas. Acres burned by grid cells were combined with predictions on the spatial distribution of the population—and thus structures—from the U.S. Geological Survey (USGS) (at 1-km x 1-km resolution) to develop a measure by ZIP code of wildfire risk that the structures in the study areas face.



Source: Authors.
Note: CDI = California Department of Insurance; RMS = Risk Management Solutions.

Figure 1.3: Overview of Data Used and Modeling Done in the Study

The measure of structure risk was an input into our statistical analysis of the impact of climate change on insurance markets. We focused on the residential insurance market, which we define as insurance on one- to four-unit residential structures. We excluded renters' policies, insurance on condominium structures, and insurance on individual condominium units from the analysis when possible. As will be discussed in Chapter 4, homeowners can buy coverage in the admitted market, the surplus lines market, or from the California FAIR Plan. Detailed data on the policies in force in the admitted market were provided by the California Department of Insurance (CDI). Information was provided by ZIP code, the most detailed geographic unit for which the data were available. ZIP code–level data were also provided by the Surplus Line Association and the California FAIR Plan. In addition, several admitted insurers provided information that was not available from the CDI. We also used data from the U.S. Census Bureau and RMS to characterize the housing stock in the study area ZIP codes. The variation in structure risk across the ZIP codes in the study areas allowed us to examine the impact of wildfire risk on the insurance market, including the following market indicators:

- market shares of the admitted insurers, surplus lines market, and the FAIR Plan
- policy nonrenewal rate
- number of insurers writing coverage in the admitted market
- insurance take-up rate
- premiums per policy and rate per $1,000 of coverage
- ratio of coverage to insurable value
- size of the deductible
- underwriting profit.

While this analysis at the ZIP code level is informative, it might not identify problems that occur in a small subarea of a ZIP code. We also examined underwriting profit at the statewide level (underwriting profit is not reported by insurers at a more spatially disaggregated level).

We used the relationship between current structure risk and current market indicators to project changes in these indicators as structure risk changes because of climate change. These projections are based on the current practices and behaviors of regulators, insurers, and policyholders; projections for how much and where population will grow; current fuel loads and firefighting capabilities; and current levels of structure-risk mitigation.

Our analysis was informed by qualitative data through interviews with insurers, regulators, consumer advocates, and county staff. We conducted the interviews on a confidential basis to encourage participation and candor.

1.4 Organization of This Document

Chapter 2 provides a more detailed discussion of data sources and the type and number of stakeholders interviewed.

Chapter 3 examines current wildfire risk (acres burned) in the study areas and projects changes through 2099. It is based on the predictions of the Westerling wildfire model and projections from the USGS population model. After summarizing current wildfire risk in the study areas, we present findings on how structure risk varies across the study areas and how it is expected to evolve through the end of the century.

Chapter 4 examines current indicators in the residential insurance market in the two study areas. It also examines the overall financial health of the admitted market and identifies key issues that influence the willingness of admitted insurers to write coverage in high-risk areas.

Chapter 5 explores how the change in wildfire risk due to climate change might affect insurance markets through the end of the century. It also identifies factors that can affect future insurance market conditions.

Chapter 6 summarizes answers to the four study questions.

Five appendixes provide additional detail on various aspects of the analysis.

Chapter 2: Data and Methods Used in the Analysis

Chapter 1 provided an overview of the data and methods used in the analysis. This chapter lays out the data and methods used in the analysis in more detail. We first discuss the wildfire model and the approach we used to develop a measure of the wildfire risk that the structures face in the study areas (what we refer to as the *structure-risk index*). We then describe the data we used to assess the effect of structure risk on current insurance market indicators and the impact of climate-induced changes in structure risk on future insurance market conditions.

2.1 Wildfire Modeling and Developing a Measure of Structure Risk

2.1.1 Overview

The Westerling model is a statistical model that is based on historical data about climate, vegetation, population density, fire history, and regionally downscaled climate projections. It provides estimates of how wildfire risk today varies throughout the state (these estimates are used in the analysis in Chapters 3 and 4). It also provides estimates of how wildfire risk would change if future climate conditions were imposed on current fuel loads, fire response capabilities, and vegetation types (these estimates are used in Chapters 3 and 5).[5]

A key output from this wildfire model is acres burned by 1/16-degree grid cells (approximately 6 km by 6 km) by yearly time steps through 2099. This output provides a basis for our analysis of changing wildfire risk over time and space in the two study areas: the SFSA and the SBSA.

Also, although acres burned is a very important input for our analysis of the residential insurance market, acres burned alone is not a good indicator of the damages a wildfire can cause because damage costs depend highly on where structures are located in relation to the fire. For example, although the third-largest wildfire by acreage in modern California history—the 2012 Rush fire in Lassen County—burned 271,911 acres, it did not burn any structures.[6] In contrast, the 1991 Tunnel fire in Oakland Hills burned 1,600 acres and 2,900 structures.[7] Therefore, we developed a structure-risk index, which reflects both the changes in acres burned and structure locations.

2.1.2 Wildfire Modeling Assumptions and Scenarios

In this study, we use climate projections and wildfire modeling to characterize changes in wildfire risk through the end of the century—out to 2099. As is true in predicting any events far into the future, climate projections and wildfire modeling are fraught with uncertainty. For example, projected wildfire risk may not be accurate or informative if the actual GHG

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[5] The model does not condition projections of the number of acres burned on acres burned in previous years. For example, the model might predict a large fire in one year, but does not consider the reduced likelihood of fire in that area in following years. Also, although the model does factor in urban growth and the reduced likelihood of wildfires in areas that have been urbanized, it does not consider the impact of climate change on vegetation patterns outside urban areas. Therefore, the Westerling model is not a full simulation model of the time path of acres burned in various parts of the state.

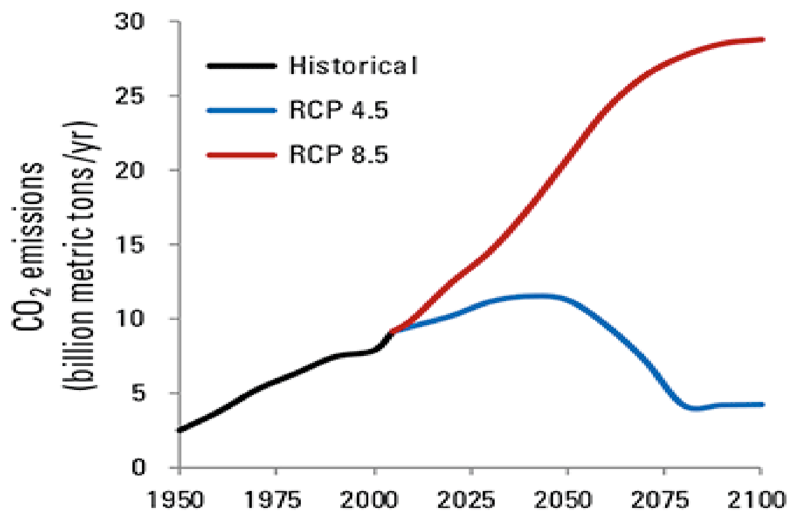
[6] CAL Fire, "Top 20 Largest California Wildfires," January 12, 2018a.

[7] CAL Fire, "Top 20 Most Destructive California Wildfires," January 12, 2018b.

emissions—hence, climate conditions—differ from those used to make the projections. To account for the uncertainty, and to be consistent with other research teams that are participating in the Fourth Assessment, our analysis draws on a range of scenarios that California may experience. These include scenarios developed based on two GHG emission scenarios, four different climate models, and three population growth projections. We discuss each in turn.

2.1.2.1 GHG Emission Levels

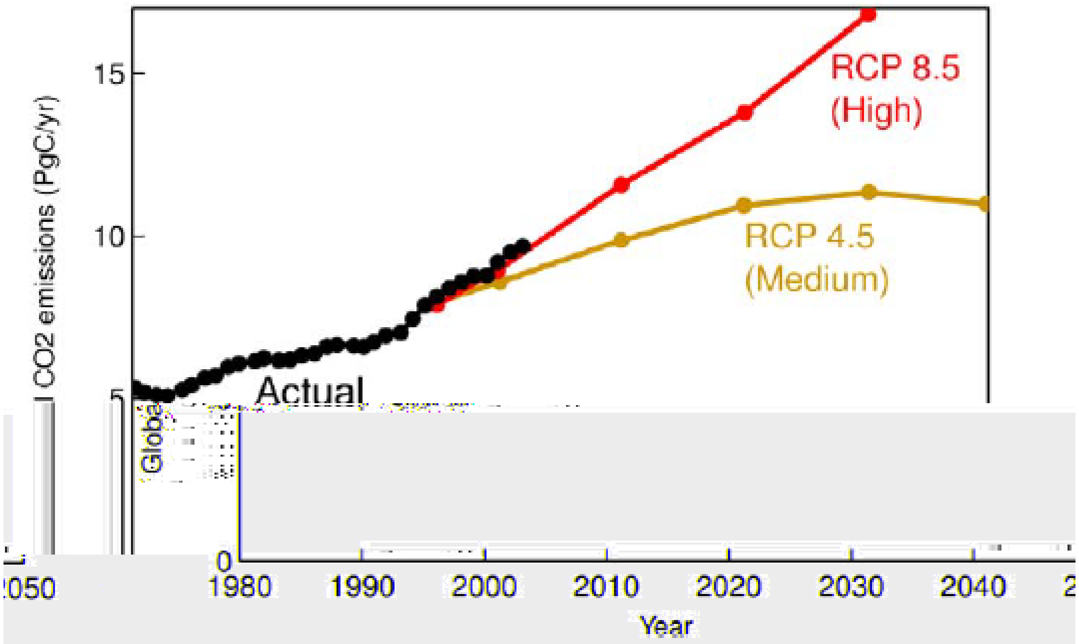
Our analysis examines two possible Representative Concentration Pathways (RCPs): RCP 4.5 and RCP 8.5. RCP 4.5 assumes "strong mitigation" and is considered a "medium-low" level of emissions by the Intergovernmental Panel on Climate Change (IPCC). In this scenario, carbon dioxide emissions peak around 2040 and decline thereafter (blue line in Figure 2.1). In contrast, RCP 8.5 assumes business as usual and is considered a "high" level of emissions by the IPCC. In this scenario, emissions continue to increase through the end of the century (red line in Figure 2.1).



Source: K. Oakley, T. Atwood, D. Douglas, K. Rode, and M. Whalen, "Changing Arctic Ecosystems—Updated Forecast: Reducing Carbon Dioxide (CO2) Emissions Required to Improve Polar Bear Outlook," USGS Fact Sheet, 2015.

Figure 2.1: Carbon Dioxide Emissions Associated with RCP 4.5 and RCP 8.5

Figure 2.2 extends the "historical" data to 2012 based on actual emissions data. As the figure shows, actual emissions have significantly surpassed RCP 4.5 and are following the RCP 8.5 trajectory. Nevertheless, both RCP 4.5 and 8.5 scenarios are considered possible, depending on the mitigation actions taken globally to limit climate change.



Source: David W. Pierce, Daniel R. Cayan, and Lauren Dehann, *Creating Climate Projections to Support the 4th California Climate Assessment*, California Energy Commission, 2017.

Figure 2.2: Carbon Dioxide Emissions—Actual Versus Assumptions Underlying RCP 4.5 and RCP 8.5

2.1.2.2 Global Climate Models

Besides GHG emission scenarios, one source of uncertainty in climate modeling stems from the tools used to simulate the climate system. There is a great deal of active research in climate modeling, and more than 30 global climate models (GCMs) have been developed by research centers around the world.[8] These models have subtle, but important, differences in the representation of specific features of the climate system (e.g., atmospheric processes, ocean processes, aerosol effects).[9] These differences can cause significantly different results among models. To account for these differences, our analysis is built on a "multimodel ensemble" to cover a range of possible futures.

The California Climate Action Team's Research Working Group recommends that Fourth Assessment research teams use regionally downscaled projections from four GCMs.[10] These

[8] Z. Stott, *Pan-European Survey of the Climate Modelling Community: Phase One Analysis and Synthesis Report*, Assimila, 2016.

[9] D. A. Randall, R. A. Wood, S. Bony, R. Colman, T. Fichefet, J. Fyfe, V. Kattsov, A. Pitman, J. Shukla, J. Srinivasan, R. J. Stouffer, A. Sumi and K. E. Taylor, "Climate Models and Their Evaluation," in *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge: Cambridge University Press, 2007.

[10] California Energy Commission, *Projected Climate Scenarios Selected to Represent a Range of Possible Futures in California*, 2017.

GCMs were originally developed for the Coupled Model Intercomparison Project, Phase 5 and are part of the suite of global climate modeling experiments that formed the basis of the IPCC's Fifth Assessment Report.[11] The four models that are part of the multimodel ensemble are:

- **HadGEM2-ES**, which can be characterized as "warm/dry"
- **CNRM-CM5**, which can be characterized as "cool/wet"
- **CanESM2**, which can be characterized as "middle"
- **MIROC5**, which can be characterized as "complementary," i.e., it covers a range of outputs.

These four GCMs were selected to represent a range of possible futures that California may face, while maintaining a manageable subset of the considerable number of GCMs available.[12]

To the extent that simulation errors among the GCMs are independent, the mean of the ensemble can be expected to outperform (i.e., produce more-likely outcomes) than any individual model. The multimodel ensemble approach is an established practice in climate change research.[13]

The Westerling wildfire model uses a number of outputs from these climate models, including rainfall, temperature, humidity, and windspeed.[14]

2.1.2.3 Population Scenarios

Population scenarios for the Fourth Assessment were developed by the California Department of Finance and the USGS.

The Demographic Research Unit of the California Department of Finance is designated as the single official source of demographic data for state planning. It produces county-level population estimates at five-year increments through 2060 for state planning purposes. Specifically, for the Fourth Assessment, Ethan Sharygin extended the following county-level population scenarios through 2095:[15]

- **low**: assumes a decrease in net migration by 30 percent, constant fertility rates after 2060, and mortality rates that remain constant at 2015 levels
- **medium**: assumes constant population growth rate from 2060 onward

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[11] IPCC, *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, Geneva, Switzerland, 2014.

[12] More details on the choice of these models can be found in California Energy Commission, 2017.

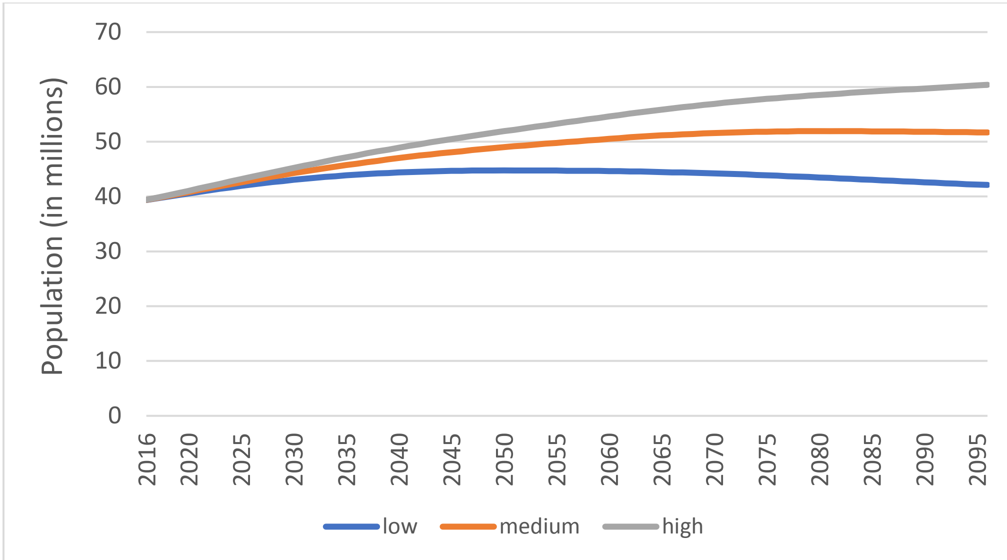
[13] S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K. B. Averyt, M. Tignor and H. L. Miller, eds., *Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge, United Kingdom and New York, 2007, Section 10.5.4.1.

[14] Benjamin P. Bryant and Anthony L. Westerling, *Scenarios to Evaluate Long-Term Wildfire Risk in California: New Methods for Considering Links Between Changing Demography, Land Use, and Climate*, California Energy Commission, CEC-500-2012-303, July 2012.

[15] Ethan Sharygin, *Modeling Methodology for the 2016 Baseline California Population Projections*, Sacramento: Demographic Research Unit, California State Department of Finance, January 20, 2018.

- **high**: assumes an increase in net migration by 30 percent, fertility rates remaining constant at 2015 levels, and mortality rates that remain constant at 2060 levels.

These three population scenarios for California are depicted in Figure 2.3.

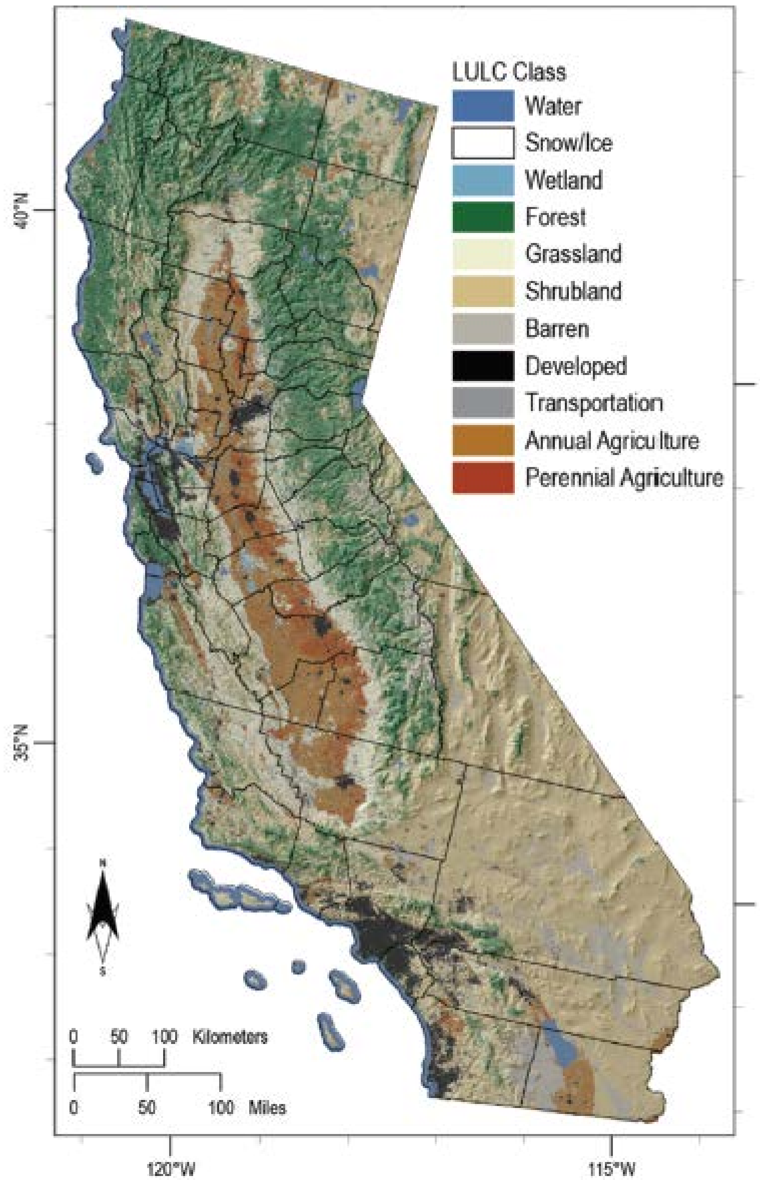


Source: Based on Sharygin, 2018.

Figure 2.3: Population Scenarios Used in California's Fourth Climate Change Assessment

Sleeter et al. used the California Department of Finance's county-level projections as inputs to their spatially explicit land-use and land-cover model, the Land-Use and Carbon Scenario Simulator (LUCAS).[16] The LUCAS model uses a state-and-transition simulation mechanism for modeling land-use change processes, such as urbanization, agricultural expansion and contraction, forest harvest, and other processes (Figure 2.4).

[16] B. M. Sleeter, T. S. Wilson, E. Sharygin, and J. T. Sherba, "Future Scenarios of Land Change Based on Empirical Data and Demographic Trends," *Earth's Future*, Vol. 5, No. 11, October 16, 2017, pp. 1068–1083.



Source: Sleeter et al., 2017.
Note: LULC = land-use and land-cover.

Figure 2.4: Land-Use and Land-Cover Classes in the U.S. Geological Survey Land-Use and Carbon Scenario Simulator Model

The LUCAS model operates on a yearly time step and at a fine level of geographic detail—1-km by 1-km grid cells. It starts with county-level population projections from the California Department of Finance and allocates population to those grid cells defined as "developed area." It then assumes that the population density in developed areas remains constant in subsequent years. To accommodate an increase in population, cells next to existing developed cells are converted to developed cells as needed.

2.1.3 Structure-Risk Index

We combine outputs from the wildfire and LUCAS models to develop a structure-risk index. We do so by overlaying fire risk projections from the wildfire model with the population projections from the land-use model using geographic information system (GIS) software and compute the expected annual percentage of structures affected by wildfire by ZIP code. This variable will be used in Chapter 4 to characterize the wildfire risk facing the structures in a given ZIP code.

We use ZIP codes as geographical units because the insurance data to which this structure-risk index is linked are only available at that level. A ZIP code is a relatively coarse geographical unit,[17] and we use the higher-resolution wildfire modeling cells to come up with ZIP code–level estimates. Thus, our calculation considers population distribution *within* each ZIP code. For example, a ZIP code with population concentrated in the low-fire-risk part of the ZIP code would be estimated to have a lower expected percentage of structures affected compared with the expected percentage of acres burned in the ZIP code.

In each of the wildfire modeling cells, we assume that the percentage of the population affected by wildfire is equal to the expected percentage of acres burned annually for that cell. The results are aggregated across all the wildfire modeling cells in the ZIP code to generate the percentage of the population affected by wildfire in that cell. Given the number of structures per capita, we can determine the percentage of structures affected. The percentage is converted to decimal form and multiplied by 100 to generate the structure-risk index (e.g., 1 percent of structures affected is equal to a structure-risk index of 1.0).

2.2 Data and Approach Used to Analyze Impact of Changing Wildfire Risk on the Residential Insurance Market

Our analysis focuses on insurance for one- to four-unit residential structures, which we refer to as "residential structures." Excluded from this definition are apartment buildings with five or more units (sometimes referred to as "commercial residential structures") and renters' policies. When possible, we also exclude condominium units from the analysis. Insurance on the overall condominium structure is typically written in the commercial insurance market. Individual unit owners take out policies written in the residential market, but because our focus is on insurance for one- to four-unit structures, we exclude these from our analysis.

2.2.1 Data on Policies, Premiums, Losses, and Expenses

We obtained data on residential insurance policies from a number of sources.

The CDI. The CDI provided a wealth of data for the study. The data were collected from the admitted insurers operating in the state through CDI data calls. The CDI provided the following data for the study:

- **Community Service Statement Database (CSS)**. The CSS contains data on the number of written and earned exposures in exposure-months, total earned and written premiums by experience year, ZIP code, insurance line, policy form, and insurance

[17] There are 47 ZIP codes and 234 wildfire modeling grid cells in the SFSA, and 55 ZIP codes and 105 wildfire modeling grid cells in the SBSA.

group.[18] The database covers admitted insurers and the FAIR Plan, and individual insurers are identified. We received data for National Association of Insurance Commissioners (NAIC) Line 1 (Fire) and NAIC Line 4 (Homeowners Multiple Peril). Data were provided for experience years 2007, 2013, and 2014. 2013 and 2014 were the most recent years for which data were available at the time of this study. 2007 was the first year that the current, more comprehensive database was available.

- **Personal Property Experience Database (PPE**). The PPE contains a record for each residential policy in the state, with data on the amount of coverage provided, the deductible, the number of dwelling units covered, the policy form on which the policy was written, and the ZIP code. The insurer writing the policy is not identified. Data were provided for policies in force as of December 31, 2007, 2013, and 2015. The PPE is collected every other year, and 2013 and 2015 were the most recent years for which the data were available. 2007 was the first year that the current, more comprehensive database was available.
- **New, Renewal, and Nonrenewal Policy Database**. This database provides data on the number of new residential policies written, the number of policies renewed, and the number of policies nonrenewed by ZIP code in 2015 and 2016. The data provided exclude condominium and renters' policies and are not broken out by insurer. Figures on the number of policies nonrenewed are further broken down into insurer-initiated nonrenewals and insured-initiated nonrenewals.
- **Annual Statement Database**. This database provides data on premiums, losses, and expenses in California by insurer, year, and insurance line from 2001 through 2017. These data are taken from the annual statement filed by admitted insurers with the NAIC. The data provided were for the Fire and Homeowners Multiple Peril lines.

The Surplus Line Association of California. The Surplus Line Association provided data by year on the number of policies and the total premiums collected on residential policies in the state from 2000 through 2017. Figures were also provided separately for each ZIP code in the two study areas.

The FAIR Plan. The FAIR Plan provided information on the number of policies written by the FAIR Plan and the total insured value by ZIP code and year from 2000 through 2017.

RMS. RMS provided data on the number of single-family dwellings, two- to four-unit dwellings, and mobile homes by ZIP code as well as the total structure value and contents value for each of these dwelling types by ZIP code. One set of values reflecting recent conditions in the ZIP codes was provided. The data were based on the most-recent information available to RMS. For example, some of the data were based on results from the U.S. Census Bureau 2013 American Community Survey (ACS). Other data were provided by their insurer clients or were drawn from county property registries The data provided by RMS were used to calculate the average value per structure by ZIP code.

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[18] *Earned exposure-months* refers to the number of months in a given calendar year that the policy is in effect. There is a separate record in this database for each ZIP-code, insurance-line, policy-form, insurance-group, and experience-year combination.

U.S. Census Bureau. Data were extracted on median income and housing stock characteristics by ZIP code from the ZIP Code Tabulation Areas database (ZCTA).

Admitted Insurers. These data were provided on a confidential basis by five admitted insurers. These insurers were all among the top 15 insurers by market share in the Homeowners Multiple Peril line. Together, they accounted for just under 50 percent of the premiums earned in the Homeowners Multiple Peril line in 2016. The information provided included total dollar losses by year on residential policies in California, losses on fire claims (wildfire and nonwildfire), and losses on wildfire claims. Some insurers also broke smoke and ash claims out separately. Insurers also reported the number of wildfire claims and the number that paid at the policy limit. Data were typically provided from 2000 through 2016. These data underlie only a small part of the analysis in this report—in the discussion of the percentage of overall losses due to wildfire and the percentage of claims that pay at the policy limit.

2.2.2 Interviews

Interviews were conducted with a range of stakeholders during the project. The interviews were conducted on a confidential basis by phone and lasted from 30 minutes to two hours. A semistructured interview protocol was developed that covered recent trends in the residential insurance market, factors affecting the cost and availability of coverage, and expectations about how increasing fire risk would affect the market. Interviews were conducted with

- five admitted insurers
- the FAIR Plan
- one consumer group
- one Fire Safe Council
- Fire Marshal or Office of Emergency Services staff in three of the four counties that overlay the two study areas.

2.2.3 Analysis Approach

We examined the relationship between current wildfire risk and current insurance market indicators for which data were available. We examined the following market indicators:

- market shares of the admitted market, the surplus lines market, and the FAIR Plan
- the policy renewal rate in the admitted market
- the number of insurers writing coverage in the admitted market
- the insurance take-up rate, which refers to the percentage of residential structures that are insured (whether by the admitted market, surplus lines market, or FAIR Plan)
- premium per policy and rate per $1,000 of coverage
- the ratio of the policy limit to the structure value
- the policy deductible.

We conducted the analysis at the ZIP-code level because that is the most disaggregated unit at which the insurance data were available. It is important to keep in mind that even if we find no evidence of a particular effect at the ZIP-code level, it is still possible that there might be pronounced effects in some parts of the ZIP code. These sub–ZIP code areas might be too small to have much influence on the average for the indicator for the overall ZIP code.

We examined the relationship between current structure risk and current insurance market indicators across ZIP codes (cross-section analysis). We also examined the relationship between structure risk and changes in market indicators over the last seven to ten years. We used regression analysis to better isolate the effect of wildfire risk from other differences across the counties, taking advantage of census data to control for housing stock characteristics.

To predict how insurance market conditions may evolve over time, we applied the structure risk levels predicted in the future to the estimated relationship between current indicators and structure risk. Such projections in effect assume that current regulatory policies, insurer underwriting and pricing practices, and consumer demand remain unchanged. We then identified the types of regulatory and other changes that could affect future market conditions.

Chapter 3: The Effect of Climate Change on Wildfire Risk in the Two Study Areas

This chapter discusses the effect of climate change on wildfire risk in the two study areas. We first present projections of the average number of acres burned annually through the end of the century. We then turn to a description of the expected population growth.[19] Here, the spatial distribution of the population is used as a proxy for the location of residential structures to inform the development of a structure-risk index. We then project the expected changes in structure risk through the end of the century.

3.1 Changing Fire Risk

Wildfire damage may be extensive during one year and minimal during other years. To smooth out the year-to-year variation and to provide an indication of how the overall trend is changing, we focus on average acres burned annually within each decade through 2099. The average (referred to as the average annual acres burned) is not our "prediction" of future damage, because not every year is like the average year; rather, it is a characterization of risks.

The average annual acres burned for each ten-year period projected here are based on 80,000 simulations from the wildfire model—four climate models, ten years per decade, 100 fire simulations per year, ten land-use simulations per fire simulation, and two population growth scenarios (high and low). Overall, 720,000 simulations were used for the nine decades between 2010 and 2099.

3.1.1 Current Fire Risk

For the current decade, the wildfire model projects that 8,802 acres will burn annually in the SFSA, which amounts to 0.46 percent of the land area (Table 3.1). The projected average annual acres burned is 5,792 in the SBSA, or 0.67 percent of the land area. As shown in the bottom row of Table 3.1, these percentages are substantially higher than the average risk statewide.[20]

[19] As discussed in Chapter 2, population growth scenarios are one of many inputs to wildfire modeling (because ignition probability increases with population). In this chapter, we pay particular attention to population trends and spatial distribution because the location of population (hence residential structures) is of critical importance to the structure risk estimation.

[20] We also recognize the importance of studying extreme values in managing catastrophic risks. Thus, in Appendix A, we report the full distribution of acres burned in the SFSA that is projected using one climate change model.

Table 3.1: Expected Annual Acres Burned Between 2010 and 2019

	SFSA	SBSA	Statewide
Area (acres)	1,896,709	860,921	104,765,440
Projected average annual acres burned	8,802	5,792	74,522
Projected percentage of area burned annually	0.46%	0.67%	0.07%

Source: Author analysis of Westerling, 2018.

As discussed in Chapter 2, the wildfire model generates results for a grid of 1/16th-degree cells (roughly 6 km x 6 km).[21] To examine the variation in wildfire risk within the study areas, we divide cells into four wildfire risk categories based on the projected fire risk in the current decade:

- **very low**: expected annual acres burned equal to zero
- **low**: expected annual acres burned greater than zero and less than or equal to 0.35 percent of cell area
- **medium**: expected annual acres burned greater than 0.35 percent of cell area and less than or equal to 0.70 percent of cell area
- **high**: expected annual acres burned greater than 0.70 percent of cell area.

These cut-off points were chosen so that the cells in the two study areas with non-zero wildfire risk were divided into three roughly equal groups.

As shown in Table 3.2, 8 percent of the land area in the SFSA is in the high-risk category, with 63 percent in the medium-risk category. In the SBSA, 60 percent of the land area is high risk and 21 percent is medium risk.

Table 3.2: Percentage of Land Area by Fire Risk Category for 2010 Through 2019

Fire Risk Category	SFSA (%)	SBSA (%)
Very low	5	13
Low	24	5
Medium	63	21
High	8	60
All risk categories	**100**	**100**

Source: Author analysis of output from Westerling, 2018.

The expected annual acres burned reaches a maximum of 0.8 percent of the cell area in the highest-risk cells in the SFSA and 1.2 percent of the cell area in the highest-risk cells of the SBSA. Even though the expected annual percent burned seems very small even in the highest-

[21] There are 234 wildfire modeling cells that fully or partially overlap the SFSA and 105 wildfire modeling cells that fully or partially overlap the SBSA.

risk cells, the statistical distribution for the acres burned has large variance, and a large number of acres could burn in a particular year.

The urbanized parts of the study areas are assumed to face zero fire risk, because there is not enough vegetation. Five percent of the land area in the SFSA faces zero risk. For San Bernardino, it is 13 percent (Table 3.2).[22]

Figures 3.1 and 3.2 show how, currently, fire risk varies spatially within the two study areas. In the SFSA (Figure 3.1), fire risks increase as distance from Sacramento increases. The risk is highest in the area in the vicinity of and to the north of Pollock Pines. Fire risk is high in a large part of the SBSA (Figure 3.2), including areas near Lake Arrowhead, Big Bear Lake, Yucaipa, San Gorgonio Mountain, Rancho Cucamonga, and Chino Hills State Park. Overall, the SBSA currently faces higher risk than the SFSA.[23]

Source: Authors.

Figure 3.1: Wildfire Risk Within the Sierra Foothills Study Area, 2010 to 2019

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[22] The 2017 wildfires in Northern California showed that structures in urban areas can be at risk due to wind-blown embers. The parts of urban areas that are assumed to have zero risk may need to be updated.

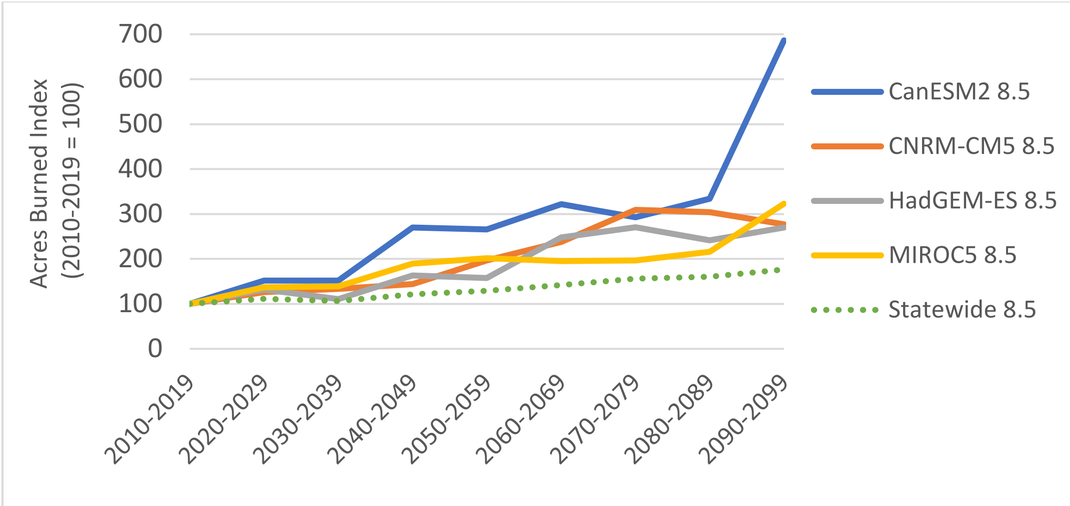
[23] To see how the fire risk in the two study areas compares with that of the rest of the state, see Westerling, 2018.

Source: Authors.

Figure 3.2: Wildfire Risk Within the San Bernardino Study Area, 2010 to 2019

3.1.2 Projected Annual Acres Burned Through 2099

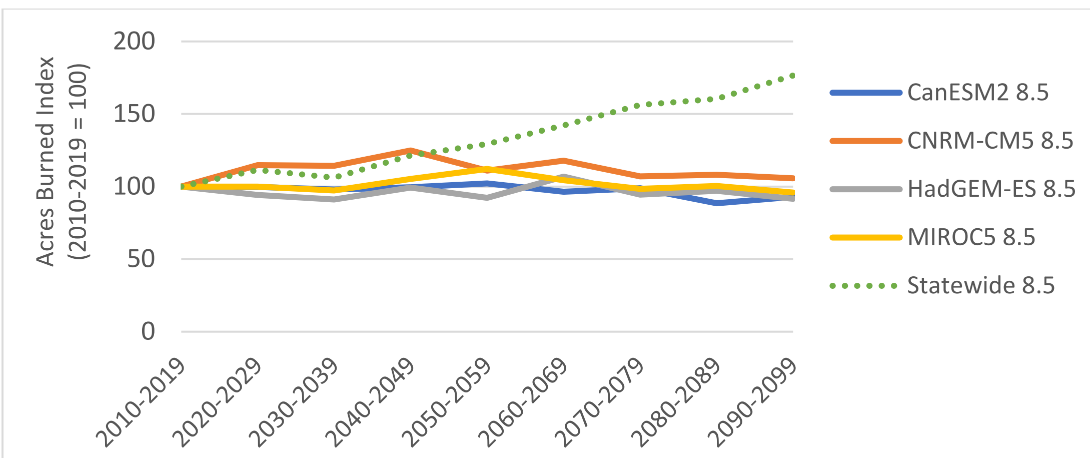
In addition to facing different fire risks today, the two study areas are expected to face very different *changes* in fire risk. The SFSA is expected to face a dramatic increase in the projected average acres burned annually, because rising temperatures are likely to create a warmer and drier Sierra Nevada climate. By midcentury (2050–2059), the average annual acres burned increases from 1.6 to 2.6 times under RCP 8.5, depending on what climate model is used. By the end of the century, average annual acres burned has increased roughly threefold for three out of the four climate models under RCP 8.5 (Figure 3.3).



Source: Authors.

Figure 3.3: Average Annual Acres Burned in the Sierra Foothills Study Area Through 2099, by Climate Model (RCP 8.5, 2010–2019 = 100)

In contrast, the SBSA sees only modest changes in expected annual acres burned through the end of the century, according to the Westerling wildfire model (Figure 3.4).

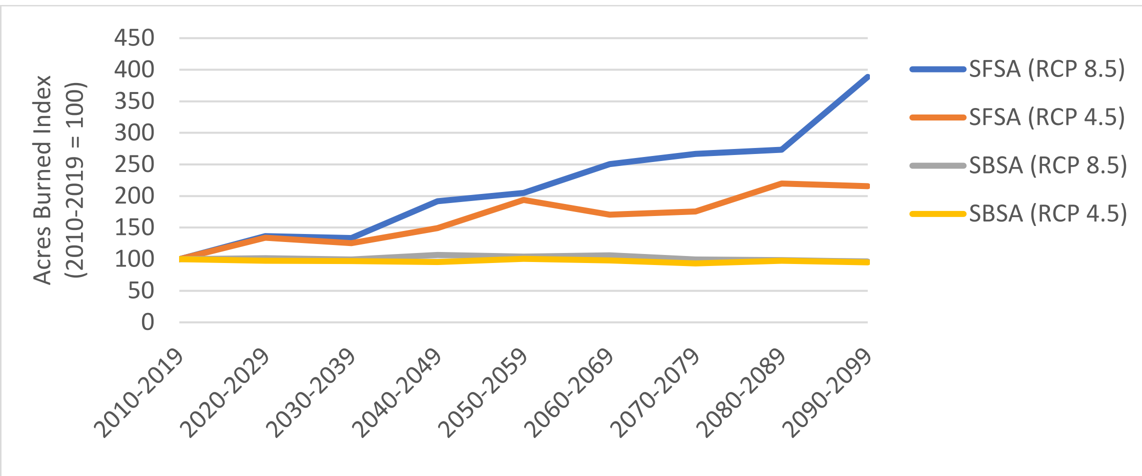


Source: Authors.

Figure 3.4: Average Annual Acres Burned in the San Bernardino Study Area Through 2099, by Climate Model (RCP 8.5, 2010–2019 = 100)

A limitation of Westerling's projections of future wildfire risk is that they do not consider changes in wind speed. Wildfires in Southern California are often significantly magnified by the dry Santa Ana winds. The effect of climate change on these Santa Ana winds is still uncertain. If climate change results in more-frequent and intense Santa Ana conditions, it is possible that the Westerling model underestimates the changes in the fire risk level in southern California. Jin et al. generated projections that factor in increased wind speeds projected by some climate models.[24] They project that the overall area in Southern California burned by fires during the Santa Ana wind season (October through April) will increase by 64 percent on average in 2041–2060 relative to 1981–2000. The projected increase is mostly due to lower relative humidity and secondly to higher wind speed. They also project that acres burned in the non–Santa Ana wind season (June through September) will increase by 77 percent, mainly due to a warmer and drier climate. We use projections from the Westerling model in our analysis, and, based on this model, find that climate change will have negligible impact on insurance market outcomes in the SBSA (see Chapter 5). If the Jin et al. model turns out to be more accurate, climate change *would* be expected to affect insurance market outcomes in the SBSA.

A successful carbon emission control strategy that reduces emissions to RCP 4.5 results in a substantial reduction in wildfire risk in the SFSA. Figure 3.5 compares the projected average annual acres burned under RCP 8.5 and RCP 4.5 when the results using all four climate models are pooled together. As can be seen, there is not a great deal of difference in the results by midcentury for the SFSA. In contrast, wildfire risk grows considerably in the SFSA between midcentury and the end of the century under RCP 8.5, but remains roughly constant under RCP 4.5. There is little change in wildfire risk in the SBSA, regardless of whether RCP 8.5 or RCP 4.5 is assumed.



Source: Authors.

Figure 3.5: Projected Change in Average Annual Acres Burned by Greenhouse Gas Emission Scenario (2010–2019 = 100)

As shown in Table 3.3, climate change increases the percentage of land in the SFSA that is in the high-risk category defined previously. Although the SFSA has a lower percentage of high-risk land than the SBSA in the current decade, the projected percentage rises rapidly and surpasses that in the SBSA by midcentury. Furthermore, the percentage of high-risk land in the SFSA is expected to continue rising through the end of the century.

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[24] Yufang Jin, Michael I. Goulden, Nicolas Faivre, Sander Veraverbeke, Fenpeng Sun, Alex Hall, Michael S. Hand, Simon Hook, and James T. Randerson, "Identification of Two Distinct Fire Regimes in Southern California: Implications for Economic Impact and Future Change," *Environmental Research Letters*, Vol. 10, 2015.

Table 3.3: Projected Average Annual Acres Burned as a Percentage of Land Area for Selected Decades Under RCP 8.5

	SFSA			SBSA		
Fire Risk Category	**2010 to 2019 (%)**	**2050 to 2059 (%)**	**2090 to 2099 (%)**	**2010 to 2019 (%)**	**2050 to 2059 (%)**	**2090 to 2099 (%)**
Very low	5	5	5	13	13	13
Low	24	13	11	5	13	13
Medium	63	17	10	21	17	25
High	8	65	74	60	58	49
All risk categories	**100**	**100**	**100**	**100**	**100**	**100**

Source: Author analysis of output from Westerling, 2018.

3.2 Changing Population

In this section, we take a closer look at how the population is expected to change in the two study areas. Both study areas are expected to experience high population growth based on the LUCAS model described in Chapter 2, which is one reason why they were selected for study. The population in the SFSA is expected to increase by 27 percent by 2095 according to the low-growth scenario and 96 percent according to the high-growth scenario (last column of Table 3.4). While not as dramatic, the population in the SBSA is expected to increase by 17 percent (low-growth scenario) and 35 percent (high-growth scenario) by 2095. For brevity, the medium scenario is not shown.

Table 3.4: Population Scenarios for the Two Study Areas

Year	**2016 (millions)**	**2055 (millions)**	**2095 (millions)**	**Percentage Change, 2016 to 2055**	**Percentage Change, 2016 to 2095**
SFSA					
Low-growth scenario	0.659	0.778	0.835	18%	27%
High-growth scenario	0.653	0.990	1.280	52%	96%
SBSA					
Low-growth scenario	1.464	1.685	1.706	15%	17%
High-growth scenario	1.462	1.860	1.973	27%	35%

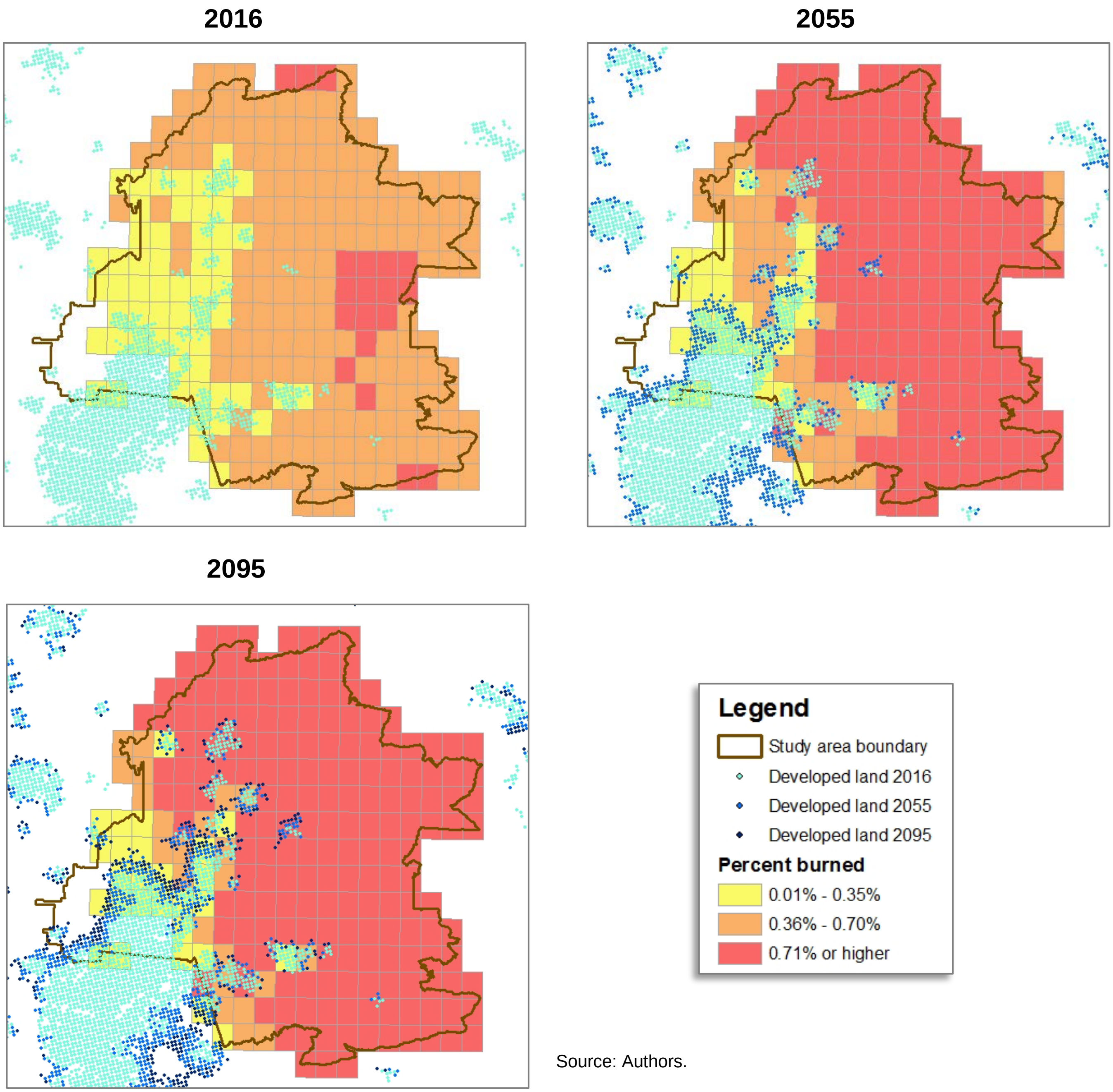
Source: Authors' analysis of Sleeter et al., 2017.

The percentage of the population living in high-risk fire areas is also expected to increase in the SFSA (Table 3.5). In contrast, the percentage of the population living in the high-risk areas of the SBSA is expected to decline. This difference reflects differences in where growth is projected to occur in the study areas. Figures 3.6 and 3.7 show the location of developed land (i.e., population) now and in the future overlaid on top of the projected fire risk for the selected years.

Table 3.5: Distribution of the Population by Fire Risk Category

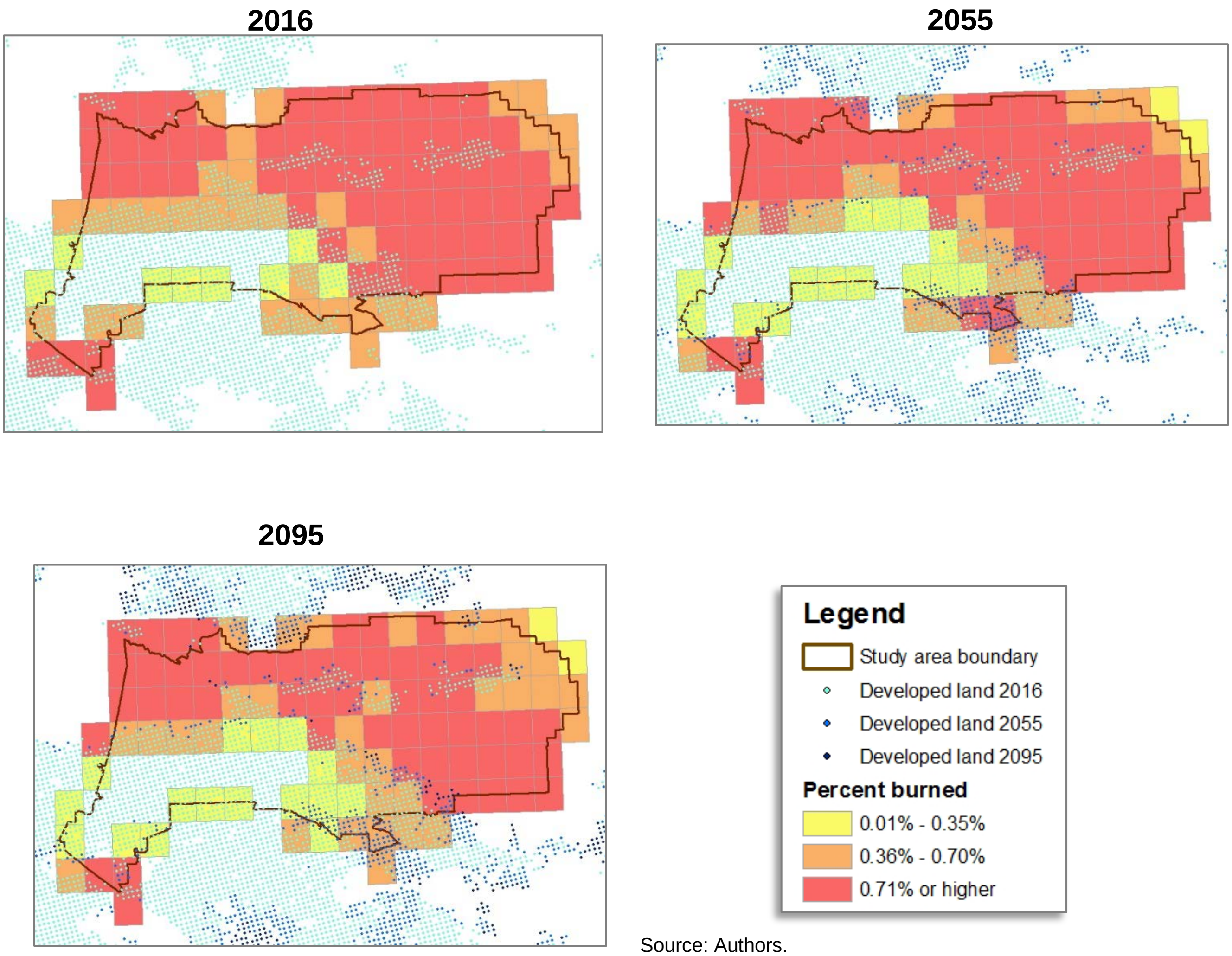
	SFSA			SBSA		
Fire Risk Category	**2010 to 2019 (%)**	**2050 to 2059 (%)**	**2090 to 2099 (%)**	**2010 to 2019 (%)**	**2050 to 2059 (%)**	**2090 to 2099 (%)**
Very low	27	24	22	40	35	34
Low	60	45	43	15	30	30
Medium	12	13	13	27	19	25
High	1	18	22	18	16	11
All risk categories	**100**	**100**	**100**	**100**	**100**	**100**

Source: Authors.
Note: The spatial resolution of this analysis is the 1/16th-degree cell of the wildfire model.



Source: Authors.

Figure 3.6: Developed Land in the Sierra Foothills Study Area and Fire Risk Category by Year



Source: Authors.

Figure 3.7: Developed Land in the San Bernardino Study Area and Fire Risk Category by Year

3.3 Changing Structure Risk

As discussed in Chapter 2, we developed a structure-risk index that considers the combined effects of the changing fire risk and the changing population (and, hence, structure) distribution. The structure-risk index is based on the percentage of structures affected by wildfire in the study areas. We use the term "affected" because structures and their contents may be damaged by smoke and ash as opposed to being burned. The absolute level of the structure-risk index is of secondary value; rather, we use the structure index to measure differences in structure risk across ZIP codes and over time.

3.3.1 Current Structure Risk Within Study Areas

The structure-risk index is developed at the ZIP-code level because the insurance data is disaggregated only to this level. To examine the variation in structure risk within the study areas, we divide ZIP codes into three structure-risk categories:

- **low**: structure-risk index less than 0.2
- **medium**: structure-risk index greater than or equal to 0.2 and less than 0.5
- **high**: structure-risk index greater than or equal to 0.5.[25]

Current structure risk by ZIP code for the two study areas is shown in Figures 3.8 and 3.9. Considering the spatial distribution of structures does make a difference. The spatial variation in structure risk is somewhat different than that for acres burned in the SFSA (compare Figures 3.8 and 3.1) and not much different in the SBSA (compare Figures 3.9 and 3.2).

[25] These cut-off points were chosen so that the number of ZIP codes in each category across the two study areas combined would be roughly equal. They are different from the cut-off used in Section 3.1 because ZIP codes are larger geographical units than the 1/16th-degree wildfire modeling cells and smooth out some of the spatial variations at the grid-cell level.

Source: Authors.

Figure 3.8: Structure-Risk Index for 2016 for the Sierra Foothills Study Area

Source: Authors.

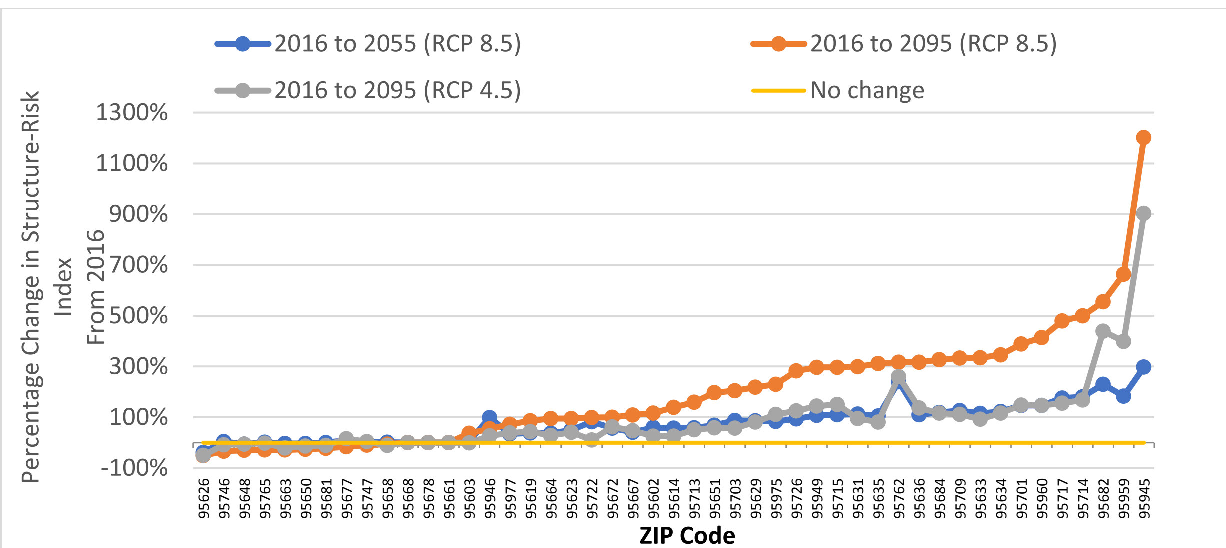
Figure 3.9: Structure-Risk Index for 2016 for the San Bernardino Study Area

3.3.2 Projected Structure Risk Through 2099

Figures 3.10 and 3.11 show the percentage change in the structure-risk index between 2016 and 2055 and between 2016 and 2095 for the two study areas.[26] The ZIP codes are ordered by the magnitude of the percent change between 2016 and 2095, assuming RCP 8.5.

By 2055, the structure-risk index is projected to increase by 100 to 199 percent in 30 percent of the ZIP codes in the SFSA, assuming RCP 8.5 (blue line in Figure 3.10). Three additional ZIP codes experience increases of 200 percent or more, with the most extreme case experiencing just under a 300-percent increase. Nearly 20 percent of the ZIP codes see little or no change in structure risk between 2016 and 2055, with the remaining ZIP codes falling in between.

By 2095, the structure-risk index is expected to increase by 300 percent or more from 2016 levels in 30 percent of SFSA ZIP codes, assuming RCP 8.5 (orange line in Figure 3.10). Reducing carbon emissions to RCP 4.5 makes a substantial difference by 2095 (gray line). With only a few exceptions, the structure-risk index at the end of the century under RCP 4.5 is similar to that at midcentury.[27]



Source: Authors.
Note: ZIP codes are arranged along horizontal axis in order of the percentage change in the structure-risk index from 2016 to 2095 (RCP 8.5).

Figure 3.10: Changes in Structure-Risk Index for Each ZIP Code, Sierra Foothills Study Area

Figure 3.11 shows that the structure-risk index actually falls in most ZIP codes in the SBSA. When there are increases, they are modest.

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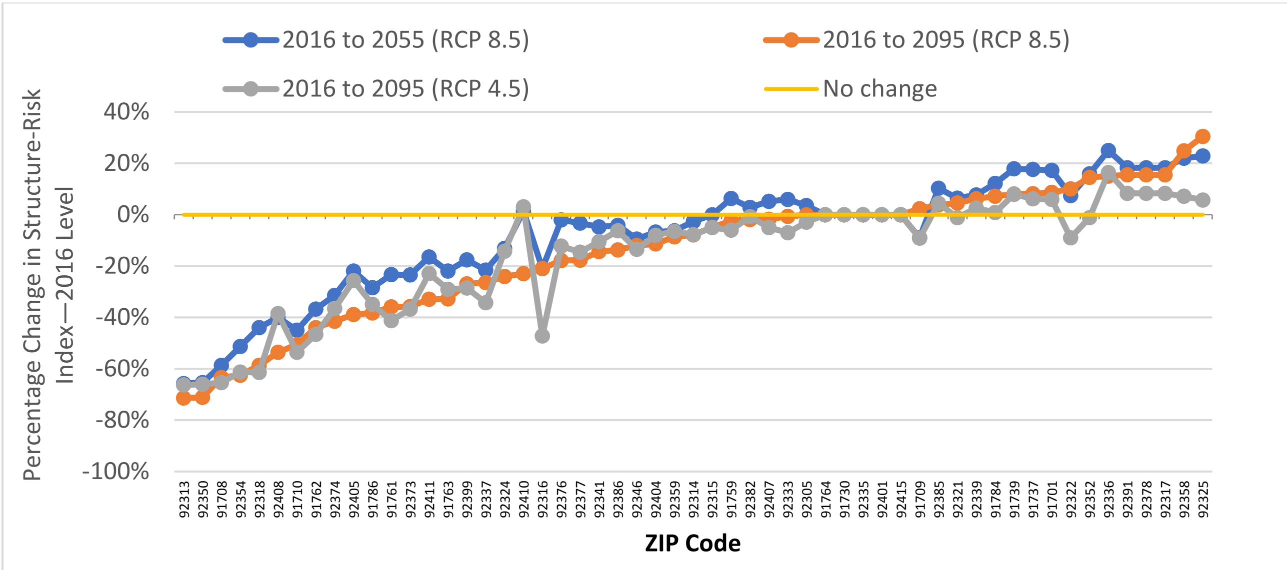
[26] For ease of exposition, 2016 refers to 2010–2019, 2055 refers to 2050–2059, and 2095 refers to 2090–2095.

[27] We do not show the data for RCP 4.5 in 2055 because the results are very similar to those for RCP 8.5 in 2055.

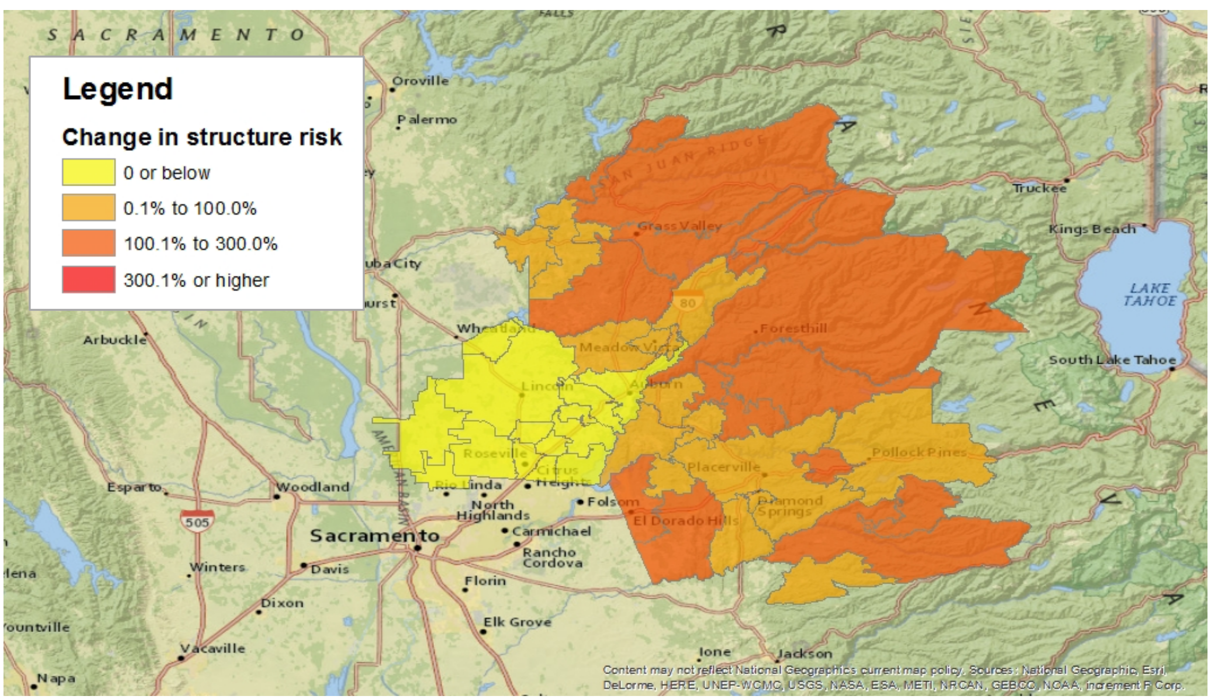


Source: Authors.

Note: ZIP codes are arranged along horizontal axis in order of the percentage change in the structure-risk index from 2016 to 2095 (RCP 8.5).

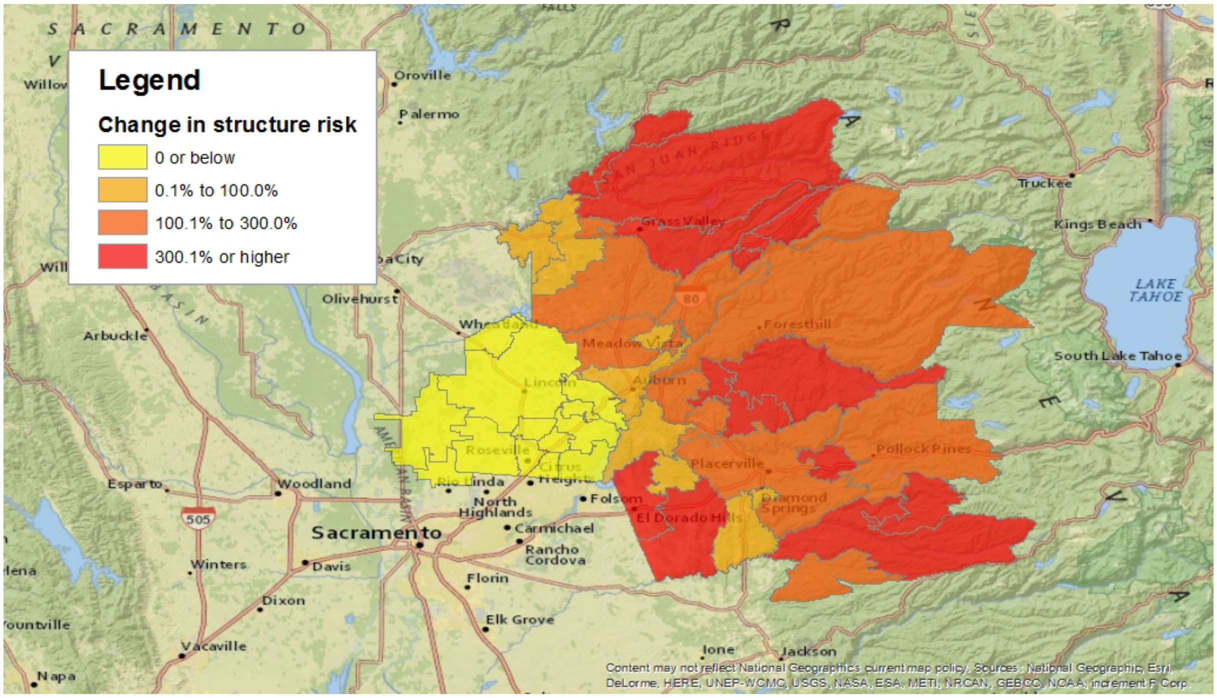
Figure 3.11: Changes in the Structure-Risk Index for Each ZIP Code, San Bernardino Study Area

Figures 3.12 and 3.13 show where in the SFSA the largest changes in the structure-risk index are expected to occur. For both 2055 and 2095, there is little change in the structure-risk index in the westernmost part of the SFSA. The largest increases are in the mountainous eastern portion of the SFSA.



Source: Authors.

Figure 3.12: Changes in Structure-Risk Index by ZIP Code, 2016 to 2055, RCP 8.5, Sierra Foothills Study Area



Source: Authors.

Figure 3.13: Changes in Structure-Risk Index by ZIP Code, 2016 to 2095, RCP 8.5, Sierra Foothills Study Area

Appendix B provides additional detail on the change in the structure-risk index. It shows how the structure-risk index in the SFSA is less than that in the SBSA in 2015 but catches up by midcentury and greatly surpasses the structure-risk index in the SBSA by 2095.

Chapter 4: Current Conditions in the Residential Insurance Market

This chapter examines current conditions in the residential insurance market in the two study areas. After providing some background on the potential sources of insurance for homeowners, we investigate how key market indicators vary by structure risk, focusing on how the market is performing in high-risk areas. As noted in Chapter 1, we examine the following market indicators:

- market shares of admitted insurers, the surplus lines market, and the FAIR Plan
- nonrenewal rates for policies in the admitted market
- the number of insurers writing coverage in the admitted market
- the insurance take-up rate (whether from the admitted market, surplus lines market, or FAIR Plan)
- premiums per policy and rate per $1,000 of coverage
- ratio of coverage to insurable value
- size of the deductible
- underwriting profit.

Except for underwriting profit, our analysis is done primarily at the ZIP-code level because ZIP code was the most detailed geographic unit at which insurance data were available to us. This means that some areas within ZIP codes might experience particularly strong effects that are either offset by opposite effects in other parts of the ZIP code or that are restricted to areas too small to have much effect on the indicator for the overall ZIP code.

After describing current market conditions, we discuss rate regulation and identify key issues that influence the willingness of admitted insurers to write coverage in high-risk areas.

4.1 Background

Homeowners can buy insurance in the admitted market, in the surplus lines market, or from the FAIR Plan.[28]

As will be shown shortly, the vast majority of policies are bought in the admitted market. The CDI must preapprove the rate schedules of admitted insurers. Admitted insurers are required to contribute in the California Insurance Guarantee Association (CIGA), which provides protection should the insurers become insolvent. If an admitted carrier becomes insolvent, CIGA will pay outstanding claims up to the insured's policy limit or $500,000, whichever is less.

Homeowners who are not able to find coverage in the admitted market can turn to the surplus lines market (also known as the nonadmitted market). Insurers offering coverage in the surplus lines market are overseen by the insurance regulator in their state of domicile but are not subject to rate regulation in California. They are also not covered by CIGA, opening policyholders to risk in the event of insolvency. By California law, brokers attempting to place coverage with surplus lines insurers must be declined three times in the admitted market before seeking

[28] By *homeowners*, we refer to owners of one- to four-unit residential structures.

coverage in the surplus lines market.[29] The coverage surplus lines policies offer can be similar to that offered in the admitted market, although the premium is typically higher because the properties that end up in the surplus lines market are those that could not be covered at rates approved for the admitted market. The surplus lines market is also known for writing "high end" homes with unique features that may require more-specific coverage requirements than are typically available on admitted market coverage forms.

Established under California law, the FAIR Plan ensures the availability of basic property insurance for residential and commercial structures in the state. The FAIR Plan is not an insurance company; rather, it is a syndicated fire insurance pool composed of all the admitted insurers in the state.[30] The FAIR Plan distributes financial returns on its operations to member insurers and can assess member insurers if claim obligations exceed the plan's ability to pay claims. Until recently, a person seeking coverage from the FAIR Plan was required to show that he or she was unable to obtain coverage from at least three admitted insurers or surplus lines brokers. However, the CDI eliminated this requirement in January 2016.[31] All properties in California, regardless of structure risk, are eligible for coverage from the FAIR Plan, assuming they meet reasonable underwriting standards. Policies offered by the FAIR Plan provide more-limited coverage than those typically available in the admitted market.[32] For example, the FAIR Plan policy does not include liability coverage, a standard feature of a homeowners policy.

Insurers use underwriting guidelines to help identify which properties they are willing to write. Underwriting guidelines vary from company to company and are not directly regulated by the CDI except to ensure that they must not be unfairly discriminatory and must be related to risk of loss. Consequently, admitted insurers can refuse to write a new policy or renew an existing policy at their discretion. In 2016, the CDI reviewed the underwriting guidelines for 27 homeowners insurers accounting for two-thirds of the California homeowners market. The most common factors included in underwriting guidelines relevant to wildfire were

- roof type, focusing on whether the structure has a wood shingle roof or a less combustible roofing material
- fire protection class (the grade for the fire protection system where the structure is located)
- wildfire risk score (wildfire risk scores produced by Fireline and Corelogic are the most commonly used; some insurers will not write new policies, and in some cases will not renew existing policies, when the wildfire risk score exceeds a certain threshold)
- brush and vegetation clearance to the property line

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[29] Benjamin J. McKay, "Testimony of Benjamin J. McKay, J.D., M.P.A., as Prepared for Delivery Before the California State Senate Standing Committee on Insurance," Surplus Line Association of California, March 9, 2016.

[30] California FAIR Plan Association, "General Information," webpage, undated-a.

[31] CDI, "In the Matter of The California FAIR Plan Association," order, File No. MI-2016-00021, January 20, 2016a.

[32] For a comparison of the coverage provided by a FAIR Plan policy with the standard HO-3 homeowners policy offered in the admitted market, see California FAIR Plan Association, "Insurance Policy Comparison CFP Dwelling Policy to HO-3," undated-b.

- brush within 1,000 feet (or other specific measurement) of the structure.[33]

These underwriting guidelines can mean that there are some areas and some types of properties for which few, if any, admitted carriers are willing to write coverage. Indeed, several of the insurers participating in this study thought that there were areas in the state where no admitted carrier would write. Property owners in these areas can turn to the surplus lines market or the FAIR Plan or decide to forgo coverage altogether.

4.2 Market Share of Admitted Insurers

Figure 4.1 shows that a high percentage of residential policies statewide are written in the admitted market.[34] As of December 31, 2015, 98.3 percent of an estimated 8.118 million residential policies were written in the admitted market.[35] Only 0.2 percent were written by surplus lines insurers, and the remaining 1.5 percent were written by the FAIR Plan. The situation is similar in both the SFSA and the SBSA. More detail on the types of policies written is provided in Appendix C.

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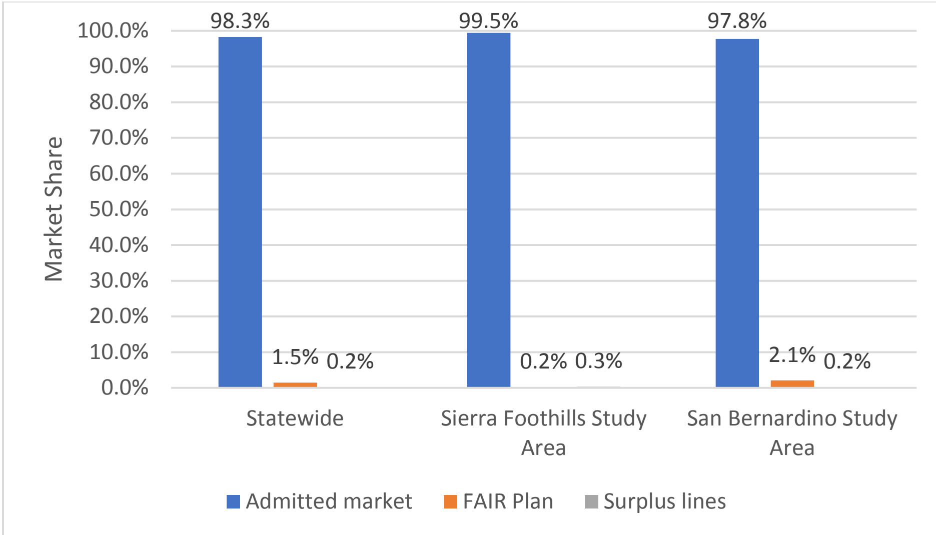
[33] CDI, "CDI Fact Sheet: Fire and Wildfire Underwriting Guidelines, Handout 2 for Senate Committee on Insurance Hearing on Preparing for Global Warming and Drought: State of the Homeowners' Insurance Market," March 9, 2016b.

[34] All figures and tables in this chapter are based on the analysis datasets created by the authors. These datasets use information from the CDI, Community Service Statement dataset provided to the RAND Corporation, July 2017a; CDI, Personal Property Experience dataset provided to the RAND Corporation, July 2017b; CDI, Annual Statement Database dataset provided to the RAND Corporation, 2018a; New, Renewal, and Nonrenewal Policy Database dataset provided to the RAND Corporation, 2018b; Surplus Line Association of California, dataset provided to the RAND Corporation, December 2017; California FAIR Plan Association, dataset provided to the RAND Corporation, December 2017; RMS, dataset provided to the RAND Corporation, 2017; Westerling, 2018; and Sleeter et al., 2017.

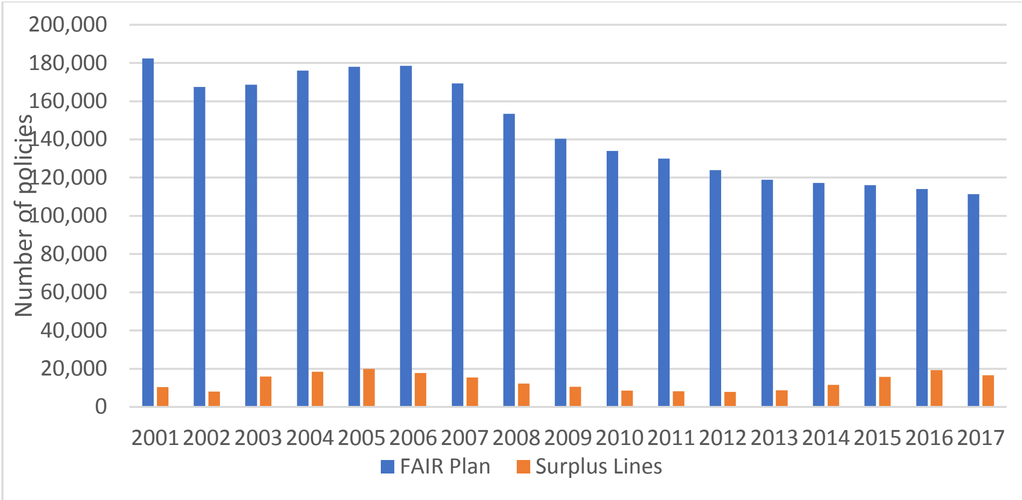
[35] Excludes renter policies and policies on individual condominium units. December 31, 2015, is the last date for which data on the admitted policies were available at the time of this writing.



Source: Author calculations based on the CDI CSS dataset, 2017a; California FAIR Plan Association dataset, 2017; and the Surplus Line Association of California dataset, 2017.
Note: Percentages are based on 8.118 million policies statewide; 194,000 policies in the SFSA, and 343,000 policies in the SBSA.

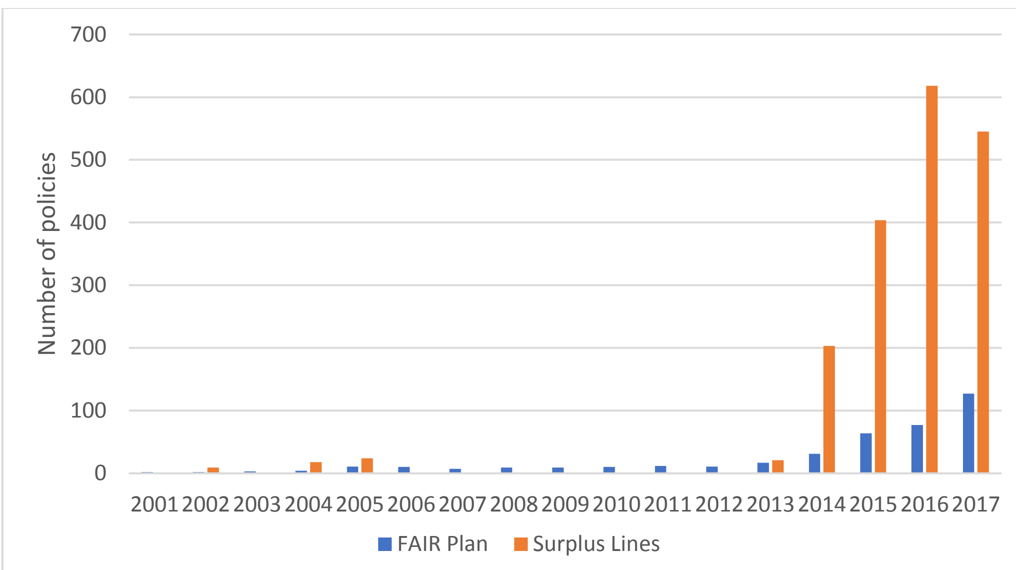
Figure 4.1: Market Share of Admitted Insurers, Surplus Lines Market, and FAIR Plan, as of December 31, 2015

As shown in Figure 4.2, there has been no upward trend in the number of surplus lines residential policies statewide since 2001, and the number of FAIR Plan policies has declined considerably since 2006. However, the situation is different in the two study areas. In the SFSA, the number of policies in the surplus lines market has grown considerably since 2013, and the number of FAIR Plan policies has also grown since 2013, but the overall number remains at low levels (Figure 4.3). In the SBSA, the number of FAIR Plan policies has grown substantially since 2013, with some growth in the surplus lines market (Figure 4.4).



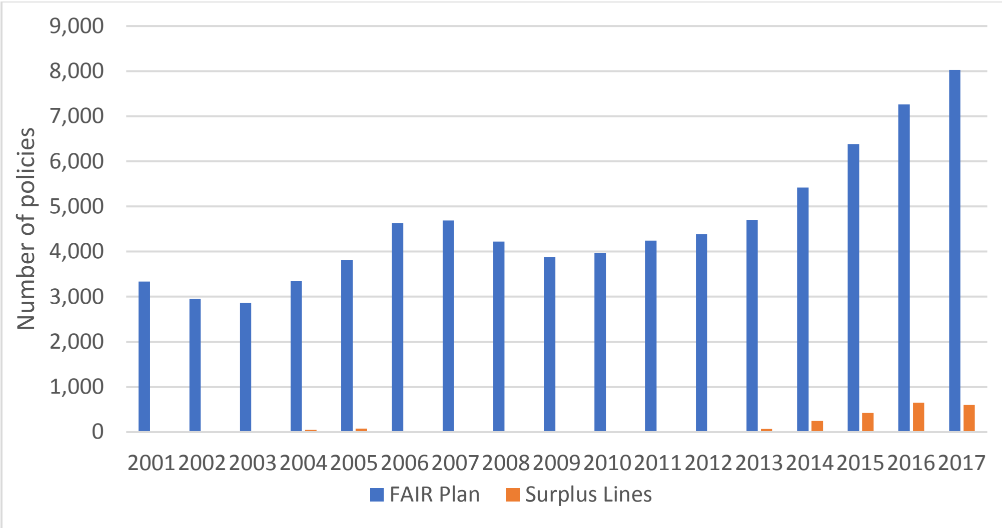
Sources: Author calculations based on California FAIR Plan Association dataset, 2017, and Surplus Line Association of California dataset, 2017.

Figure 4.2: Number of FAIR Plan Policies and Residential Surplus Lines Market Policies Statewide



Source: Author calculations based on the California FAIR Plan Association dataset, 2017, and Surplus Line Association of California dataset, 2017.

Figure 4.3: FAIR Plan and Surplus Lines Policy Counts in the Sierra Foothills Study Area



Source: Author calculations based on California FAIR Plan Association dataset, 2017, and Surplus Line Association of California dataset, 2017.

Figure 4.4: FAIR Plan and Surplus Lines Policy Counts in the San Bernardino Study Area

Analysis at the ZIP-code level provides additional insight into the relationship between the market share of admitted insurers and structure risk. Following the approach used in Chapter 3, we grouped the ZIP codes in the two study areas into three categories using the structure-risk index in 2016. The ZIP codes are categorized using cut-off points that result in a fairly even number of ZIP codes in each of the three categories.

At the ZIP-code level, the percentage of policies in the admitted market tends to decline as the structure risk increases and has declined more rapidly in recent years in ZIP codes with higher structure risk. As shown in the first column of Table 4.1, 99.9 percent of policies on average are in the admitted market for the 13 ZIP codes in the SFSA with low structure risk. The average falls slightly to 97.5 percent for the 14 ZIP codes with high structure risk. The difference is larger in the SBSA, with 97.5 percent of policies in the admitted market for the ZIP codes with low structure risk and 90.8 percent for ZIP codes with high structure risk.

In addition, the market share of admitted insurers has declined more rapidly in the high–structure risk ZIP codes. For example, the second column of Table 4.1 shows that the market share of admitted insurers in the SBSA fell 7.2 percentage points between 2007 and 2015 in the high-risk ZIP codes, but rose 0.5 percentage points in the low-risk ZIP codes.

Table 4.1: Relationship Between Structure Risk and Source of Coverage in Two Study Areas

	Admitted Market		FAIR Plan		Surplus Lines Market	
ZIP Code Structure Risk[a]	2015 Market Share (%)	Change from 2007 to 2015	2015 Market Share (%)	Change from 2007 to 2015	2015 Market Share (%)	Change from 2007 to 2015
SFSA						
Low (n = 13)	99.9	–0.1 pp	<0.1	<0.1 pp	0.1	0.1 pp
Middle (n = 20)	98.9	–1.1 pp	0.4	0.4 pp	0.7	0.7 pp
High (n = 14)	97.5	–2.4 pp	1.5	1.4 pp	1.0	1.0 pp
SBSA						
Low (n = 16)	97.5	0.5 pp	2.5	–0.5 pp	<0.1	<0.1 pp
Middle (n = 13)	98.8	0.1 pp	1.2	–0.1 pp	<0.1	<0.1 pp
High (n = 24)	90.8	–7.2 pp	8.1	6.0 pp	1.1	1.1 pp

Source: Authors.
Note: pp = percentage points.
[a] Each ZIP code was weighted equally in calculating averages.

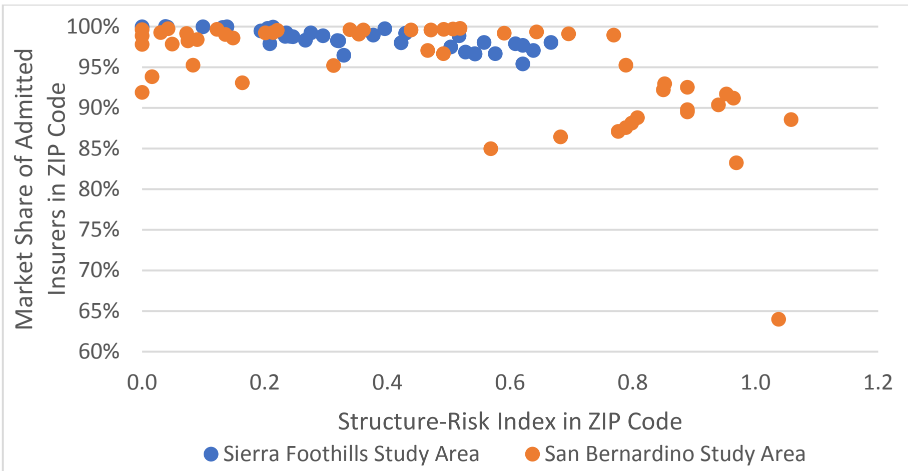
The averages reported in Table 4.1 weight each ZIP code equally. We use these simple averages, rather than weight each ZIP code by the number of policies, because we are interested in examining how structure risk affects the outcomes in each ZIP code. We treat each ZIP code as a separate, equally important realization of how the level of structure risk affects outcomes. There is substantial variation in the number of policies by ZIP code, with the high-risk ZIP codes having fewer policies on average (see Table C.2 in Appendix C). The result is that more than half of SFSA policies are in the low-risk ZIP codes (53 percent), 41 percent are in the middle-risk ZIP codes, and only 6 percent are in the high-risk ZIP codes. Approximately 40, 34, and 24 percent of policies are in the low-, middle-, and high-risk ZIP codes of the SBSA, respectively. For reference, averages weighted by the number of policies in each ZIP code are reported in Table C.3.[36]

In contrast to the decline in the market share of admitted insurers, the 2015 market shares for the FAIR Plan and surplus lines market rise as structure risk increases (third and fifth columns of Table 4.1). Similarly, the increase in market share between 2007 and 2015 for the FAIR Plan and surplus lines market is greater in the high-risk ZIP codes (fourth and last columns of Table 4.1).

Figure 4.5 graphs the percentage of policies in the admitted market versus structure risk for each of the individual ZIP codes in the study areas. The 47 ZIP codes in the SFSA are shown in blue and the 53 ZIP codes in the SBSA are shown in orange. The graph shows a downward relationship between the proportion of policies in the admitted market and the structure-risk index; however, the graph does not control for other housing stock differences across ZIP codes.

[36] Table C.3 also reports the "weighted averages" for other market indicators discussed in this chapter.

We used regression analysis to examine whether the declines in admitted market share are correlated with the change in structure risk when other characteristics of the housing stock (such as the percentage of owner-occupied housing units with mortgages; the percentage of housing units that are for seasonal, recreational, or occasional use; and the average structure value of single-family homes) are held constant. This analysis is described in Appendix D. We found a negative and statistically significant relationship between the market share of the admitted insurers and structure risk. To give a sense of the magnitude of the effect, we compared the market share predicted by the regression relationship when there is no structure risk and when the structure-risk index is at the upper end of the levels observed in 2016 (1.0; see horizontal axis of Figure 4.5). The analysis predicts that the market share of the admitted market would be 7.8 percentage points lower when the structure-risk index is at the high level compared with when there is no structure risk (the 95-percent confidence interval runs from –11.8 percentage points to –3.7 percentage points).



Source: Authors.

Figure 4.5: Market Share of the Admitted Insurers Versus Structure-Risk Index by ZIP Code

4.3 Nonrenewal Rate in the Admitted Market

The percentage of policies in the admitted market that are not renewed each year reflects decisions by insurers to drop coverage (insurer-initiated nonrenewals) and decisions by policyholders to terminate coverage (insured-initiated nonrenewals). Insurers may cancel coverage to reduce exposures in high-risk areas. Policyholders may terminate coverage when they sell their properties or when they are able to find more-attractive premiums or coverage with another carrier. The entry of new competitors into the market may spur policyholder nonrenewals. The distinction between insurer-initiated and insured-initiated nonrenewals can be blurry. For example, insured-initiated nonrenewals might be spurred by a rate increase by the current insurer or by demands that the policyholder take certain mitigation measures in order to renew the policy.[37]

As shown in the first column of Table 4.2, insurer-initiated nonrenewals were higher in the high-risk ZIP codes than in the low-risk ZIP codes of the SFSA, but the difference is not large. The insurer-initiated nonrenewals average 2.9 percent in 2016 in the high-risk ZIP codes versus 1.3 percent in the low-risk ZIP codes. In contrast, insured-initiated nonrenewals drop as fire risk increases in SFSA (second column of Table 4.2). The result is that the overall nonrenewal rate in the SFSA (insurer and insured combined) shows no consistent relationship with wildfire risk (last column of Table 4.2). The patterns are less pronounced in the SBSA.

Table 4.2: Nonrenewal Rates in the Admitted Market for 2016

ZIP Code Structure Risk[a]	Insurer-Initiated Nonrenewal Rate (%)	Insured-Initiated Nonrenewal Rate (%)	Overall Nonrenewal Rate (%)
Statewide	1.4	5.7	7.1
SFSA			
Low (n = 13)	1.3	5.8	7.0
Middle (n = 20)	1.7	4.5	6.3
High (n = 14)	2.9	4.2	7.1
SBSA			
Low (n = 16)	1.6	7.0	8.6
Middle (n = 12)	1.2	6.4	7.6
High (n = 21)	1.7	5.9	7.6

Source: Authors.
[a] Each ZIP code was weighted equally in calculating averages.

The more pronounced patterns in the SFSA than in the SBSA could potentially be due to faster changes in perceived wildfire risk in the SFSA than in the SBSA.[38] (Note, however, that we do not have evidence that the perceived risk is changing faster in one area than another.) More rapidly increasing risk will likely result in more insurer-initiated nonrenewals as insurers attempt to reduce risk exposures. Less insurance availability may in turn result in lower

[37] The CDI provides general definitions of insurer and insured-initiated nonrenewals in its data calls to admitted insurers, but in the end, it is up to the insurer to bin nonrenewals into the two categories. For insured-initiated nonrenewals, the CDI asked insurers to provide the total number of policies nonrenewed for which the nonrenewal was initiated by the insured (e.g., nonpayment). For insurer-initiated nonrenewals, the CDI asked insurers to provide the total number of policies nonrenewed for which the nonrenewal was initiated by the insurer (e.g. underwriting criteria) (Luciano Gobbo, CDI, personal communication, April 17, 2018).

[38] Such a perception would be consistent with the much more rapid change in wildfire risk projected through midcentury in the SFSA than in the SBSA (see Chapter 3).

insured-initiated nonrenewals, as policyholders find it increasingly difficult to obtain competing bids at better rates or at all.

When differences in other ZIP code characteristics in the two study areas are accounted for, the insurer-initiated nonrenewal rate rises by 0.9 percentage points as the structure-risk index moves from zero to the upper end of the range observed in 2016 (95-percent confidence interval runs from –0.1 to 1.9 percentage points). The regression coefficients for insured-initiated nonrenewals and total renewals are not statistically different from zero (Appendix D).

Our analysis does not find a great deal of difference in nonrenewal rates across ZIP-code risk category. However, there may well be higher nonrenewal rates in certain subareas of the ZIP codes. There is some evidence of higher nonrenewal rates in areas where wildfires have recently struck. United Policyholders, a consumer advocacy group, conducts surveys after wildfire events. The surveys are filled out by homeowners attending United Policyholders events or taking advantage of services provided by United Policyholders. According to surveys conducted in March 2016, six months after the Valley and Butte fires, 21 percent of policyholders whose policies had come up for renewal after the fires had received nonrenewal or cancellation notices.[39] However, the number of survey respondents whose policies had come up for renewal since the fires was fairly small (63) and may not be representative of all homeowners affected by the two fires.

4.4 Number of Insurers Writing in the Admitted Market

The number of insurers writing coverage is another indicator of the health of the admitted market. In this section, we examine the relationship between the number of admitted insurers writing coverage and structure risk. A decline in the number of insurers could signal reduced competition and portend greater difficulty for homeowners in finding coverage in the admitted market.[40]

Table 4.3 shows the number of admitted insurance groups writing coverage using the homeowners policy form in the two study areas.[41] To account for differences in the number of policies across ZIP codes, the table also reports the number of insurance groups per 100

[39] Author analysis of United Policyholders, "Butte Fire—6 Month Survey," 2016a, and United Policyholders, "Valley Fire—6 Month Survey," 2016b. The Butte Fire started in September 2015 and burned in Amador and Calaveras Counties. The Valley Fire started in September 2015 and burned in Lake, Napa, and Sonoma Counties.

[40] The health of the market is determined by multiple factors, of which the number of insurers is one. Also important are the size, capitalization, and rating of the insurers operating in the market. It might be, for example, that a market dominated by a few large, highly competitive insurers is healthier than one characterized by many small, poorly capitalized insurers. In any case, an examination of how the number of insurers varies by structure risk can help alert policymakers as to whether there might be problems in areas with high structure risk.

[41] Insurance groups can consist of multiple insurance companies under the same principal ownership. Condominium and renter policies are excluded from the analysis.

admitted policies.[42] The first column shows that the number of insurance groups writing coverage per ZIP code in each structure risk category is substantial. Once normalized by the number of policies in the ZIP code, the number of groups writing coverage is actually greater in ZIP codes with high structure risk (third column of Table 4.3), and the last column of the table suggests faster growth in the number of insurance groups per 100 policies in the high-risk ZIP codes than in the low-risk ZIP codes. When differences in other ZIP code characteristics in the two study areas are accounted for, the number of insurance groups per 100 policies increases by 10.7 groups and the structure-risk index moves from zero to the upper end of the range observed in 2016 (95-percent confidence interval runs from 1.9 to 19.6 groups per 100 policies). There could conceivably be pockets within ZIP codes where there are few insurance groups per 100 policies, but any such pockets could not be detected by this analysis.

Table 4.3: Number of Insurance Groups Writing Coverage on the Homeowners Policy Form in the Admitted Market

	Number of Groups		Number of Groups per 100 Policies	
ZIP Code Structure Risk[a]	**2014**	**2007 to 2014 Change (%)**	**2014**	**2007 to 2014 Change (%)**
SFSA				
Low (n = 13)	40.3	–3.4	2.2	–0.1
Middle (n = 20)	35.5	–0.9	3.0	4.5
High (n = 14)	23.3	–0.5	7.3	9.4
SBSA				
Low (n = 16)	38.9	–5.3	2.1	5.0
Middle (n = 13)	40.4	–4.7	6.7	2.6
High (n = 24)	26.7	–1.4	3.9	13.3

Source: Author calculations based on data in the CDI CSS dataset, 2017a.
[a] Each ZIP code was weighted equally in calculating averages.

4.5 Take-Up Rate

Although homeowners with mortgages are required by their lenders to carry fire insurance, homeowners without mortgages can in principle decide to forgo insurance if it is too expensive or difficult to maintain and bear the risk themselves.[43]

To construct an estimate of the percentage of residential properties with fire insurance, we linked data on the combined number of policies written in the admitted market, surplus lines

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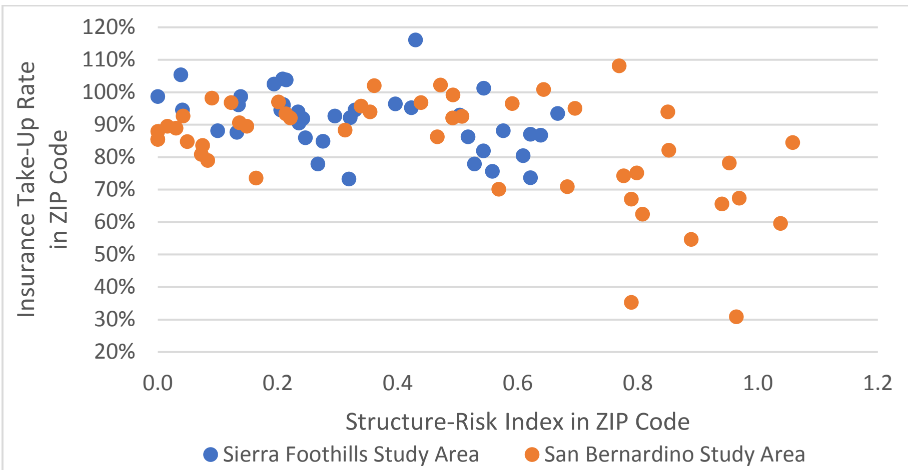
[42] Study-area ZIP codes with higher structure risk tend to have fewer policies (see Table C.2 in Appendix C).

[43] Nationwide, 64 percent of owner-occupied housing units have mortgages (U.S. Census Bureau, "American FactFinder, Selected Housing Characteristics, 2012–2016 American Community Survey 5-Year Estimates," webpage, 2018).

market, and the FAIR Plan by ZIP code with data on the number of structures from the U.S. Census Bureau's ACS.[44] Estimates of the number of single-unit dwellings can be pulled directly from the ACS, but the number of two-, three-, and four-unit structures can only be approximated. We thus restrict our analysis of take-up to single-unit structures.[45]

Figure 4.6 displays the take-up rate in 2015 for 94 ZIP codes under analysis.[46] The dispersion of estimates for any given value of the structure-risk index is fairly wide and results in take-up rates greater than 100 percent in some ZIP codes. This dispersion likely reflects uncertainty in the estimate of the number of single-unit structures in each ZIP code. Even so, there appears to be a negative relationship between the structure-risk index and the take-up rate, and the average take-up rate drops substantially in both the SFSA and the SBSA as structure risk increases (Table 4.4).



Source: Authors.

Figure 4.6: Take-Up Rate in 2015 for Single-Unit Structures Versus Structure-Risk Index by ZIP Code

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[44] U.S. Census Bureau, "ZIP Code Tabulation Areas (ZCTAs)," undated. We use data from the 2012 through 2016 ZCTA file. These Census estimates are based on ACS surveys conducted between 2012 and 2016.

[45] The CDI PPE database reports the number of units covered by each policy written by the admitted market or the FAIR Plan, allowing the take-up rate calculations to be restricted to single-unit structures for these two markets. Ninety-six percent of the admitted market policies (excluding condominium policies and renters' policies) are written on single-unit structures. Data provided by the Surplus Line Association did not indicate the number of units covered. However, including all surplus lines policies in the take-up rate calculation rather than only policies on single-family structures will likely have minimal effect on the difference in the take-up rate across ZIP codes.

[46] Six ZIP codes with estimated take-up rates greater than 150 percent or less than 25 percent were dropped from the analysis.

Table 4.4: Take-Up Rate in 2015 for Single-Unit Structures

ZIP Code Structure Risk[a]	Average Take-Up Rate (%)
Statewide	N/A
SFSA	
Low (n =13)	94
Middle (n = 19)	93
High (n = 14)	83
SBSA	
Low (n = 15)	87
Middle (n = 12)	95
High (n = 21)	75

Source: Authors.
[a] Each ZIP code was weighted equally in calculating averages.

Although there is a negative correlation between take-up rate and structure risk, this relationship disappears when other housing stock characteristics are controlled for (Appendix D). Particularly important is the percentage of housing units that are for seasonal, recreational, or occasional use. The regression results in Appendix D show a strong negative relationship between take-up rate and the percentage of housing units that are for seasonal, recreational, or occasional use. So even though take-up is lower in the high-risk ZIP code, the decrease is explained by the higher percentage of housing units that are for seasonal, recreational, or occasional use in these ZIP codes, rather than by structure risk.

In its surveys of policyholders affected by wildfire, United Policyholders found take-up rates somewhat higher than those found for the higher-risk ZIP codes in the study areas. The take-up rate found in three surveys—which were conducted six months after the Butte, Valley, and 2007 Southern California wildfires—average 88 percent, higher than the 83 percent and the 75 percent for the high-risk ZIP codes in the SFSA and SBSA, respectively (shown in Table 4.4). Again, however, the United Policyholders surveys are not based on a random sample of homeowners and may not be representative of all homeowners in areas affected by the fires.

4.6 Premiums

Annual premiums are expected to rise as structure risk increases and, in this section, we investigate the relationship between premium and structure risk. Table 4.5 reports the average premium per policy for the admitted market, surplus lines market, and FAIR Plan. Note that the premiums do not control for the amount of coverage.[47]

[47] We have data on policy limits for the admitted market, which we discuss next, but we do not have policy-limit data for the surplus lines market or the FAIR Plan.

Table 4.5 suggests that premiums do increase as structure risk increases in both the admitted market and for the FAIR Plan. The first column shows the results for policies written in the admitted market on the homeowners' form and the second column shows the results for the narrower coverage provided by the dwelling policy form.[48] In both cases, premiums in the high-risk ZIP codes are higher than those in the low-risk ZIP codes. FAIR Plan policies also tend to increase in price as structure risk increases. As discussed above, FAIR Plan policies are more similar to dwelling policies than homeowners policies, but note that FAIR Plan policies tend to be more expensive than the dwelling policies (compare the second and third columns of Table 4.5). In addition to differences in the rate schedules offered by the FAIR Plan and the admitted insurers, the gap between average FAIR Plan and admitted market premiums might be due to differences in what is covered, the amount of coverage purchased, and the location of properties within the ZIP code. For example, it might be that FAIR Plan policies are in the riskier parts of the ZIP code. Further analysis is needed to substantiate the possible explanations.

The relationship between premium and structure risk does not hold up in the surplus lines market. As expected, surplus lines policies tend to be considerably more expensive than either FAIR Plan policies or admitted-market policies, but the average premium does not increase with wildfire. However, the amount of coverage per policy could vary across structure risk, and the results might be different if the amount of coverage were controlled for.

[48] To be clear, we calculate the average premium in a ZIP code and then average the averages for the ZIP codes within each structure-risk category.

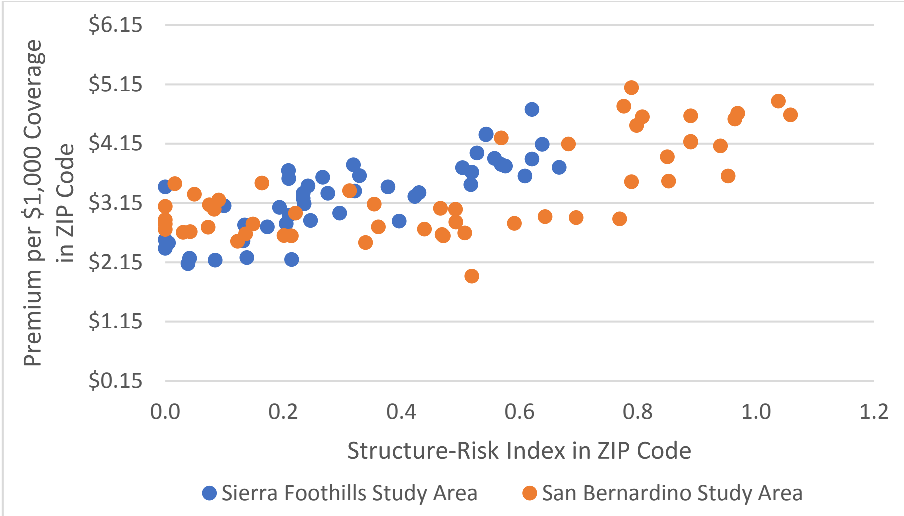
Table 4.5: Average Premium per Policy in 2014

	Admitted Market		FAIR Plan	Surplus Lines Market
ZIP Code Structure Risk[a]	Homeowners Policy Form[b]	Dwelling Policy Form[b]	Dwelling Policy Form[c]	All Residential Forms[d]
Statewide	$1,020	$400	$440	$2,370
SFSA				
Low	$1,010	$550	$850	$2,610
Middle	$1,200	$590	$1,120	$1,710
High	$1,230	$610	$1,010	$1,630
SBSA				
Low	$780	$320	$300	$1,550
Middle	$930	$380	$470	$2,300
High	$1,160	$480	$720	$1,750

[a] Each ZIP code was weighted equally in calculating averages.
[b] Based on 13, 20, and 14 ZIP codes in the lowest, middle, and highest structure risk categories for the SFSA, respectively, and 16, 13, and 24 ZIP codes in the SBSA, respectively.
[c] Based on 12, 20, and 12 ZIP codes with nonzero FAIR Plan premiums in the lowest, middle, and highest structure risk categories for the SFSA, respectively, and 16, 12, and 24 ZIP codes in the SBSA, respectively.
[d] Based on eight, 19, and 13 ZIP codes in the lowest, middle, and highest structure risk categories for the SFSA, respectively, and seven, seven, and 13 ZIP codes in the SBSA, respectively.

Adequate data were available to calculate the rate per $1,000 of coverage policies in the admitted market. Figure 4.7 shows a positive relationship between the rate per $1,000 of coverage in the ZIP code and structure risk.[49] As can be seen in the third and fourth columns of Table 4.6, the rate per $1,000 of coverage are considerably higher in the high-risk ZIP codes in both study areas and have been rising faster in the high-risk ZIP codes. In fact, the rate per $1,000 of coverage fell in the admitted market between 2007 and 2014 in the low-risk ZIP codes of both study areas and in the state as a whole. In contrast, the rate per $1,000 of coverage rose 12 percent and 15 percent between 2007 and 2014 in the high-risk ZIP codes of the SFSA and SBSA, respectively.

[49] Rate per $1,000 of coverage is calculated using the amount of coverage provided by the policy for the primary structure (Coverage A).



Source: Authors.

Figure 4.7: Average Rate per $1,000 of coverage in 2014 for Policies Written in the Admitted Market on Homeowners Forms Versus Structure-Risk Index by ZIP Code

Table 4.6: Average Rate per $1,000 of Coverage in 2014 for Policies Written in the Admitted Market on Homeowners Forms

ZIP Code Structure Risk[a]	Average Premium per Policy in 2014	Average Coverage per Policy in 2014[b]	Average Rate per $1,000 of Coverage in 2014	Percentage Change in Average Rate per $1,000 from 2007 to 2014
Statewide	$1,020	$399,000	$2.68	–13
SFSA				
Low (n = 13)	$1,010	$395,000	$2.60	–12
Middle (n = 20)	$1,200	$378,000	$3.23	2
High (n = 14)	$1,230	$314,000	$3.93	12
SBSA				
Low (n = 16)	$780	$267,000	$2.94	–12
Middle (n = 13)	$930	$331,000	$2.83	–9
High (n = 24)	$1,160	$308,000	$3.91	15

[a] Each ZIP code was weighted equally in calculating averages.
[b] Amount of coverage on the primary structure (Coverage A).

When we control for other ZIP code characteristics, there is a statistically significant relationship between the rate per $1,000 of coverage and structure risk at the ZIP-code level. The rate per $1,000 of coverage $1.04 per $1,000 coverage as structure risk increases from zero to near the maximum observed in 2016 (95-percent confidence interval: $0.68 to $1.40). This would translate into a $312 increase in premium for a home with $300,000 in coverage, which, as shown in the second column of Table 4.6, is a typical amount of coverage in the high-risk ZIP codes. Although this increase is substantial, it may or may not fully capture the actual difference in structure risk across ZIP codes. We will return to this topic later in this chapter.

4.7 Amount of Coverage Purchased

Higher premium costs in areas with higher structure risk may induce those who have purchased policies to purchase less coverage than they would otherwise and to select higher deductibles.[50] However, policyholders may not have a great deal of flexibility in the amount of coverage they can purchase. Banks typically provide guidelines on the amount of coverage that must be purchased for homes with mortgages, and many insurers require that coverage exceed a certain percentage of structure value regardless of whether the structure has a mortgage.

4.7.1 Coverage-to-Value Ratio

We constructed a measure of the ratio of coverage to insurable value by ZIP code for policies in the admitted market written for single-unit structures on the homeowners form. To do this, we used data from the CDI PPE database on the average coverage for single-unit structures and data from RMS on the average insurable value of single-unit structures by ZIP code.[51] Note that the coverage limit provided by the homeowners and dwelling policies in California does not distinguish between the cause of the fire (wildfire or not).

The results of the analysis are shown in the first column of Table 4.7. Estimates for the ratio of coverage to insurable value are high and show no obvious relationship with structure risk. Examination of the individual observations shows considerable variation in the ratio around any particular value of the structure-risk index. This variation most likely reflects error in the measure of insurable value. Nevertheless, we do find a statistically significant relationship between the coverage-to-value ratio and structure risk when other ZIP-code characteristics are held constant (Appendix D). When differences in other ZIP-code characteristics in the two study areas are accounted for, the coverage-to-value ratio falls by 10.5 percentage points as the structure-risk index moves from zero to the upper end of the range observed in 2016 (95-percent confidence interval runs from –22.0 to 0.9 percentage points).

[50] Policyholders may also decide to switch from the homeowners form to the less comprehensive dwelling form (perhaps with the same coverage limits). This issue deserves further investigation.

[51] The amount of coverage includes the sum of the policy limits for Coverage A and Coverage B reported by the CDI for each policy in the ZIP code (from the PPE file). Coverage A provides coverage for the primary structure and Coverage B provides coverage for other structures on the property. Coverage B was 11 percent of Coverage A across the study areas as a whole for policies written on the homeowners form in 2014. The RMS figures on average insurable value do not differentiate between insured and uninsured structures. We assume that any bias due to overlooking this distinction is the same across ZIP codes (our focus is primarily on differences across ZIP codes).

Table 4.7: Coverage-to-Value Ratio and Deductible for Policies Written in the Admitted Market on Homeowners Form in 2015

ZIP Code Structure Risk[a]	Coverage-to-Value Ratio	Deductible
Statewide	N/A	
SFSA		
Low (n = 13)	0.93	$1,670
Middle (n = 20)	1.00	$1,830
High (n = 14)	1.00	$1,800
SBSA		
Low (n = 16)	1.04	$1,130
Middle (n = 12)	0.94	$1,260
High (n = 21)	0.94	$1,730

Source: Author calculations based on CDI CSS dataset, 2017a, and CDI PPE dataset, 2017b.
[a] Each ZIP code was weighted equally in calculating averages.

Our analysis suggests that coverage-to-value ratios might be higher in high-risk areas, and there is some evidence that the policyholders affected by wildfires do not have adequate coverage. The admitted insurers participating in this study reported the number of residential wildfire claims in California between 2000 and 2016 and the number that paid at the policy limit.[52] The percentage of wildfire claims that paid at the wildfire limit averaged approximately 6 percent across the insurers reporting.

A more dramatic picture emerges from the United Policyholders surveys. Survey respondents were asked whether they had enough insurance to cover replacing or rebuilding their homes. Across the three surveys conducted six months after the Valley, Butte, and 2007 Southern California wildfires, 64 percent reported that they did not have sufficient coverage to replace or rebuild their homes. And in a follow-up survey conducted two years after the 2007 Southern California wildfires, respondents who received an insurance settlement were asked whether the amount of the settlement was sufficient to rebuild their homes—41 percent said no.

There are many potential reasons why policyholders affected by wildfire might not have adequate coverage to rebuild:

[52] The *policy limit* is defined to include any extended coverage on policy. If a policyholder selects coverage limits close to the estimated replacement cost of the home, many insurers will provide "extended coverage" on the policy. With extended coverage, the insurer will pay up to a multiple of the coverage limit to repair or replace the structure. The multiples vary by insurer and state. Typical multiples in California are 1.25 and 1.5, and some insurers will pay up to twice the coverage limit. Many insurers provide this extended coverage at no additional charge; others provide it at an additional charge.

- One insurer observed that when there are problems with coverage limits, it is often for the coverage on nonprimary structures (such as barns) and that such problems are more common in rural areas.
- It is also possible that the policy limit is not the issue; rather, the policy simply does not cover certain items.
- The limit on coverage for debris removal in some policies is 5 percent of the policy limit. However, this can be inadequate for wildfires because fire debris is considered hazardous waste in California, with an often-high associated disposal cost.
- An increase in the cost to rebuild when large numbers of structures are damaged (demand surge) can cause coverage to be insufficient following a large wildfire.
- The insurer might rely on the policyholder's estimate of the valuation, which might be inaccurately low because of the policyholder's lesser knowledge of replacement cost and cost drivers or because of the policyholder's deliberate action to keep premiums low.
- Even if an insurer relies on its own valuation estimates, it might fail to update that valuation on a timely basis, so the valuation is outdated when the fire hits.
- Some homeowners might have built additions to their homes or made other major improvements (e.g., upgrading kitchens and bathrooms, adding decks) without informing the insurer.

A more detailed investigation is needed to determine the extent to which insurance coverage falls below replacement cost in areas exposed to wildfire risk and to better understand the reasons that might be the case.

4.7.2 Deductibles

Admitted insurers and the FAIR Plan currently do not offer wildfire-specific deductibles in California. This contrasts to practices in other states for some perils. We use the policy-specific deductibles reported in the CDI PPE database to calculate the average deductible per ZIP code and then examine the relationship between deductible and ZIP code structure risk.

Consistent with the findings for the coverage-to-value ratio, there is some indication that policyholders tend to select higher deductibles on policies written on the homeowners form in the admitted market when structure risk increases. The second column of Table 4.7 shows that the average deductible ranges from $1,000 to $2,000 in the ZIP codes examined and tends to rise with structure risk. When other ZIP-code characteristics are controlled for, a positive relationship between deductible and structure risk remains. The relationship is statistically significant and the deductible increases by $179 as the structure-risk index moves from zero to the upper end of the range observed in 2016 (95-percent confidence interval runs from –$33.0 to $391).

4.8 Underwriting Profit in the Admitted Market

The ability of admitted insurers to make a reasonable profit is critical to their ongoing willingness to provide coverage for structure risks. In this section, we examine the underwriting profitability of the admitted market in the state.

Admitted insurers file annual statements with the NAIC summarizing their losses and expenses by state. Premiums, losses, and expenses are reported separately by insurance line, and the relevant lines for this analysis are the Fire line (NAIC Line 1) and the Homeowners Multiple Peril line (NAIC Line 4). The Fire line includes policies written on dwelling-owner-occupied and dwelling-tenant-occupied forms. The Fire line includes both commercial and residential policies, and CDI staff indicated that Fire line policies in California are approximately two-thirds residential and one-third commercial. The Homeowners Multiple Peril line covers insurance policies written on the homeowners' policy form (ISO HO-3 forms and equivalent).[53] These policies provide coverage for a broad range of perils in addition to fire.

Table 4.8 reports the premiums, losses, and expenses by line for 2001 through 2017 combined.[54] Expenses are broken down into the categories contained in the annual statement. As can be seen in the first column, the premium earned in the Homeowners Multiple Peril line totals just over $100 billion over this 17-year period with losses (insurance claims) amounting to about 60 percent of that ($61.6 billion). Expenses for the marketing and sale of policies, adjusting claims, and other insurance operations came to an additional $41.2 billion in the Homeowners line. The Homeowners line is approximately seven times larger in terms of premium earned than the Fire line.

[53] The Homeowners Multiple Peril line does not include only owner-occupied homes. For example, one insurer participating in the study indicated that, in their case, the line included policies on the structure of renter-occupied units and renter-occupied condominium units. Also included were policies on manufactured homes.

[54] The CDI provided premiums, losses, and expenses for this study for NAIC Lines 1 and 4 for all insurance companies operating in California for each year between 2001 and 2017. In 2001, 285 insurance companies and 102 insurance groups in Line 1 reported direct earned premiums greater than zero. In the same year, 169 insurance companies and 81 insurance groups reported direct earned premium greater than zero in Line 4. The corresponding numbers in 2016 were: 235 insurance companies and 81 insurance groups for Line 1 and 121 companies and 54 groups for Line 4.

Table 4.8: Insurer Premiums, Losses, and Expenses for California Industry-Wide by Line for 2001 Through 2017 ($ billions)

Insurer Premiums, Losses, and Expenses for California	Homeowners Multiple Peril (NAIC Line 4)	Fire (NAIC Line 1)
Direct premium earned	$103.7	$18.1
Direct losses incurred	$61.6	$8.4
Expenses	$41.2	$6.4
Defense and cost containment paid	$2.9	$0.4
Claim adjusting and other	$7.8	$0.9
Commission and brokerage	$14.0	$2.2
Taxes, licenses, and fees	$2.6	$0.5
Other acquisition costs	$9.0	$1.2
General	$4.8	$1.3
Total losses and expenses	**$102.8**	**$14.9**
Combined ratio (percentage)	99%	82%

Source: Authors.

The combined ratio (shown at the bottom of Table 4.8) is a measure of the profitability of an insurer's insurance operations, or underwriting profit. The combined ratio is defined as

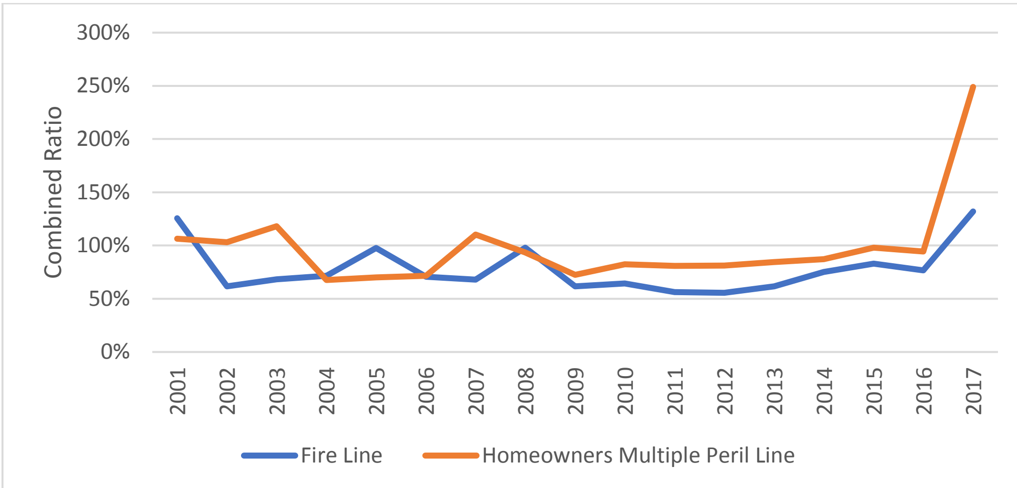
$$combined\ ratio = \frac{losses + expenses}{premium\ earned}.$$

When the combined ratio is less than 100 percent, the insurer is making a profit on its insurance operations.[55] The combined ratio does not consider investment return, which includes the investment income on surplus, loss reserves, and unearned premium. Therefore, it is not a measure of overall insurer profitability. As shown in the last row of Table 4.8, underwriting profit industrywide in the Fire line has been positive across the period as a whole. In contrast, underwriting profit in the Homeowners Multiple Peril line has been very close to zero between 2001 and 2017. Underwriting profits vary from year to year and were highly negative for the Homeowners Multiple Peril line in 2017 (Figure 4.8). Insurers reported $15.4 billion and $9.0 billion in direct losses incurred in the Homeowners Multiple Peril and Fire lines, respectively, in 2017 alone. A substantial portion of the 2017 losses were due to wildfire. In January 2018, the

[55] When an electric utility contributes to the ignition or spread of a wildfire, an insurer can in some circumstances recover some or all of its claims payments related to the wildfire from the utility. The recoveries are reflected in the reported losses in the insurer's annual statements.

CDI reported that insured residential property losses from the October and December 2017 wildfires in northern and Southern California totaled $10.3 billion.[56]

Figure 4.8: Combined Ratio in California Industry-Wide Between 2001 and 2017 by Line



Source: Authors.

Some insurance companies and groups have done much worse than others between 2001 and 2017. As shown in Figure 4.9, 45 percent of the 132 insurance companies and 43 percent of the 76 insurance groups that wrote at least $10 million in direct written premium over this period had combined ratios greater than or equal to 100 percent. Therefore, from an underwriting perspective, homeowners insurance has been a losing proposition for nearly one-half of insurers between 2001 and 2017.

This distribution of the combined ratio suggests ongoing change and dynamism in the industry. There are a number of strategies an insurer could take to address poor profitability, such as:

- increasing overall premium levels (which could drive away risks that are attractive from the insurer's perspective)
- tailoring rates to better differentiate between high and low risks to better address the part of their insurance portfolio that is putting downward pressure on profitability
- changing the mix of properties underwritten
- pulling back from the market.

Better-performing firms might fill any resulting coverage gap, at least to some extent.[57]

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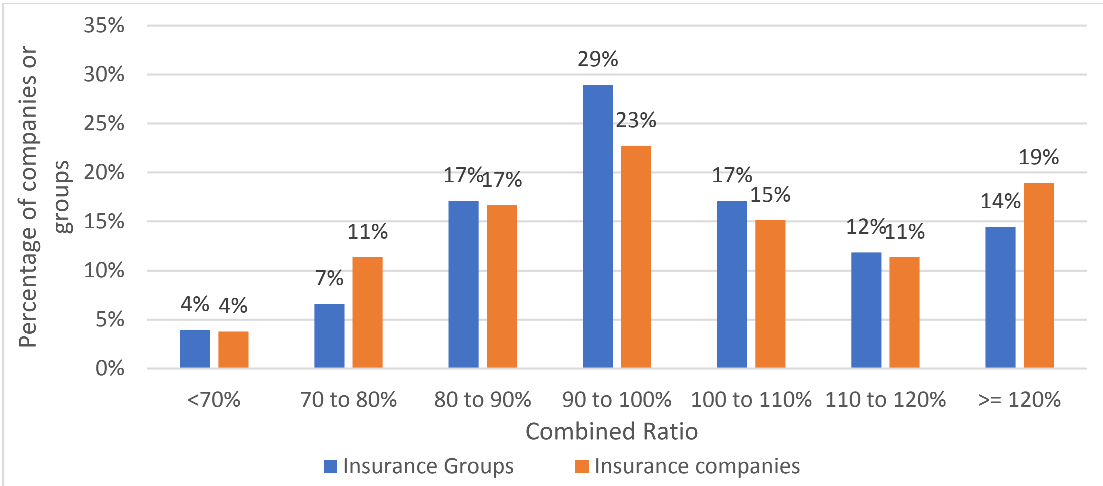
[56] CDI, *Statewide Insured Losses from the October and December 2017 Wildfires,* January 31, 2018c.

[57] Note that regardless of changes in the mix of insurers, the risk profile of the properties to be insured does not change at a given point in time (absent mitigation measures). Thus, the highest-risk properties



Source: Authors.
Note: Based on 132 insurance companies and 76 insurance groups with direct written premiums totaling at least $10 million between 2001 and 2017.

Figure 4.9: Combined Ratio between 2001 and 2017 for Insurance Companies and Groups in the Homeowners Multiple Peril Line

To better understand the extent to which wildfire losses have a substantial impact on the combined ratio, we asked the admitted insurers participating in the study to report the percentage of overall insurance claims payments in California that are the result of wildfires. The percentage of overall losses in the homeowners' line that were the result of wildfire varied by insurer and ranged from roughly 5 to 15 percent for total losses between 2000 and 2016.[58] At the time insurers provided data, losses for 2017 were not available; including 2017 data would undoubtedly increase the percentage of total losses caused by wildfire.

Although wildfire losses do not appear to have been a particularly large percentage of overall losses between 2000 and 2017, they still appear to have had a considerable impact on the industry's combined ratio. Figure 4.10 plots the combined ratio against the annual number of acres burned statewide by wildfire between 2001 and 2017. A trend line fit to the data shows an upward relationship between the number of acres burned and the combined ratio. When acres burned is at the low end of the observed range (e.g., 250,000 acres), the trend line predicts a combined ratio of approximately 75 percent, a good year for underwriting profit. When acres

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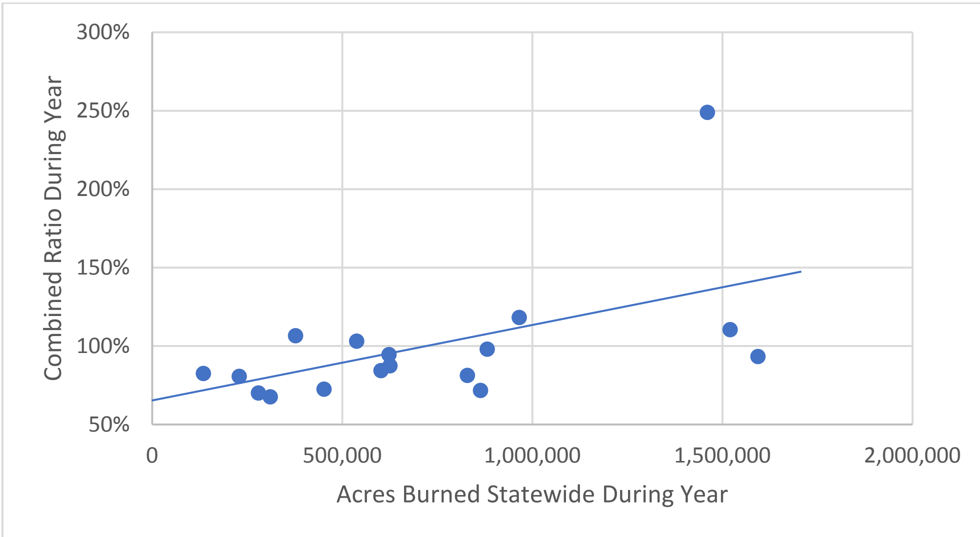
might be passed back and forth between insurers, and the highest-risk properties might still need to go to the surplus lines market or the FAIR Plan for coverage.

[58] Wildfire losses include smoke and ash claims from wildfires. Insurers also report that fire losses (wildfire and nonwildfire) were in the range of 20 to 40 percent of total losses and that wildfire losses were on the order of 15 to 35 percent of fire losses. As a point of reference, the Insurance Information Institute reports that 24 percent of losses incurred on homeowners' policies nationwide in 2015 were from fire and lighting (Insurance Information Institute, "Facts + Statistics: Homeowners and Renters Insurance," undated).

burned is at the higher end of the observed range (e.g., 1.5 million acres), the trend line predicts a combined ratio of approximately 140 percent, a year of large underwriting losses. The substantial spread around the trend line reflects annual variation in the many other causes of loss faced by insurers.[59]



Source: Authors.

Figure 4.10: Relationship Between the Combined Ratio and Acres Burned Statewide by Year from 2001 to 2017 for Homeowners Multiple Peril Line

The underwriting experience between 2001 and 2017 illustrates that an extended period of underwriting profits can be wiped out by a very large wildfire or other catastrophic event (a fire following an earthquake, for example).[60] Underwriting profits in the Homeowners Multiple Peril and Fire lines totaled $12.1 billion from 2001 through 2016 combined, and were almost completely wiped out by the results for 2017.[61] Insurers may not believe that the return is adequate to justify the risk, even once investment returns are included.

4.9 Rate Regulation and Factors that Affect Insurers' Willingness to Write High-Risk Properties

As directed by California's Proposition 103, the CDI regulates rates in the residential insurance market. The CDI's prior-approval rate-making formula provides a minimum and maximum

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[59] The adjusted *R*-squared for a linear regression of the combined ratio on acres burned statewide and a constant is 0.26.

[60] Most residential earthquake insurance in the state is written by the California Earthquake Authority. However, private insurance policies cover fire following earthquake.

[61] Industrywide underwriting profit between 2001 and 2016 was calculated from the CDI CSS dataset, 2017a, and CDI PPE dataset, 2017b.

allowable premium for its portfolio of policies, with the maximum subject to the following constraint:

$$\frac{underwriting\ profit + investment\ income}{imputed\ surplus} < allowable\ after - tax\ rate\ of\ return.$$

Appendix E breaks this equation down into more-basic elements (such as premium, losses, and expenses). During the rate-approval process, the CDI and the insurer negotiate where in the range of permitted premiums the insurer's future aggregate premium should fall. The outcome determines the overall attractiveness of writing in the state. There is plenty of disagreement between the CDI and insurers about whether the premiums approved are adequate, given the risks involved. The examination of this issue is relevant to maintaining the overall health of the admitted market in the state, but is beyond the scope of this study. In the remainder of this section, we instead identify three aspects of the regulatory process that affect insurers' willingness to write residential insurance policies in high–wildfire risk areas:

- use of probabilistic wildfire models
- variation of rates by wildfire risk
- exclusion of net reinsurance costs in the rate-setting process.

These issues were highlighted by the admitted insurers participating in this study.

Use of Probabilistic Wildfire Models. The CDI must approve the average rate level for an insurer's overall book of business. In their rate applications, insurers are required to project expected future losses, but CDI regulations do not allow insurers to use probabilistic wildfire models to do so.[62] Rather, insurers are required to use past loss history to set the so-called catastrophe load for wildfire risk. From the CDI's point of view, the complexity and proprietary nature of probabilistic models make the assessment of their accuracy difficult. Further, those models are open to manipulation or misuse by end users. These factors contribute to the CDI's reluctance to allow them to be used in the rating process.[63] However, from the insurers' perspective, past loss history is based on a period that is too short to include a representative range of loss events.[64] In addition, they believe that approved rates do not adequately reflect current wildfire risk and tend to lag actual risk as wildfire risk increases.[65] They also believe that the rates do not appropriately reflect risk because of the large variation in potential losses.

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[62] The CDI does allow insurers to use probabilistic models to determine how to vary rates across structures by wildfire risk. However, insurers typically use deterministic scoring models (such as Fireline or Corelogic) to set these relativities.

[63] To help improve the empirical basis for setting rate relativities, the CDI is currently undertaking an effort to collect industry fire/wildfire premium, loss, and exposure data that an insurer could use to supplement its own data.

[64] For catastrophic risk, such as wildfire, earthquake, or flood, very rare 1-in-250-year and 1-in-500-year events are critical to estimating overall fire risk.

[65] Basing projected losses on history can also in principle overstate wildfire risk. A few very large events, such as the 2017 Northern California and Southern California fires, could cause history to overstate expected losses in some areas.

Insurers argue that the inability to use models reduces their willingness to write policies in risky areas.

Variation of Rates by Wildfire Risk. Insurers typically apply factors to increase rates for properties considered to be at high wildfire risk relative to those thought to be at lower wildfire risk. These "relativities" must be approved by the CDI, and several of the insurers interviewed felt that the approved relativities are "flatter" than they should be—that is, the allowed difference between rates for high-risk and low-risk properties is not as great as is indicated by actual risk. We do find that premiums have grown substantially faster in recent years in high-risk ZIP codes than in low-risk ZIP codes (Table 4.6); however, we do not have the data to validate the assertion that premium differences still do not reflect actual risk differences. The CDI has approved substantial rate increases for high-risk areas but holds that insurers have not provided sufficient evidence that actual risk supports all requested differentials between high- and low-risk properties. If the premium difference does not reflect the difference in risk, the result would be that high-risk properties are being subsidized by lower-risk properties and rates are inadequate for higher-risk properties. Flattening the relativity curve reduces the willingness of admitted insurers to write policies in risky areas.

Exclusion of Net Reinsurance Costs in the Rate-Setting Process. Finally, CDI regulations do not allow insurers to include the reinsurance margin as an expense in the rate-approval process. The reinsurance margin measures that part of the reinsurance premium above the expected loss on the policy and includes the reinsurer's claims adjustment costs, brokers fees, and risk load.[66] The CDI takes this position for several reasons:

- The CDI cannot ensure that these margins are reasonable and not excessive because it does not regulate reinsurance rates.
- The primary insurer may have some financial stake in the reinsurer, creating a conflict of interest that works to the disadvantage of policyholders.
- Insurers may be able to use reinsurance to circumvent the stringent rate regulatory system created by California's Proposition 103.
- The CDI allows insurers to use a "catastrophe load" in the rate setting process. The load is intended to be used to cover future catastrophic losses, but it could also be used to purchase reinsurance.
- The CDI's prior approval rate formula is applied on a direct basis. That is, while the formula does not compensate for reinsurance costs, it also does not reduce approved rates to reflect the payments and claim reimbursements the insurers obtain from reinsurance.[67]

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[66] The primary insurer on average should expect to receive the expected loss on the reinsurance policy, and it would not make sense to include this part of the reinsurance premium in the expenses of the primary insurer.

[67] CDI, Availability and Affordability of Residential Insurance Task Force, "The Availability and Affordability of Coverage for Wildfire Loss in Residential Property Insurance in the Wildland-Urban Interface and Other High-Risk Areas of California: CDI Summary and Proposed Solutions," December 2017c, pp. 12–13, and personal communications with the authors.

However, from the perspective of many insurers, reinsurance is needed to reduce the risk that potentially very large wildfire losses could financially impair or even bankrupt the company. When insurers are not able to include reinsurance margins in their filings, they have an incentive to reduce the cost of their reinsurance; a primary way to do this is to reduce the number of high-risk properties insured. Insurers argue that, although allowing the reinsurance margin to be included as an expense would cause average rates to rise (depending on the relativities, rates may increase primarily on high-risk properties), it would allow them to more aggressively write higher-risk properties.

4.10 Summary

The market share of admitted insurers is high overall in the SFSA and the SBSA, but there is evidence that the admitted market is working less well in the higher-risk wildfire areas. The market share of admitted insurers is lower in high-risk ZIP codes than in ZIP codes with little wildfire risk—7.8 percentage points lower when other factors are controlled for. (See Table 4.9, which summarizes the findings from the ZIP code–level analyses in this chapter.) There is also evidence that insurer-initiated nonrenewal rates are greater in high-risk ZIP codes—although the difference is not great.

Table 4.9: Summary of Analyses at the ZIP-Code Level

Market Indicator	Current Level in Low-Risk ZIP Codes of SFSA	Current Level in Low-Risk ZIP Codes of SBSA	Predicted Difference Between High and No Structure Risk	95-Percent Confidence Interval
Market share of admitted insurers	99.9%	97.5%	–7.8** pp	[–11.8, –3.7]
Nonrenewal rate in admitted market				
Insurer-initiated	1.3%	1.6%	0.9* pp	[–0.1, 1.9]
Insured-initiated	5.8%	7.0%	—[a]	—
Total	7.0%	8.6%	—[b]	—
Number of admitted insurance groups writing coverage per 100 policies	2.2	2.1	10.7	[1.9, 19.6]
Take-up rate	94%	87%	—[b]	—
Rate per $1,000 of coverage in the admitted market	$2.60	$2.94	$1.04**	[0.68, 1.40]
Coverage-to-value ratio in the admitted market	0.93	1.04	–10.5 pp*	[–22.0, 0.9]
Deductible in the admitted market	$1,670	$1,130	179**	[–33, 391]

Source: Authors.
Note: pp = percentage points.
* The 90-percent confidence interval does not contain zero.
** The 95-percent confidence interval does not contain zero.

[a] A negative statistical relationship between the indicator and ZIP code structure risk was found, but it is not statistically different from zero with 90-percent probability.
[b] A positive relationship between the indicator and ZIP code structure risk was found, but it is not statistically different from zero with 90-percent probability.

There may well be pockets within ZIP codes where the admitted market has little presence. Several admitted insurers interviewed for this study believed that there were areas where few, if any, admitted carriers would write, and surveys by United Policyholders document high nonrenewal rates in some areas after wildfires—at least for some policyholders. There is also evidence that the problems in the admitted market are accelerating. The market share of admitted insurers declined much faster between 2007 and 2015 in the high-risk ZIP codes than it did in other ZIP codes.

The rate per $1,000 of coverage in the admitted market increases substantially with wildfire risk, but many insurers believe that the current difference between premiums for low- and high-risk properties does not fully reflect the actual risk difference. The CDI holds that insurers have not provided sufficient evidence that actual risk supports greater differentials between high- and low-risk properties, and we have not been able to examine the extent to which rate differentials reflect actual risk differences. Premiums that accurately reflect risk difference are important to avoid cross-subsidization, provide appropriate incentives for risk mitigation, and preserve the overall health of the insurance market.[68]

Homeowners can always turn to the surplus lines market or the FAIR Plan for coverage if coverage in the admitted market is limited, although they might also decide to forgo coverage. We did find that the take-up rate (for insurance from any source) tends to be lower in the high-risk ZIP codes, but this appears to be due to the higher percentage of homes in these ZIP codes that are for seasonal, recreational, or occasional use. Structure risk itself does not appear to have much impact on take-up rate.

Even though we did not find that take-up rate falls as structure risk increases, we did find evidence that homeowners in high-risk areas are purchasing less coverage relative to structure value and selecting higher deductibles than homeowners in lower-risk ZIP codes. There is evidence from policyholder surveys that at least some policyholders affected by wildfire did not have coverage sufficient to repair or rebuild their homes. More-precise data and further analysis of this relationship are warranted.

In terms of financial performance, admitted insurers in the Homeowners Multiple Peril line basically broke even in terms of underwriting profit between 2001 and 2017. Results for the Fire line were better, with the combined ratio well below 100 percent over the same period. Overall profits will be higher once overall investment returns are considered; however, the experience between 2001 and 2017 illustrates how a large event can wipe out many years of underwriting (and investment) profits.

[68] An insurer that cross-subsidizes high-risk properties by increasing rates on low-risk properties would be vulnerable to a competitor that only writes low-risk properties.

In the face of the large risk presented by wildfire, insurers identified the following aspects of the CDI's rate-approval process that reduce their willingness to write in areas with high wildfire risk:

- inability to use probabilistic wildfire models to project expected wildfire losses
- inability to set premiums that fully reflect the difference between high- and low-risk properties
- inability to include reinsurance margins in premiums.

The CDI holds that insurers have not provided sufficient evidence that larger differentials between low- and high-risk properties are justified. There is also a number of reasons that the CDI is reluctant to change its policies on the use of probabilistic wildfire models and the exclusion of reinsurance margins from rate filings.

Chapter 5: Effects of Climate Change on the Residential Insurance Market in the Study Areas

Based on the statistical relationships developed in Chapter 4, this chapter projects how climate change might affect the residential insurance market in the two study areas. After expanding on the overview of our approach presented in Chapter 2, we project change by ZIP code in the two study areas for the following indicators:

- rate per $1,000 of coverage in the admitted market
- market share of the admitted insurers
- coverage-to-value ratio in the admitted market
- policy deductible in the admitted market.

Statistically significant relationships between these indicators and structure risk were found in Chapter 4, justifying projections of how these indicators would change as climate change affects structure risk. The effect of structure risk on the take-up rate is very small and not statistically significant, so we do not expect climate change to affect take-up. We found a statistically significant relationship between insurer-initiated nonrenewal rate and structure risk, but we do not project changes in this indicator because it reflects the speed at which markets are adjusting as opposed to the states to which they might eventually evolve. We also found a positive and statistically significant relationship between structure risk and the number of insurance groups per $100 writing coverage, but do not project how the number of insurance groups per $100 might change in the future because this does not appear to be an area of concern.

We conclude this chapter by identifying factors that can affect future insurance market outcomes.

5.1 Approach

To project the effect of increasing structure risk on insurance markets, we take advantage of the currently observed differences in market indicators across ZIP codes—as captured by the regression analysis in Chapter 4. In ZIP codes where current structure risk is low but increases over time to become comparable to that in ZIP codes that currently have high structure risk, our approach in effect projects that insurance markets in current low-risk ZIP codes will become similar to those observed today in the current high-risk ZIP codes. In ZIP codes where the structure risk increases beyond that observed today, we use the regression relationships to extrapolate outside the current observed range of the structure-risk index. Extrapolating outside the current observed range is subject to more uncertainty than projecting within the observed range of risk.

The analysis in Chapter 3 and Appendix B shows that the distribution of the structure-risk index across the ZIP codes in the SFSA is lower than that in the SBSA for the current decade. The projected distribution of the structure-risk index in the SBSA does not change much through the end of the century; however, the distribution for the SFSA does. By midcentury, the distribution in the SFSA is similar to that for the SBSA today, but with somewhat higher risk. Thus, projections for the SFSA through midcentury are based largely on the range of structure risk observed in the SBSA today. In contrast, the distribution of the structure-risk index in 2095 for the SFSA is much higher than the range of risk observed today in the SBSA. Consequently, projections of insurance market conditions in 2095 should be interpreted with care.

Our approach for projecting the effects of climate change on insurance markets rests on many assumptions about the behavior of insurers and regulators. The CDI will need to approve increases in an insurer's aggregate statewide rates as well as its methods for varying rates across structures; therefore, the projections assume a continuation of current practices regarding the approval of aggregate rates and rate relativities. The projections also rest on the continuation of current policies that affect the admitted market's appetite for wildfire risk, such as the exclusion of reinsurance margins in the rate setting process and the prohibition of probabilistic wildfire models in rate setting. In addition, as discussed in Chapter 2, the wildfire risk models underlying our analysis impose future climate conditions on the context today, which assume current firefighting effectiveness and current fuel loads.[69]

Later in this chapter, we will discuss how changes in CDI practices could affect future market conditions.

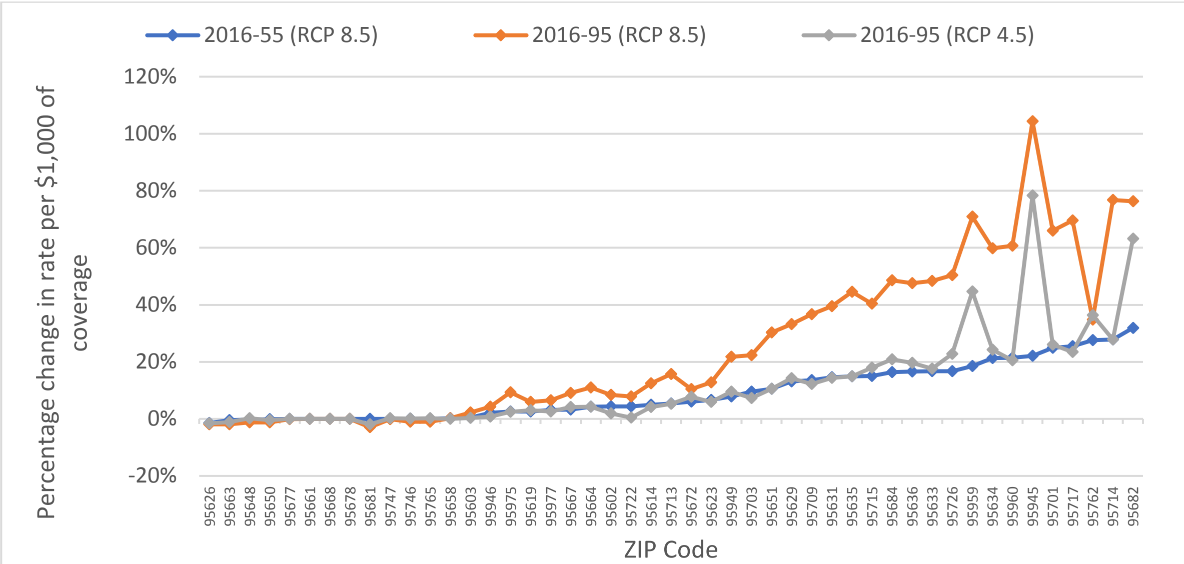
5.2 Projected Impact of Climate Change on the Residential Insurance Market in the Study Areas

5.2.1 Projected Change in Rate per $1,000 of Coverage in the Admitted Market

Figure 5.1 projects the impact of climate change on the rate per $1,000 of coverage in the admitted market for the SFSA. The blue line shows the projected percentage change in premiums for each ZIP code between 2016 and 2055, assuming RCP 8.5. Each point on the line represents a ZIP code, and the ZIP codes are sorted by the magnitude of the percentage change in premium per $1,000 between 2016 and 2055. As shown, little or no change is projected in roughly one-third of the 47 ZIP codes, about 20 percent see increases from 20 to 40 percent, and the remaining ZIP codes see increases somewhere in between.

[69] One might expect firefighting effectiveness to improve over time as equipment and practices improve as a result of lessons learned from previous fires. Any such improvement could cause the wildfire models to overstate changes in projected structure risk.

Figure 5.1: Projected Percentage Change in Rate per $1,000 of Coverage in the Admitted Market in the Sierra Foothills Study Area by ZIP Code



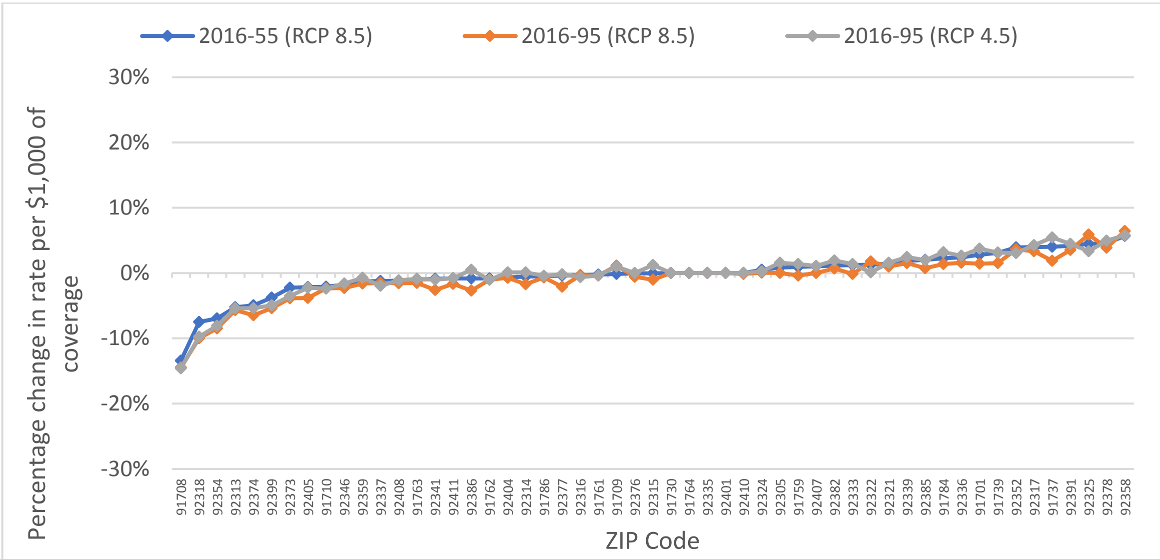
Source: Authors.
Note: ZIP codes are arranged along the horizontal axis in order of the percentage change in rate per $1,000 from 2016 to 2055 (RCP 8.5).

Increases are much larger for many ZIP codes in the SFSA between 2016 and 2095, assuming there is little success in reducing GHG emissions (orange line). About 30 percent of the ZIP codes see premium increases in excess of 50 percent.

The gray line illustrates the substantial impact that a successful GHG emission reduction strategy could have on premiums. If carbon emissions are reduced to those in RCP 4.5 (Figure 2.1 in Chapter 2), premiums in 2095, with few exceptions, are not projected to increase a great deal from those in 2055.

Consistent with the finding that climate change will not have a great deal of impact on structure risk in the SBSA, there is little change in the projected rate per $1,000 in the SBSA (Figure 5.2). The average rate per $1,000 increases by no more than 6 percent in any of the scenarios examined, and it falls in a considerable number of the 53 SBSA ZIP codes. These declines are driven in part by increased urbanization in some ZIP codes.

Figure 5.2: Projected Percentage Change in Rate per $1,000 of Coverage in the San Bernardino Study Area by ZIP Code

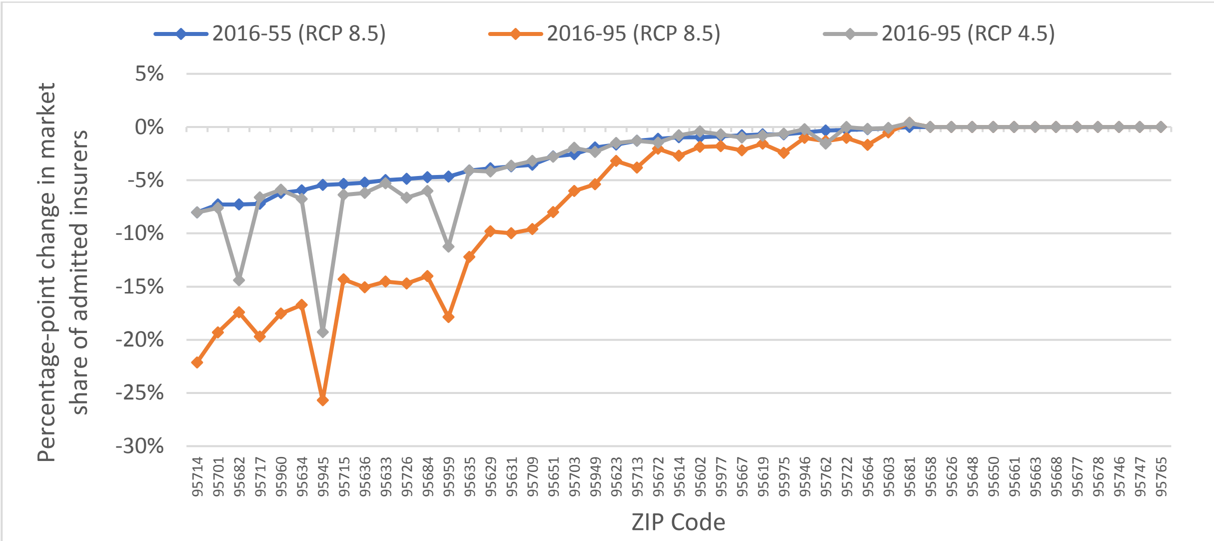


Source: Authors.
Note: ZIP codes are arranged along the horizontal axis in order of the percentage change in the rate per $1,000 from 2016 to 2055 (RCP 8.5).

5.2.2 Projected Change in the Market Share of Admitted Insurers

We project that the market share of admitted insurers will fall somewhat in the SFSA. The blue line in Figure 5.3 indicates that market share will drop by 5 percentage points or more by midcentury in roughly 30 percent of the ZIP codes, given current regulations and behaviors. Declines of 10 percentage points or more are not uncommon by the end of the century in the high–GHG emission scenario (orange line). As before, success in reducing carbon emissions to RCP 4.5 results in market share declines by 2095 (gray line) that are similar to those projected for 2055.

Figure 5.3: Projected Percentage-Point Change in the Market Share of Admitted Insurers in the Sierra Foothills Study Area

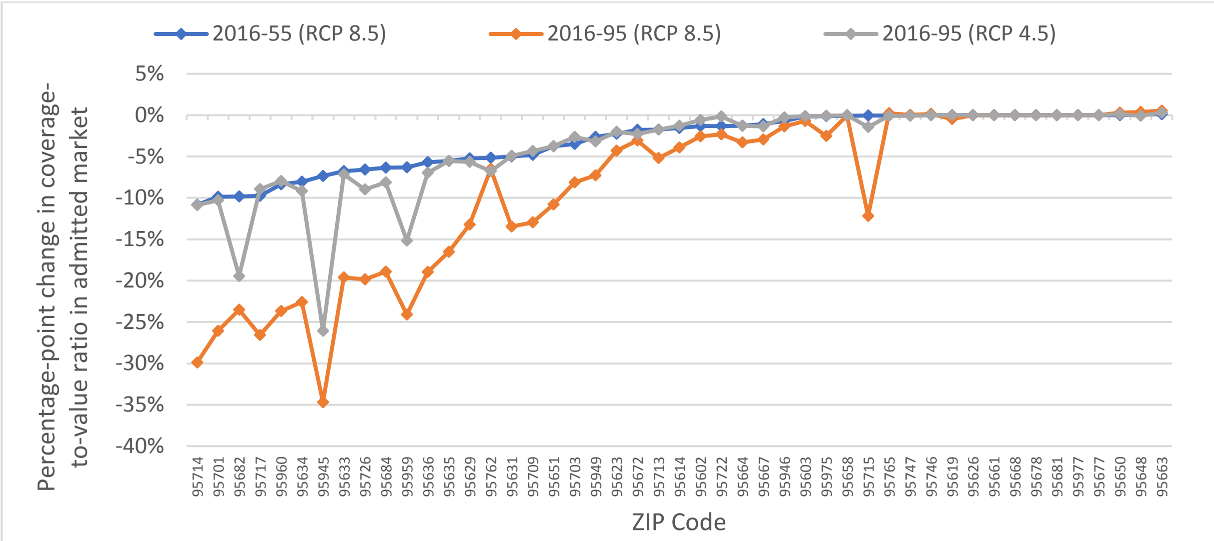


Source: Authors.
Note: ZIP codes are arranged along the horizontal axis in order of the percentage-point change in the market share of the admitted insurers from 2016 to 2055 (RCP 8.5).

5.2.3 Projected Change in the Coverage-to-Value Ratio and Deductible

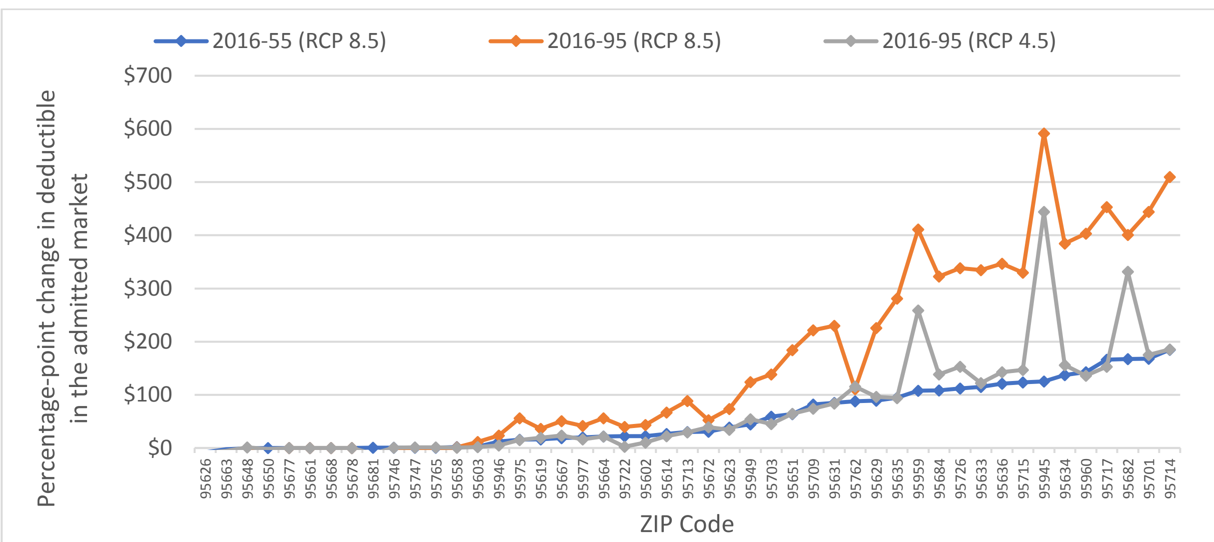
Although there is no indication that insurance take-up will fall as wildfire risk increases, we do project that the ratio of insurance coverage to structure value will fall and deductibles will rise in the SFSA. The coverage-to-value ratio is projected to fall by 5 percentage points or more in approximately 35 percent of the SFSA ZIP codes by midcentury (blue line in Figure 5.4). Deductible increases of $100 or more are expected in a similar percentage of ZIP codes (blue line in Figure 5.5).

Figure 5.4: Projected Percentage-Point Change in the Coverage-to-Value Ratio Market Share in the Admitted Market in the Sierra Foothills Study Area



Source: Authors.
Note: ZIP codes are arranged along the horizontal axis in order of the percentage-point change in the coverage-to-value ratio in the admitted market from 2016 to 2055 (RCP 8.5).

Figure 5.5: Projected Dollar Change in the Deductible in the Admitted Market in the Sierra Foothills Study Area



Source: Authors.
Note: ZIP codes are arranged along the horizontal axis in order of the dollar change in the deductible in the admitted market from 2016 to 2055 (RCP 8.5).

5.2.4 Location of Projected Change Within the Sierra Foothills Study Area and Percentage of Homeowners Affected

Where in the SFSA will the largest climate change impacts occur? Table 5.1 demonstrates that the largest changes will be in the ZIP codes with higher current structure risk. The 47 ZIP codes in the SFSA are grouped by structure risk using the same three categories as in Chapter 4. The average projected percentage change across the ZIP codes in each group is calculated for the indicators of interest. As can be seen by moving down the rows in Table 5.1, the impacts are negligible in ZIP codes with low current structure risk and increase as current structure risk increases.[70] The ZIP codes with low current structure risk are primarily urbanized, and given current ember cast assumptions, these ZIP codes have little wildfire risk now or in the future.

Table 5.1: Projected Changes in Insurance Market Indicators in the Sierra Foothills Study Area by Current Structure Risk

Current ZIP Code Structure Risk[a]	2016 to 2055 (RCP 8.5)	2016 to 2095 (RCP 8.5)	2016 to 2095 (RCP 4.5)
Market share of admitted insurers (percentage point change)			
Low	0 pp	–0.1 pp	0 pp
Middle	–2 pp	–5 pp	–3 pp
High	–5 pp	–15 pp	–6 pp
Average rate per $1,000 of coverage (percentage change)			
Low	0.1	–0.1	–0.1
Middle	9	24	15
High	18	51	19
Coverage-to-value ratio (percentage point change)			
Low	–0.1 pp	0 pp	0 pp
Middle	–2.6 pp	–7.4 pp	–4.4 pp
High	–6.5 pp	–19.4 pp	–7.1 pp
Policy deductible (dollar change)			
Low	0	0	0
Middle	47	130	78
High	121	341	131

Source: Authors.
Note: pp = percentage point.
[a] Each ZIP code is weighted equally in calculating averages.

Roughly one-third (14 of 47) of the SFSA ZIP codes fall in the high-risk category, based on today's structure risk. However, they account for a disproportionately low percentage of the overall population in the SFSA. Five percent of the population resided in these ZIP codes in 2016. The population in these ZIP codes is not projected to increase substantially through the

[70] The projected indicators either show improvement or little change in the SBSA for all ZIP code categories from 2016 to 2055 and from 2016 to 2095 and are not included in the table.

end of the century.[71] Thus, the projections in Table 5.1 for today's highest-risk ZIP codes affect relatively few homeowners.

5.3 Factors That Will Affect Projected Changes in Market Conditions

Our findings indicate that climate change could have a substantial impact on the residential insurance market in some parts of the SFSA. For the 14 SFSA ZIP codes that currently face the highest wildfire risk according to our structure-risk index, we project on average that, by 2055:

- market share of admitted insurers will drop by 5 percentage points
- rates in the admitted market per $1,000 coverage will increase by 18 percent
- the coverage-to-value ratio will fall by 6.5 percentage points
- the deductible will increase by approximately $120 (Table 5.1).

The projected changes by 2095 are substantially greater under RCP 8.5 than RCP 4.5. Additionally, the difference in the market indicators for the two study areas indicate that climate change will not necessarily affect insurance markets in all areas of the state. The projected effects in the SBSA through either 2055 or 2095 are negligible or show improvement for some indicators, and, even in the SFSA, effects are small in those ZIP codes currently facing the lowest wildfire risk.

These projections are based on a number of factors, including

- carbon emission scenarios
- the current level of structure risk mitigation
- current fuel loads and firefighting capabilities
- projections of how much and where population will grow
- the current practices and behaviors of regulators, insurers, and policyholders.

All these factors could change, affecting future conditions in insurance markets. In the remainder of this chapter, we discuss how key factors identified in discussions with stakeholders during this study could affect future market conditions.

5.3.1 Greenhouse Gas Emissions

Successful effort to reduce GHG emissions will not make a great deal of difference in insurance market indicators in the study areas by midcentury because of the inertia of the climate system. However, we do find that reducing emissions from the levels underlying RCP 8.5 to those underlying RCP 4.5 will substantially reduce impacts by 2095.

5.3.2 Structure Vulnerability

Building new structures that are less vulnerable to wildfire and modifying existing structures to be less vulnerable to wildfire risk would lessen the impacts from those projected here. Community-based organizations, such as Fire Safe Councils, which provide defensible space

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[71] The midpoint projections of the overall SFSA population in 2016, 2055, and 2095 are 628,000, 855,000, and 1,027,000. The midpoint projections for the high-risk ZIP codes (based on current conditions) in the same years are 28,000, 29,000, and 30,000. The midpoint projections for the middle-risk ZIP codes are 272,000, 354,000, and 438,000. The midpoint projections for the low-risk ZIP codes are 356,000, 501,000, and 590,000. We have not attempted to project the number of insurance policies by ZIP code.

verification services; insurance industry–backed research organizations, such as the Insurance Institute for Business and Home Safety, which conducts research on fortifying homes; and government agencies, such as the California Building Standards Commission, which is responsible for the state's building code, all have a role to play in reducing structure vulnerability. Similarly, from a land-use planning perspective, concentrating growth and new development in lower-risk areas would reduce impacts.

5.3.3 Fuel Control

Reducing fuel loads and improving fuel breaks would also lessen impacts. As is true for reducing GHG emissions and reducing structure vulnerability, controlling fuels would lower overall wildfire risk and could simultaneously improve both the affordability and availability of coverage.

5.3.4 Rate Relativities

The extent to which the CDI constrains future rates from reflecting the full variation of wildfire risk across properties will have important ramifications for the residential insurance market (we do not have sufficient evidence to determine whether the CDI currently constrains rate relativities). As wildfire risk increases, any such cross-subsidies are an increasing concern. Such cross-subsidies

- are arguably unfair to homeowners in low-risk areas
- reduce the incentives for insurers to write in high-risk areas
- reduce the ability of insurers to provide mitigation discounts because the premiums charged on the high-risk properties are inadequate to begin with
- reduce the incentives for homeowners to invest in structure risk–mitigation measures and avoid risky areas.

Maintaining rates that reflect risk will undoubtedly cause rates to be higher in some areas than they would be otherwise; however, doing so will likely result in less reduction in the market share of admitted insurers. Higher rates in some areas may create affordability problems for some households, illustrating the common trade-off between affordability and availability. The higher rates could also reduce coverage-to-value ratios and increase deductibles in some areas.

5.3.5 Loss Projection

The methods that insurers are allowed to use to project future losses for rate filing will influence the effect of increasing wildfire risk on insurance markets. As discussed in Chapter 4, CDI regulations do not allow insurers to use probabilistic wildfire models in projecting losses for rate filings. Relying only on past loss history can result in an overall average rate for an insurer's book of business that does not accurately reflect expected loss. Climate change is causing wildfire risk to increase over time, and is requiring insurers to use historic losses will tend to result in rates that do not keep up with actual wildfire risk. Conversely, a recent large event—such as the 2017 fires—may cause the overall average rate to exceed appropriate levels, at least for some time.

Average rates that are too low would limit an insurer's ability to charge full-risk rates on high-risk properties, which would discourage them from writing policies in high-risk areas. One might argue that insurers could raise rates on low-risk properties to offset the shortfall on high-risk properties, but competition from insurers who focus on properties in low-risk areas would presumably prevent this from being a viable strategy.

5.3.6 Net Reinsurance Costs

Policies on how an insurer's reinsurance expenses are considered in the rate-approval process can also affect market outcomes. CDI regulations that do not allow insurers to include reinsurance margins in rate filings will likely have greater impact as fire risk increases. The ability to include the net cost of reinsurance in rates would presumably increase the willingness of admitted insurers to purchase reinsurance and to write in risky areas. Doing so would enable admitted insurers to better compete with surplus lines carriers who face no such restriction, thus improving options available to homeowners. Allowing net reinsurance costs to be considered in the rate filing process would likely lead to higher average overall rates, but depending on rate relativities allowed, insurers may be able to concentrate increases in the risky areas.[72] These higher premiums would create incentives for homeowners to avoid or mitigate wildfire risk, but the higher premiums come with associated affordability challenges.

Although allowing insurers the flexibility of including the net reinsurance margin in the rate filing should, in principle, increase an insurer's willingness to write in high-risk areas, it is uncertain how large the effect would be. The CDI argues that some insurers that currently purchase reinsurance are restricting writing in high-risk areas.[73] However, it could be that insurers would be restricting it even more if insurers did not buy reinsurance at all. Further empirical work is needed to better understand how practices in this area might affect future market conditions.

5.3.7 FAIR Plan Rates

The FAIR Plan is an important alternative for homeowners because it provides coverage regardless of wildfire risk, and changes in the FAIR Plan's rating practices could affect future market conditions. Currently, there is no indication that there has been any effort by either the CDI or the FAIR Plan to keep FAIR Plan rates artificially low. However, FAIR Plan officials have expressed concern that the CDI might inappropriately constrain its overall average rate or rate relativities to ensure that homeowners in high-risk areas have a source of affordable insurance. As rates on high-risk properties in the admitted market rise due to climate change, FAIR Plan rates would look increasingly attractive unless they similarly rise. If FAIR Plan rates are lower than those in the admitted market for the same risk levels, the market share of admitted insurers will tend to decrease, and, if left unchecked, could result in the bulk of homes being insured by the FAIR Plan.[74] High take-up of underpriced FAIR Plan policies could result in very large losses to the plan. Subsequent assessments of the admitted carriers to cover the

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[72] As discussed in Section 4.9, insurers are allowed to include a catastrophe load in their rate filing. The impact of allowing insurers to include net reinsurance margins in the rate filings would depend in part on how doing so would affect the allowable catastrophe load.

[73] Personal communication, Geoff Margolis, CDI, November 15, 2018.

[74] Citizens Property Insurance Corporation (the residual market in Florida) found itself in such a situation for windstorm insurance in Florida. It was the largest insurer of noncommercial residential policies in the state between 2010 and 2013 (Citizens Property Insurance Corporation, *Florida Residential Property Market Share, December 31, 2016 Report*, December 31, 2016).

losses could cause substantial financial burden on the admitted carriers.[75] Admitted carriers might then apply for a rate increase or could, with CDI approval, potentially pass the losses on to policyholders who remain in the admitted market.

[75] Such large assessments could be offset to some extent by distribution to member insurers during profitable periods. Note, however, that profitable periods may not be common if FAIR Plan policies are significantly underpriced.

Chapter 6: Conclusions

In this chapter, we summarize the answers to the four research questions posed in Chapter 1. Although our analysis focused on two study areas in California, many of the insights gained are not location-specific and are expected to be relevant not only to the areas studied but to the rest of California.

6.1 What Is the Current Wildfire Risk in the Study Areas and How Might Climate Change Affect It Through the End of the Century?

The average annual acres burned in the SFSA are projected to roughly double by midcentury. Under the business-as-usual GHG emission scenario, the average annual acres burned are projected to roughly double again by the end of the century. Assuming an aggressive, successful emission reduction strategy (as embodied in RCP 4.5) does not make a great deal of difference in average annual acres burned by midcentury, but it does roughly stabilize average annual acres burned at midcentury levels in the second half of the century. Little change in average annual acres burned is projected under either emission scenario in the SBSA through the end of the century. However, models developed by other researchers do project that climate change will affect the SBSA. Further work is needed to reconcile these findings.

We developed a measure of structure risk that combines the effects of changing wildfire risk with changing population levels and distribution. Current structure risk varies considerably across the two study areas.

Structure risk is projected to roughly double by midcentury in about one-third of the 47 ZIP codes examined in the SFSA, remain unchanged in another third, and increase somewhere in between for the remaining third. The ZIP codes with the largest increases are those that currently face high wildfire risk and are located in the more mountainous portions of the SFSA. By the end of the century, structure risk is projected to increase by 300 percent or more from current levels in 30 percent of the SFSA ZIP codes, assuming the business-as-usual emission scenario. Reducing GHG emissions to RCP 4.5 makes a substantial difference: With only a few exceptions, the ZIP code structure risk at the end of the century under RCP 4.5 is similar to that at midcentury.

Based on the wildfire models used in this study, structure risk is not projected to change a great deal in the SBSA through the end of the century.

6.2 How Well Is the Residential Insurance Market Currently Working in the Higher–Wildfire Risk Areas?

The market share of the admitted insurers is high overall in the SFSA and the SBSA, but there is evidence that the admitted market is working less well in the higher-risk wildfire areas. The market share of the admitted market is lower in the highest-risk ZIP codes than in ZIP codes with little wildfire risk—7.8 percentage points lower when other factors are controlled for. There is also evidence that insurer-initiated nonrenewal rates in the admitted market are greater in the highest-risk ZIP codes, but the difference is not large.

There might well be pockets within ZIP codes where the admitted market has little presence. There is also evidence that the problems in the admitted market are accelerating. The market share of the admitted market declined much faster between 2007 and 2015 in the high-risk ZIP codes than it did in other ZIP codes.

Insurance rates per $1,000 coverage in the admitted market increase substantially with wildfire risk and have been growing more rapidly in recent years than those in lower-risk areas. Even so, many insurers believe that the current differential between premiums for low- and high-risk properties does not fully reflect that actual risk difference. The CDI holds that insurers have not provided sufficient evidence that actual risk supports requested differentials between low- and high-risk properties.

Although we did not find that increasing structure risk tends to decrease the insurance take-up rate, we did find evidence that homeowners in high-risk areas are purchasing less coverage relative to structure value and selecting higher deductibles than homeowners in low-risk ZIP codes. A non-negligible share of wildfire insurance claims pays at the policy limit, and there is evidence from policyholder surveys that at least some policyholders with wildfire-related claims did not have sufficient coverage to repair or rebuild their homes. Further analysis of the adequacy of coverage is warranted.

In terms of financial performance, admitted insurers in the Homeowners Multiple Peril line broke even in terms of combined underwriting profit between 2001 and 2017. Results for the Fire line were better, with the combined ratio well below 100 percent over the same period. Overall, the industry was profitable when investment returns are considered; however, the experience between 2001 and 2017 illustrates how a large wildfire event can wipe out many years of underwriting (and investment) profits.

6.3 How Might the Climate-Induced Change in Wildfire Risk Affect the Residential Insurance Market in the Study Areas?

Given current practices, behaviors, and insurance regulations, our findings indicate that climate change could have a substantial impact on the residential insurance market in some parts of the SFSA. For the 14 SFSA ZIP codes that currently face the highest wildfire risk, according to our structure-risk index, we project on average that by 2055:

- The market share of admitted insurers will drop by 5 percentage points.
- Premiums in the admitted market per $1,000 coverage will increase by 18 percent.
- The coverage-to-value ratio will fall by 6.5 percentage points.
- The deductible will increase by $121.

The projected changes by 2095 are substantially greater under RCP 8.5. While our study examined impacts on only two study areas, these findings indicate that climate change will not necessarily affect insurance markets in all areas of the state. The projected effects in the SBSA through either 2055 or 2095 are negligible and, even in the SFSA, effects are small in those ZIP codes currently facing the lowest wildfire risk.

These projections are based on current practices and behaviors of regulators, insurers, and policyholders; projections for how much and where population will grow; current fuel loads and firefighting capabilities; and current levels of structure risk mitigation.

6.4 What Factors Can Influence How the Residential Insurance Market Will Be Affected by Climate Change?

Insurance regulations and public policy more generally will have important impacts on how climate change will affect the residential insurance market. Key factors identified during this study include the following:

GHG Emissions. Successful efforts to reduce GHG emissions will not make a great deal of difference in insurance market conditions in the SFSA by midcentury because of the inertia of the climate system. We do find, however, that reducing emissions from the levels underlying RCP 8.5 to those underlying RCP 4.5 will substantially reduce impacts by 2095.

Structure Vulnerability. Building new structures that are less vulnerable to wildfire and modifying existing structure to be less vulnerable to wildfire risk would lessen the impacts projected here. Hardening residential structures against ember intrusion is one example of a technique to lessen vulnerability. Similarly, concentrating growth and new development in lower-risk areas would reduce impacts.

Fuel Control. Reducing fuel loads and improving fuel breaks would also lessen impacts. As is true for reducing GHG emissions and reducing structure vulnerability, controlling fuels would lower overall wildfire risk and could simultaneously improve both the affordability and availability of coverage.

Rate Relativities. There is insufficient evidence to determine whether the CDI currently constrains rates from reflecting the full variation of wildfire risk across properties, but whether it does so in the future will have important ramifications for the residential insurance market. As wildfire risk increases, cross-subsidies can become an increasing concern. Such cross-subsidies

- are arguably unfair to homeowners in low-risk areas
- reduce incentives for insurers to write in high-risk areas
- reduce the ability of insurers to provide mitigation discounts because the premium charged on the high-risk properties is inadequate to begin with
- reduce the incentives for homeowners to invest in structure risk–mitigation measures and avoid risky areas.

Allowing rates to reflect risk will undoubtedly cause rates to be higher in some areas than they would be otherwise; however, it will likely result in less reduction in the market share of admitted insurers. Although risk-based rating may in fact increase premiums, it might serve to discourage further development in fire-prone areas. Higher rates in some areas might create affordability problems for some households, illustrating the frequent trade-off between affordability and availability.

Loss Projection. CDI regulations do not allow insurers to use probabilistic wildfire models in projecting losses for rate filings. Climate change is causing wildfire risk to increase over time, and requiring insurers to use historic losses that do not reflect increased risk will tend to result in rates that do not keep up with actual wildfire risk. In addition, the relatively brief period over which historic losses are available is likely insufficient to understand the probabilities of the different types of events that can occur. The result may be that projected losses are too low because the full range of possible losses has not been observed. It is also possible that a recent large event, such as the 2017 fires, may cause rates to exceed appropriate levels, at least for some time. Allowing probabilistic wildfire modeling might well increase premiums for higher-risk properties (to the extent that rate relativities reflect actual risk), but it will likely encourage admitted insurers to more aggressively market policies in high-risk areas. As is the case for a movement to rate relativities that reflect actual risk, increased availability may create affordability problems for some households, and the coverage-to-value ratio in high-risk areas could decline while the deductible increases.

Net Reinsurance Costs. CDI regulations that do not allow insurers to include reinsurance margins in rate filings will likely have a greater impact as fire risk increases. The ability to include the net cost of reinsurance in rates will presumably increase the willingness of admitted insurers to purchase reinsurance and to write in risky areas, although there is uncertainty on how large the effect might be. Doing so would enable admitted insurers to better compete with surplus lines carriers who face no such restriction, thus improving options available to homeowners. The possibility does remain, however, that insurers would choose, perhaps in part due to regulatory constraints, to pass costs on to all consumers with minimal corresponding change in the willingness to write in high-risk areas.

FAIR Plan Rates. The FAIR Plan is an important alternative for homeowners because it provides coverage regardless of wildfire risk, and changes in the FAIR Plan's rating practices could affect future market conditions. Currently, there is no indication that either the CDI or the FAIR Plan have made any effort to keep FAIR Plan rates artificially low. However, FAIR Plan officials have expressed concern that the CDI might inappropriately constrain its overall average rate or rate relativities in order to ensure that homeowners in high-risk areas have a source of affordable insurance. As rates on high-risk properties in the admitted market rise due to climate change, FAIR Plan rates would look increasingly attractive unless they similarly rise. If FAIR Plan rates are lower than those in the admitted market for the same risk levels, the market share of admitted insurers will tend to decrease, and, if left unchecked, could result in the bulk of homes being insured by the FAIR Plan. High take-up of underpriced FAIR Plan policies could result in very large losses to the plan. Subsequent assessments to cover the losses could cause substantial financial burden on the admitted carriers. Admitted carriers might then apply for a rate increase or could, with CDI approval, pass the losses on to policyholders that remain in the admitted market.

7: Glossary

ACS	American Community Survey
CAL FIRE	California Department of Forestry and Fire Protection
CDI	California Department of Insurance
CIGA	California Insurance Guarantee Association
CSS	Community Service Statement Database
Fourth Assessment	California's Fourth Climate Change Assessment
GCM	global climate model
GHG	greenhouse gas
IPCC	Intergovernmental Panel on Climate Change
LUCAS	Land-Use and Carbon Scenario Simulator
NAIC	National Association of Insurance Commissioners
PPE	Personal Property Experience Database
RCP	Representative Concentration Pathway
RMS	Risk Management Solutions
SBSA	San Bernardino Study Area
SFSA	Sierra Foothills Study Area
USGS	U.S. Geological Survey
ZCTA	ZIP Code Tabulation Areas Database

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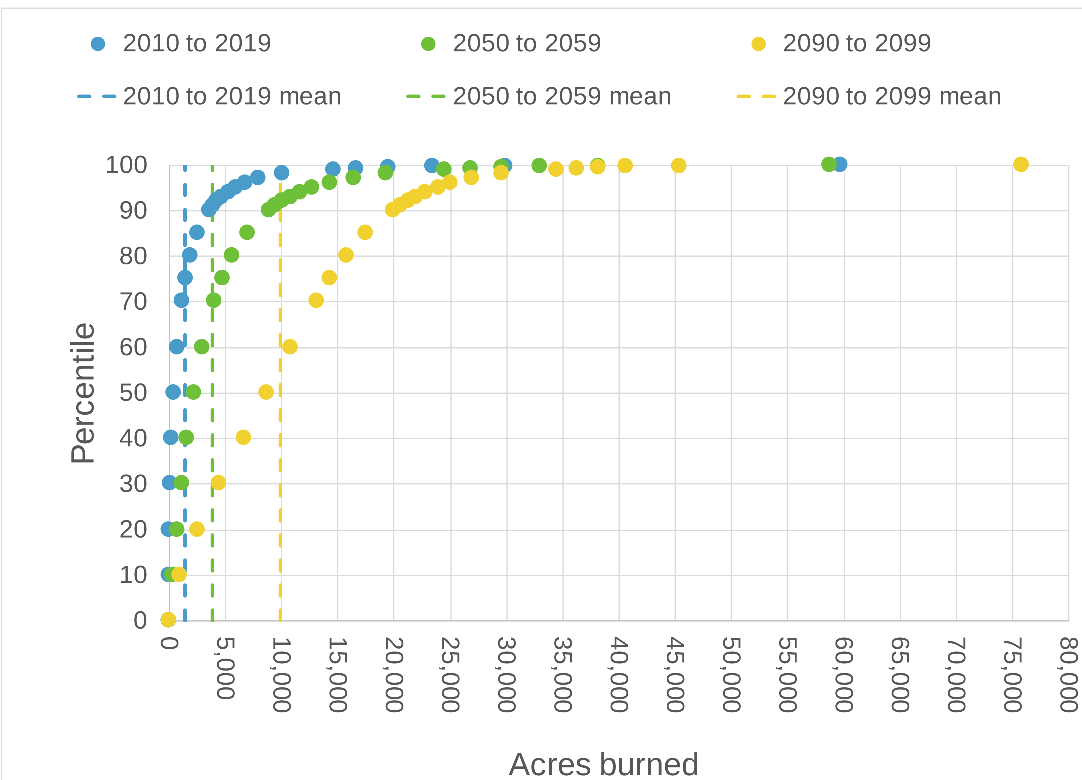
APPENDIX A: Example of the Full Distribution for the Projected Annual Acres Burned in the Sierra Foothills Study Area

For illustrative purposes, Figure A.1 shows the full distribution of the projected annual acres burned in the SFSA for one climate model (CanESM2) under one GHG emission scenario (RCP 8.5) and the average of the high and low population projections.

The figure includes three distributions. Each distribution represents the projected annual acres burned in a decade—2010 to 2019, 2050 to 2059, and 2090 to 2099. As shown, the acres-burned distributions have a "long tail." The average (mean) is larger than the median value (50th percentile), indicating that there are very large values in the extreme simulations, which drive up the mean estimate.

It is also important to note the changes over time. Both the mean and the whole distribution shift to the right (i.e., higher acreage) as time progresses.

Figure A.1: Distribution of Acres Burned in the Sierra Foothills Study Area Using Climate Model CanESM2 with RCP 8.5

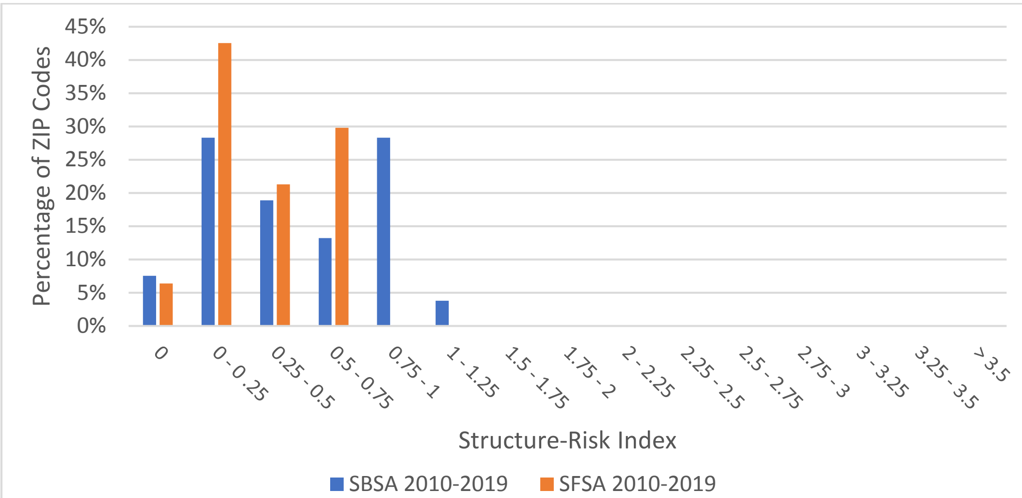


Source: Authors.

APPENDIX B: Comparisons of Structure Risk in the Two Study Areas

To better understand how structure risk in the study areas compares to structure risk observed today, Figure B.1 shows the distribution of the current structure-risk index for the ZIP codes in the two study areas. As shown, the distribution is shifted to the right for the SBSA compared with the SFSA, indicating greater fire risk in the SBSA.

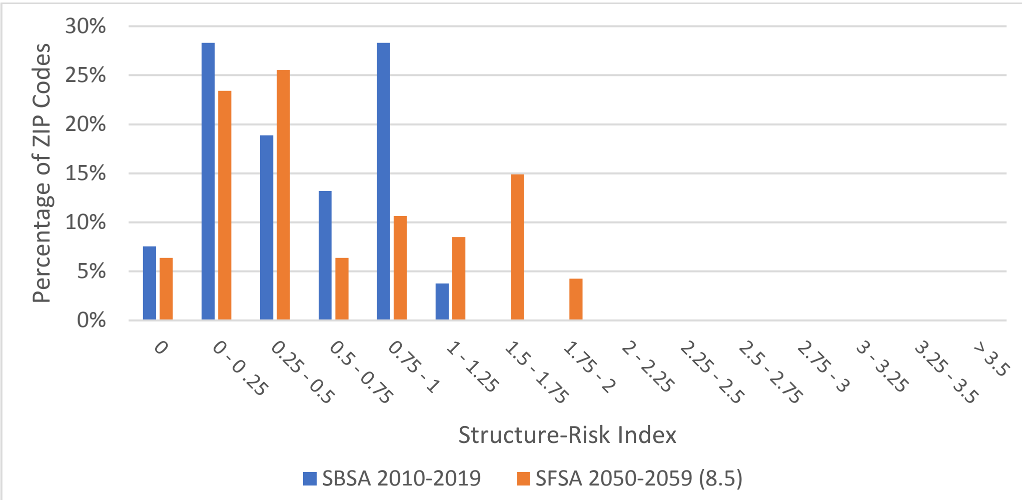
Figure B.1: Distribution of 2010–2019 Structure-Risk Index for ZIP Codes in the Sierra Foothills and San Bernardino Study Areas



Source: Authors.

We found in Chapter 3 that structure risk is not expected to change through the end of the century in the SBSA, regardless of the RCP selected. Therefore, in the following figures, we use the current structure risk distribution in the SBSA as a comparison for the future structure risk distribution in the SFSA. Figure B.2 compares the projected distribution of structure risk in the SFSA in 2055 assuming RCP 8.5 with the current distribution in the SBSA. As shown, the distribution in 2055 spans a similar range as that for the SBSA in 2016, with fire risk in some ZIP codes higher, but not dramatically higher, than that in 2016.

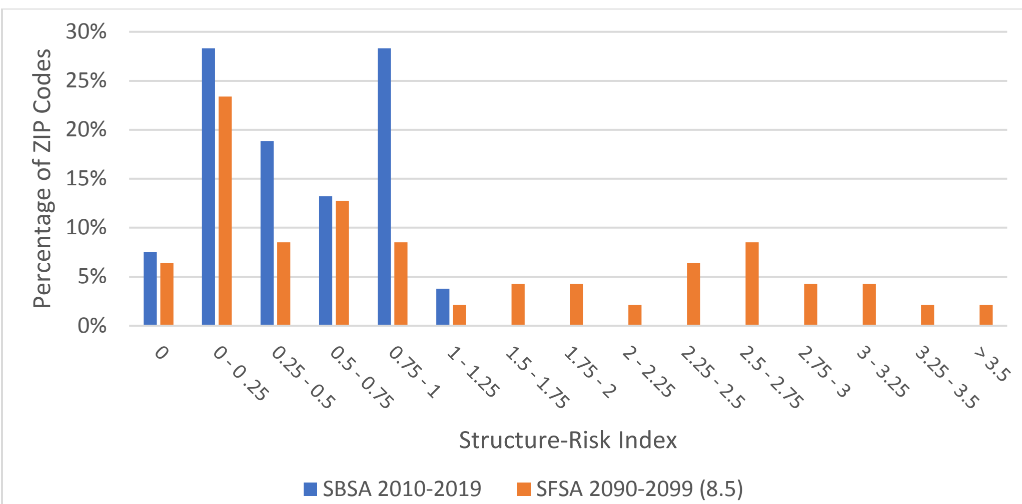
Figure B.2: Distribution of Fire Risk in the Sierra Foothills Study Area for 2050–2059 Assuming RCP 8.5, Compared with Fire Risk in the San Bernardino Study Area for 2010–2019



Source: Authors.

The situation is very different in 2095. As shown in Figure B.3, the fire risk for the SFSA in 2095 assuming RCP 8.5 is shifted far to the right of the current distribution for the SBSA.

Figure B.3: Distribution of Fire Risk in the Sierra Foothills Study Area for 2090–2099 Assuming RCP 8.5, Compared with Fire Risk in the San Bernardino Study Area for 2010–2019



Source: Authors.

The change in structure risk for the three ZIP code groups defined in Chapter 3 is shown in Table B.1. In the SFSA, there is little change in ZIP codes that have low structure risk in 2010-2019. Large increases occur in those ZIP codes that are currently in the middle- and high-risk categories.

Table B.1: Percentage Change in Average Structure-Risk Index by Current Structure Risk Group

	SFSA			SBSA		
Scenario	**Low-Risk ZIP Codes[a]**	**Middle-Risk ZIP Codes**	**High-Risk ZIP Codes**	**Low-Risk ZIP Codes**	**Middle-Risk ZIP Codes**	**High-Risk ZIP Codes**
2016 to 2055 (RCP 8.5)	2	93	119	–20	–12	5
2016 to 2095 (RCP 8.5)	–3	253	334	–31	–21	2
2016 to 2095 (RCP 4.5)	–3	153	127	–23	–13	6

Source: Authors.

[a] ZIP code structure risk categories are defined in Chapter 3. Groupings are based on current structure risks.

APPENDIX C: Breakdown of Policies by Policy Form

Table C.1 shows the number of earned exposures by policy form for the admitted market and for the FAIR Plan.

Data for the admitted market and the FAIR Plan are from the CDI CSS database. This database contains data on exposures per ZIP code written by admitted carriers on one- to four-unit residential structures. Renters' policies and condominium-unit policies are excluded from the table because our focus is on coverage for the structure. Exposures are recorded in exposure-months, which capture the number of months for which premiums were earned in that year. Exposure-months were converted to exposure years to estimate the number of policies in force in that year.[76]

Note that the FAIR Plan does not write policies on the homeowners form, but rather on the dwelling form and for mobile homes.

There are not standard, regulator-approved policy forms in the surplus lines market. Therefore, figures for surplus lines policies are not provided in Table C.1.

[76] The CDI provided data on the number of policies in force in its PPE database, but FAIR Plan policies are not distinguished from admitted market policies in that file. We thus use the earned exposures in the CSS file for this breakdown by policy form. The number of earned exposures in the CSS is higher than the number of policies in the PPE because a policy on a duplex, for example, generates two earned exposures.

Table C.1: Earned Exposure-Years in the Admitted Market and for the FAIR Plan by Policy Form in 2014

Market and Policy Form	Statewide	SFSA	SBSA
Admitted market			
Homeowners	6,008,045	158,899	246,941
Homeowners' tenant	1,741,840	26,514	47,282
Dwelling, owner-occupied	298,538	1,363	23,247
Dwelling, tenant-occupied	1,032,378	16,752	43,678
Mobile homes	288,566	7,771	10,420
Lender placed, occupied	93,251	1,217	6,513
Lender placed, unoccupied	6,189	129	379
Unoccupied	5,427	120	177
Total	9,474,234	212,765	378,637
FAIR Plan			
Dwelling, owner-occupied	89,201	209	4,594
Dwelling, tenant-occupied	52,111	61	1,687
Mobile home	1,203	28	56
Unoccupied	2,369	10	288
Total FAIR Plan	144,884	308	6,625

Source: Authors.

The ZIP codes vary in size, with the ZIP codes with higher structure risk tending to have fewer total policies (Table C.2).

Table C.2: Average Number of Residential Insurance Policies per ZIP Code in the Study Areas by Structure Risk

ZIP Code Structure-Risk Category	Average per ZIP Code[a]	Range
SFSA		
Low (n = 13)	7,917	[151, 20,084]
Middle (n = 20)	4,009	[368, 13,390]
High (n = 14)	806	[80, 3,683]
SBSA		
Low (n = 16)	8,651	[253, 16,774]
Middle (n = 13)	9,325	[22, 21,849]
High (n = 24)	3,468	[115, 15,095]

Source: Authors.
[a] For admitted market, surplus lines market, and FAIR Plan combined, as of December 31, 2015.

Table C.3 reports the weighted average of selected market indicators reported in Tables 4.1 through 4.7. The averages in Tables 4.1 through 4.7 weight each ZIP code equally, while the averages in Table C.3 consider the differing number of policies or structures in each ZIP code when calculating the average. They are equivalent to considering each study area as a single unit (the "Total study area" rows in the table) or treating the ZIP codes in each structure-risk category as a single unit.

Table C.3: Weighted Average of Selected Market Indicators Reported in Tables 4.1 through 4.7 (Part 1)

ZIP Code Structure- Risk Category	Admitted Market Share (%)	Insurer-Initiated Nonrenewal Rate (%)	Insured-Initiated Nonrenewal Rate (%)	Total Nonrenewal Rate (%)
SFSA				
Low	99.9	1.1	5.9	7.0
Middle	99.1	1.6	4.6	6.2
High	97.8	2.3	4.3	6.7
Total study area	99.4	1.4	5.3	6.7
SBSA				
Low	98.4	1.5	6.3	7.7
Middle	98.7	1.3	6.1	7.4
High	95.4	1.5	5.8	7.3
Total study area	97.8	1.4	6.1	7.5

Source: Authors.

Table C.4: Weighted Average of Selected Market Indicators Reported in Tables 4.1 through 4.7 (Part 2)

ZIP Code Structure-Risk Category	Take-Up Rate (%)	Premium per $1,000 Coverage	Coverage-to-Value Ratio	Deductible
SFSA				
Low	99.0	$2.36	0.92	$1,631
Middle	93.7	$2.94	0.96	$1,918
High	86.2	$3.79	0.96	$1,744
Total study area	95.9	$2.68	0.93	$1,748
SBSA				
Low	88.5	$2.84	1.00	$1,143
Middle	94.8	$2.73	0.95	$1,322
High	88.2	$3.22	0.95	$1,593
Total study area	90.6	$2.90	0.97	$1,320

Source: Authors.

APPENDIX D: Regression Results

The regressions used to estimate the relationship between structure risk and the various insurance market indicators of interest are reported in this appendix.

We use the following variables from the U.S. Census Bureau's ZCTA to characterize the housing stock in the ZIP code:

- the percentage of owner-occupied units that have a mortgage (Census variable B25087e2/B25002e1). Variable B25002e1 is the total number of occupied and unoccupied housing units in the ZIP code.
- the percentage of owner-occupied units that do not have a mortgage (B25087e18/B25002e1).
- the percentage of housing units for seasonal, recreational, or occasional use (B25004e6/B25002e1).[77]

Homeowners with a mortgage are required to carry homeowners insurance by their lender, so the percentage of owner-occupied units that have a mortgage is relevant to the insurance take-up rate in the ZIP code. It is also reasonable to postulate that insurance purchase and coverage decisions depend in part on whether a unit is a primary residence or for seasonal, recreational, or occasional use. We thus include the percentage of structures that are for seasonal, recreational, or occasional use in the regressions. Note that the seasonal-, recreational-, or occasional-use category includes structures with and structures without mortgages.

We also include in the regressions data from RMS on the average structure value of single-family homes in the ZIP code. Median income in the ZIP code is highly correlated with average structure value, so there was little gain from adding median income to the specification once structure value had been included. We considered added population density as a measure of urbanization in the ZIP code. However, this variable was not statistically significant in the regressions. Also, the structure-risk index picks up urbanization to some extent because the wildfire model assumes no wildfire risk in urban areas.

The unit of analysis is the ZIP code, and the regressions are run in Stata using the "regress" command (ordinary least squares).

The regression results are reported in Tables D.1 through D.4. The regressions may be interpreted as a reduced-form relationship between the endogenous variable in the supply-demand model of the insurance market (price and quantity) and the predetermined variables (wildfire risk and other ZIP code characteristics). Under reasonable assumptions about the parameters in the supply-and-demand relationships, one would expect the relationship

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[77] These three variables represent three components of the housing stock. Census data can be used to decompose the housing stock into the following five components: owner-occupied housing units with mortgages, owner-occupied housing units without mortgages; renter-occupied units; units for seasonal, recreational, or occasional-use; and other unoccupied units. Units for seasonal, recreational, or occasional use are considered unoccupied in the Census data.

between premium and wildfire risk to be positive. The relationship between quantity (in this case the take-up rate) and wildfire risk could be either positive or negative.

Table D.1: Regression Results for Market Share of Admitted Insurers and Number of Insurance Groups per 100 Policies

	Market Share of Admitted Insurers		Number of Insurance Groups per 100 Policies	
	Coefficient	95-Percent Confidence Interval	Coefficient	95-Percent Confidence Interval
Structure-risk index	–0.078**	[–0.118, –0.037]	10.7**	[1.9, 19.6]
SBSA indicator variable	–0.019*	[–0.041, 0.003]	–4.1*	[–8.9, 0.8]
Percentage seasonal	–0.027	[–0.104, 0.050]	–20.9**	[–37.7, –4.2]
Percentage owner-occupied with mortgage	0.045	[–0.032, 0.123]	–26.1**	[–42.9, –9.2]
Percentage owner-occupied without mortgage	–0.065	[–0.227, 0.096]	–17.9	[–53.1, 17.4]
Structure value of single-family homes ($ millions)	0.069	[–0.020, 0.158]	5.4	[–14.1, 24.9]
Constant	0.977**	[0.922, 1.032]	15.8**	[3.7, 27.9]
N	100		100	
Adjusted *R*-square	0.48		0.07	

Source: Authors.

* The 90-percent confidence interval does not contain zero.

** The 95-percent confidence interval does not contain zero.

Table D.2: Regression Results for Policy Nonrenewal Rates in the Admitted Market

	Insurer-Initiated Nonrenewal Rate		Insured-Initiated Nonrenewal Rate		Total Nonrenewal Rate	
	Coefficient	**95-Percent Confidence Interval**	**Coefficient**	**95-Percent Confidence Interval**	**Coefficient**	**95-Percent Confidence Interval**
Structure-risk index	0.0090*	[–0.001, 0.019]	–0.0079	[–0.023, 0.008]	0.0011	[–0.018, 0.020]
SBSA indicator variable	–0.0087**	[–0.014, –0.003]	0.0116**	[0.003, 0.021]	0.0030	[–0.007, 0.013]
Percentage seasonal	–0.0042	[–0.024, 0.015]	–0.0422**	[–0.071, –0.013]	–0.0465**	[–0.082, –0.011]
Percentage owner-occupied with mortgage	–0.0057	[–0.025, 0.014]	–0.0463**	[–0.076, –0.017]	–0.0520**	[–0.088, –0.016]
Percentage owner-occupied without mortgage	–0.0183	[–0.059, 0.023]	–0.0827**	[–0.144, –0.021]	–0.1009**	[–0.176, –0.026]
Structure value of single-family homes ($ millions)	–0.0188	[–0.041, 0.004]	0.0448**	[0.011, 0.079]	0.0260	[–0.016, 0.068]
Constant	0.0315**	[0.017, 0.046]	0.0729**	[0.052, 0.094]	0.1043**	[0.079, 0.130]
N	100		100		100	
Adjusted *R*-square	0.10		0.36		0.18	

Source: Authors.
* The 90-percent confidence interval does not contain zero.
** The 95-percent confidence interval does not contain zero.

Table D.3: Regression Results for Insurance Take-Up Rate and Premium per $1,000 Coverage in the Admitted Market

	Take-Up Rate		Premium per $1,000 Coverage	
	Coefficient	95-Percent Confidence Interval	Coefficient	95-Percent Confidence Interval
Structure-risk index	0.0243	[–0.104, 0.152]	1.042**	[0.684, 1.400]
SBSA indicator variable	–0.0246	[–0.093, 0.044]	–0.243**	[–0.439, –0.047]
Percentage seasonal	–0.4292**	[–0.685, –0.174]	1.659**	[0.980, 2.337]
Percentage owner-occupied with mortgage	0.0313	[–0.247, 0.309]	0.447	[–0.236, 1.129]
Percentage owner-occupied without mortgage	–0.2249	[–0.758, 0.308]	2.441**	[1.015, 3.867]
Structure value of single-family homes ($ millions)	0.2995**	[0.011, 0.588]	–3.337**	[–4.125, –2.547]
Constant	0.8375**	[0.653, 1.012]	3.524**	[3.035, 4.012]
N	94[a]		100	
Adjusted *R*-square	0.42		0.79	

Source: Authors.
* The 90-percent confidence interval does not contain zero.
** The 95-percent confidence interval does not contain zero.
[a] Excludes six ZIP codes with take-up rates less than 0.25 or greater than 1.5.

Table D.4: Regression Results for Coverage-to-Value Ratio and Deductible

	Coverage-to-Value Ratio		Deductible	
	Coefficient	**95-Percent Confidence Interval**	**Coefficient**	**95-Percent Confidence Interval**
Structure-risk index	–0.105*	[–0.220, 0.009]	179.2*	[–32.7, 391.2]
SBSA indicator variable	–0.025	[–0.088, 0.038]	–237.2**	[–353.4, –120.9]
Percentage seasonal	0.138	[–0.079, 0.354]	1,062.8**	[660.6, 1,465.0]
Percentage owner-occupied with mortgage	0.067	[–0.151, 0.285]	55.8	[–348.6, 460.2]
Percentage owner-occupied without mortgage	0.068	[–0.038, 0.523]	958.6**	[113.9, 1,803.3]
Structure value of single-family homes ($ millions)	–0.422**	[-0.674, –0.170]	1,571.8**	[1,104.0, 2,039.5]
Constant	1.135**	[0.979, –1.290]	736.2**	[446.6, 1,025.9]
N	100		100	
Adjusted *R*-square	0.11		0.72	

Source: Authors.
* The 90-percent confidence interval does not contain zero.
** The 95-percent confidence interval does not contain zero.

APPENDIX E: Rate Regulation

The CDI regulates insurer rate of return, as defined in Equation 1. This equation pertains to the overall rate level of the insurer's total book, not solely to high-risk policies. How this overall rate level is reflected in the premium difference between high- and low-risk properties depends on the rate relativities adopted by the insurer, as approved by the CDI.

$$(1)\ \frac{underwriting\ profit + investment\ income}{imputed\ surplus} < r^*$$

where

$$r^* = allowed\ after\ tax\ rate\ of\ return.$$

The allowed after-tax rate of return is 6 percentage points above the risk-free rate of return, or, in units compatible with Equation 1, approximately 0.08.

Underwriting profit is the difference between premiums and losses plus expenses, as shown in Equation 2. In the rate setting process, insurers, with approval from the CDI, must project anticipated losses and loss adjustment expenses during the period to be covered by the rates. For underwriting expenses, the CDI imposes an "efficiency standard" which reflects an industry underwriting expense ratio by line of business and represents the "fixed and variable cost for a reasonably efficient insurer to provide insurance and render good service to its customers."[78]

$$(2)\ underwriting\ profit = P - L - E$$

where

$$P = premium$$

$$L = losses\ (claim\ payments), claim\ adjustment\ expenses, and\ reserves$$

$$E = underwriting\ and\ other\ expenses.$$

Investment return is the return on the amount of surplus held by the insurer, loss reserves, and unearned premium reserves (Equation 3).[79] The investment return that insurers must use in the rate-approval process is specified by the CDI and is based on the mix of assets held by the insurance group. Surplus, loss reserves, and unearned premium reserves are all imputed by the CDI.

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[78] California Code of Regulations, Section 2644.12, Reinsurance, 2008.

[79] Unearned premium reserves reflect the proportion of the premium corresponding to the time remaining on an insurance policy.

(3) $investment\ income = \ y(S + R + P_u)$

where

$S = surplus$

$R = loss\ reserves$

$P_u = unearned\ premium\ reserves$

$y = projected\ yield\ on\ investments\ (e.g. 0.02).$

Substituting (2) and (3) into (1) and rearranging yields

(4) $P - L - E + y(S + R + P_u) < Sr^*$

The CDI specifies the amount of surplus that insurers are expected to hold for each dollar of premium. Inverting, this can be expressed as the leverage ratio. The leverage ratio varies by insurance line. Currently, it is 1.07 for the Homeowners Multiple Peril Line (NAIC Line 4).

(5) $l = \frac{P}{S}$

where

$l = leverage\ ratio\ (e.g. 1.07).$

Substituting (5) into (4) and rearranging yields the following upper bound on aggregate premium:

(6) $P < \frac{\left(L+E-y(R+P_u)\right)}{1-\frac{(r^*-y)}{l}}$ if $l > \ r^* - y$

As long as $l > \ r^* - y$, the allowed aggregate premium will increase if

- the allowed after-tax rate of return increases
- projected losses and expenses increase
- the surplus rises (or the leverage ratio falls)
- investment return on insurer assets falls.