

## **Multiple Hazards and Social Vulnerability Analysis**

### **Cal OES Recovery Division, Hazard Mitigation Assistance Branch**

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#### **Overview**

In this analysis, we consider five hazard types facing California communities: wildfires, earthquakes, floods, drought, and extreme heat. To identify communities that might benefit most from support to implement hazard mitigation projects, we 1) attempt to objectively estimate community exposures to each of these hazards across the state, and 2) link these estimates to measures of social vulnerability, including the Social Vulnerability Index (SVI) published by the Centers for Disease Control and Prevention (CDC) and median household income as measured in the American Community Survey.

This analysis is done at the census tract level.<sup>1</sup> All census tracts with available data are ranked from lowest to highest in terms of their overall hazard exposure and social vulnerability, and then assigned a percentile rank relative to all other census tracts in the state. This ranking ranges from zero to one, where a higher rank indicates greater estimated hazard exposure or social vulnerability. For example, if a census tract has an overall hazard percentile rank of 0.75, 75% of census tracts in the state should have lower hazard exposure than that tract and 25% should have higher exposure.

Our approach to estimating hazard exposures attempts to characterize the relative likelihood of an event occurring in a particular census tract using available data. We do not attempt to estimate the population, economic, or business damages that would result from a disaster event.

#### **Eligibility**

The key measures used to determine eligibility in this analysis are the scores across the five hazard categories, the overall hazard exposure percentile ranking, and the social vulnerability scores. Methods for calculating the five hazard percentile rankings are described below. The overall hazard exposure percentile ranking is calculated by adding the four highest hazard percentile rankings for each census tract and then ranking census tracts by this sum.

In this analysis, eligible census tracts are those that:

- Rank above the 70<sup>th</sup> percentile in terms of SVI or have a median household income of less than 80% of the state median income in 2019.

AND

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<sup>1</sup> We define census tract boundaries using 2018 TIGER/Line shapefiles published by the Census Bureau. These are based on 2010 Census geographies.

- Rank above the 85<sup>th</sup> percentile in any of the five hazard categories OR rank above the 70<sup>th</sup> percentile in overall hazard exposure OR are classified as having significant earthquake risk as described below.

## **Hazard Exposure Data**

### Wildfire

Wildfire hazard exposure is summarized as the mean current and future burn probability in each census tract. Current burn probabilities are based on the Pyrologix annual burn probability dataset. Future burn probability is calculated by averaging decadal burn probability estimates for 2020-2070 under four climate models and two climate scenarios: RCP4.5 and RCP8.5. These layers across decades and models are averaged and the final estimate takes the maximum probability across the two climate scenarios.

To rank census tracts by their overall wildfire hazard, we first ranked them by current and future burn probabilities individually and then ranked them by the sum of those individual rankings.

Sources:

- Wildfire Simulation Derived Products. "Annual decadal wildfire probability, RCP 4.5 and 8.5." Downloaded from <https://cal-adapt.org/data/download/>.
- Pyrologix California Statewide Fire Data. 2021. "Annual burn probability." Downloaded from <https://storymaps.arcgis.com/stories/32de73f1c79f80c189ccef061>.

### Flood

Flood hazard exposure is measured as the percentage of properties predicted to flood under 2020 and 2050 100-year flood scenarios. Estimates are based on the Flood Factor 1.3 model from the First Street Foundation. This data is reported at the ZIP code level, so the census-tract values used in the current analysis are based on summarizing those detailed values.

To rank census tracts by their overall flood hazard, we first ranked them by current and future flood exposures and then ranked them by the sum of those individual rankings.

Source:

- First Street Foundation. 2021. First Street Aggregated Flood Risk Summary Statistics Version 1.3. Downloaded from <https://www.arcgis.com/home/item.html?id=4df5faffaa0744349ac575940d542879>.

### Earthquake

To estimate earthquake hazard exposure, we use the annualized frequency of Minor-Damage Earthquake Shaking included in FEMA's National Risk Index. This estimate is based on a set of raster files provided to FEMA by USGS and is derived from models

used to create the 2018 USGS National Seismic Hazard Maps. Raster files were first converted to polygons and then intersected with census tract shapefiles to calculate the average probability for each census tract.

A downside of this approach is that differences in the estimated probability of an earthquake event are very small for a large percentage of all census tracts. As a consequence, percentile rankings of census tracts using this measure will tend to overstate the difference in hazard exposure between tracts with high and moderate rankings and will understate the hazard exposure for many tracts. To address this, we include an additional measure of earthquake hazard exposure: the average expected ground motion with 2% exceedance probability over 50 years derived from the California Department of Conservation Map Sheet 48. Using this measure, we classify any census tract with expected ground motion of 1 g or more to have significant earthquake hazard exposure.

Source:

- Zuzak, C., E. Goodenough, C. Stanton, M. Mowrer, N. Ranalli, D. Kealey, and J. Rozelle. 2021. National Risk Index. "Annualized earthquake probability." Federal Emergency Management Agency, Washington, DC. Downloaded from <https://hazards.fema.gov/nri/data-resources>.
- California Department of Conservation. Map Sheet 48: Earthquake Shaking Potential for California. Downloaded from <https://gis-california.opendata.arcgis.com/datasets/cadoc::cgs-map-sheet-48-earthquake-shaking-potential-for-california-revised-2016/about>

### Drought

To estimate drought exposure, we use the annualized frequency of Extreme or Exceptional drought included in FEMA's National Risk Index. This estimate is based on data from the US Drought Monitor for 2000-2017.

Source:

- Zuzak, C., E. Goodenough, C. Stanton, M. Mowrer, N. Ranalli, D. Kealey, and J. Rozelle. 2021. National Risk Index. "Annualized drought probability." Federal Emergency Management Agency, Washington, DC. Downloaded from <https://hazards.fema.gov/nri/data-resources>.

### Extreme Heat

Exposure to extreme heat is estimated as the current and future likelihood of abnormal heat events. Current exposure is based on the annualized frequency of heat waves included in FEMA's National Risk Index, which is derived from National Weather Service heat wave alerts for 2005-2017. Future exposure is based on the estimated average number of extreme heat days for 2035-2099 averaged across multiple climate models and under two future emissions scenarios: RCP 4.5 and 8.5.

To rank census tracts by their overall extreme heat exposure, we first ranked them by current and future probabilities of extreme heat events and then ranked them by the sum of those individual rankings.

Sources:

- Zuzak, C., E. Goodenough, C. Stanton, M. Mowrer, N. Ranalli, D. Kealey, and J. Rozelle. 2021. National Risk Index. "Annualized heat wave probability." Federal Emergency Management Agency, Washington, DC. Downloaded from <https://hazards.fema.gov/nri/data-resources>.
- LOCA Derived Data Products. "30-year annual average number of extreme heat days per year from 32 model maximum, RCP 4.5 and 8.5, 2035-2099." Downloaded from <https://cal-adapt.org/data/download/>.

### **Social Vulnerability**

To measure social vulnerability, we use the CDC's Social Vulnerability Index, which combines 15 measures across four themes—socioeconomic status, household composition and disability, minority status and language, and housing type and transportation. Higher values indicate greater vulnerability.

Note: two versions of the SVI are available from the CDC website, one ranking census tracts within a given geography, and one ranking tracts for the United States as a whole. In this analysis we use the former, meaning census tract percentile rankings compare all census tracts in California. This differs from the publicly-facing map published by the CDC, which compares all census tracts in the United States.

As an additional measure of social vulnerability, we identify census tracts with median household income less than 80 percent of the state median in 2019 using the American Community Survey (ACS). According to the ACS, the California median household income in 2019 was \$75,235.

Source:

- Centers for Disease Control and Prevention/Agency for Toxic Substances and Disease Registry/Geospatial Research, Analysis, and Services Program. CDC/ATSDR Social Vulnerability Index 2018 Database. California. Downloaded from [https://www.atsdr.cdc.gov/placeandhealth/svi/data\\_documentation\\_download.html](https://www.atsdr.cdc.gov/placeandhealth/svi/data_documentation_download.html).
- US Census Bureau. American Community Survey (ACS), 5-Year Estimates, 2015-2019. Downloaded from <https://www.census.gov/data/developers/data-sets/acs-5year.html>.