

# WILDFIRE RISK TO CALIFORNIA COMMUNITIES

June 30, 2021



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# 1 SUMMARY

We assessed wildfire risk to homes and communities in California as part of a larger assessment of wildfire hazard across the state. In July 2019 the Pacific Southwest Region of the U.S. Forest Service contracted with Pyrologix to conduct a spatial wildfire hazard assessment across all land ownerships. This summary of wildfire risk to California communities is the third and final part of the larger wildfire hazard assessment.

The concept of summarizing wildfire risk to housing units within a set of pre-defined communities is well-established. In 2018, Pyrologix produced a report titled “Exposure of human communities to wildfire in the Pacific Northwest” for the Pacific Northwest Region of the U.S. Forest Service<sup>1</sup>. That report identified the most at-risk communities in terms of 1) the mean risk to all housing units in a community, and 2) the cumulative risk within the community, which increases with community size (population). Following that analysis, the Wildfire Risk to Communities<sup>2</sup> project was established by the U.S. Forest Service; it produced a nationwide summary of wildfire risk to communities by generating nationally consistent web maps, summary statistics, downloadable spatial data and tables, and more for the conterminous U.S., Alaska, and Hawaii.

The wildfire hazard and risk information used in the risk to California communities analysis was produced by Pyrologix using a custom fuelscape calibrated to expected fire behavior by local experts, wildfire likelihood estimates using custom weather data for California, and custom wildfire intensity modeling based on 216 combined FlamMap fire behavior calculations using a 2-km gridded weather dataset. More information on the calibrated fuelscape methods and results can be found in the fuelscape final report<sup>3</sup>. Please reference the final hazard report for more information on the methods used to calculate wildfire likelihood and intensity measures across California<sup>4</sup>.

The results in this analysis were produced from hazard data valid for the 2020 fire season. Following the historic 2020 fire season in California, the need to update these data has been identified, and the effort to do so is already underway. Substantive edits and updates to the 2021 fuelscape are likely to change the results and shift the rank-order of the most at-risk communities across the state.

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<sup>1</sup> See report titled "Exposure of human communities to wildfire in the Pacific Northwest"

<sup>2</sup> [www.wildfirerisk.org](http://www.wildfirerisk.org)

<sup>3</sup> See report titled "A fuelscape for all land ownerships in the state of California"

<sup>4</sup> See report titled "Contemporary Wildfire Hazard across California"

## 2 ASSESSING WILDFIRE RISK TO HOMES

To assess wildfire risk to homes in California communities, we integrate two primary components of the wildfire risk framework (Figure 1): wildfire likelihood (burn probability) and wildfire consequence (the intensity of fire and the exposure and susceptibility of homes to wildfire).

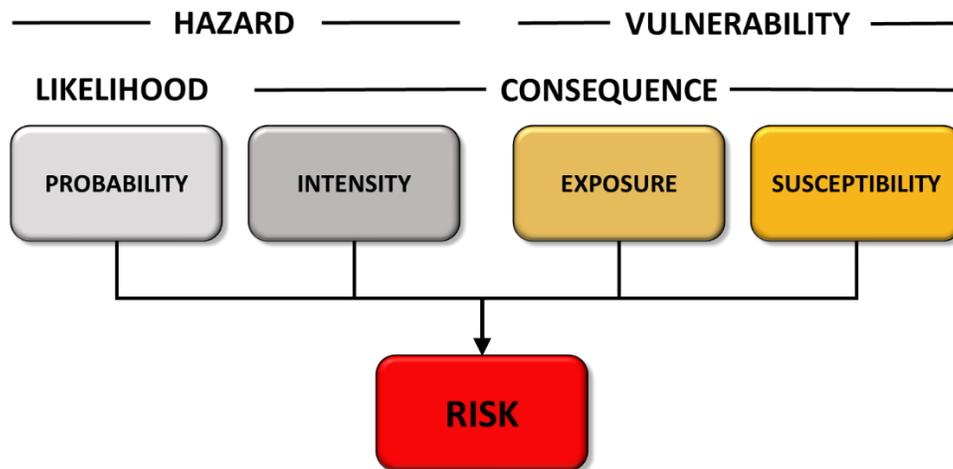


Figure 1. The main components of wildfire risk include the *probability* and *intensity* of wildfire and the *exposure* and *susceptibility* of people, assets (like homes), and resources to wildfire (see Scott and others 2013). The probability and intensity of wildfire comprise “wildfire hazard,” and the exposure and susceptibility of people, assets, and resources to wildfire comprise “vulnerability.” For this assessment, we define wildfire consequence as a function of the intensity of wildfire and the vulnerability of homes.

To begin, we first omit the “exposure” component and assess wildfire likelihood and consequence across all land exposed to wildfire in the state, whether or not homes are present. Then we later use a dataset representing the density of housing units across California to fully assess risk to homes.

For the likelihood measure, we use annual burn probability as estimated with a comprehensive fire modeling system (described in more detail below). For consequence, we use a measure called Conditional Risk to Potential Structures<sup>5</sup> (cRPS) which was developed for the Wildfire Risk to Communities project. cRPS (described in more detail below) combines fire intensity—determined from a comprehensive fire modeling application—and susceptibility. Finally, we calculate an overall measure called Risk to Potential Structures (RPS) as the product of those two measures:

$$RPS = BP * cRPS$$

This framework stops short of assessing the susceptibility of individual structures to wildfire, which would require detailed knowledge of construction materials and maintenance for individual buildings, as well as knowledge of fuel management within the home ignition zone of those buildings. Instead, home susceptibility is a rating of the general effect of fire intensity on home loss. Moreover, this assessment does not address the relative sensitivity (resilience) of different

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<sup>5</sup> “Conditional” means on the condition that a fire occurs.

households or communities to wildfire loss. We assess the only potential for wildfire loss, not the potential for recovery from it.

## 2.1 BURN PROBABILITY

This assessment relies on wildfire behavior simulations produced using a comprehensive wildfire occurrence, growth, and behavior simulation system called FSim<sup>6</sup>. The FSim modeling for California was conducted for the California Wildfire Hazard Assessment to provide reliable estimates of wildfire likelihood across the state as of the beginning of the 2020 fire season. The FSim model works by simulating 10,000 or more “iterations” to produce spatial data representing annual burn probability—the annual likelihood that a wildfire will reach a given point on the landscape. Each iteration is a possible realization of a complete calendar year. More details on the FSim methods for the California Hazard Assessment can be found in the full report.

## 2.2 CONDITIONAL RISK TO POTENTIAL STRUCTURES

For this assessment, we use an index of wildfire consequence that measures fire intensity in the context of its potential for damage to a generic residential structure. That is, we apply a stylized, generic response function (RF) to characterize the potential for housing-unit damage from wildfire as a function of fire intensity. The RF is not specific to any type of structure, construction materials, community mitigation measures, or home ignition zone fuel complexes. Instead, we simply attempt to capture the range of home losses possible at different intensities or flame lengths. The response function characterizing potential consequences to an exposed structure was applied to all exposed fuel types on the landscape regardless of whether an actual structure is present. The response function values applied are shown in Table 1.

Table 1. Table of response function (RF) values used by Fire Intensity Level (flame-length class) to calculate Conditional Risk to Potential Structures (cRPS). In a comprehensive assessment of wildfire risk to multiple resources and assets, some of which may benefit from fire, adverse fire effects are traditionally given negative response function values and beneficial fire effects are given positive values. In this case, we have only one “asset” to consider (homes), so we used all-positive response function values to simplify. This effect of wildfire on homes is adverse at any Fire Intensity Level; the larger the response-function value, the greater the potential for adverse effects.

Fire Intensity Level	Response Function value
0<FL<2	25
2<FL<4	40
4<FL<6	55
6<FL<8	70
8<FL<12	85
12<FL	100

<sup>6</sup> Finney and others 2011

A given location on the landscape can burn at a range of intensity values depending on the weather and spread direction at the time of burning. Spread direction refers to the alignment of the flaming fire front with respect to the direction of maximum spread. When aligned, fire intensity is at its peak. This occurs at the “head” of the fire, and fire simulation models inherently estimate fire intensity for the head. But the alignment of the flame front with respect to the direction of maximum spread varies around the perimeter of a fire. Fire intensity is lowest where the flame front is spreading opposite the direction of maximum spread—a backing fire.

Given the wide range of fire intensity that can be produced for the same fuel complex from different weather conditions and spread directions, the estimation of cRPS comes by first estimating the relative probabilities of the flame-length classes occurring—called flame-length probability (FLP). For a given location, the FLPs for the six Fire Intensity Levels defined above must always sum to 1 (unless the location is not exposed to wildfire).

For this assessment of risk to homes, the FLPs were developed at a 30-m resolution from the WildEST wildfire behavior results. The FLPs incorporate both variable weather conditions and variable spread directions. Please reference the full Contemporary Wildfire Hazard Across California<sup>7</sup> report for more information on WildEST methods and products.

## **2.3 RISK TO POTENTIAL STRUCTURES**

As mentioned earlier, Risk to Potential Structures (RPS) is the simple product of BP and cRPS; that is, it represents risk to homes as the product of likelihood and consequence (Figure 2). Because we map RPS across all land—not just land near homes—it can be used to assess wildfire risk in places where development may be considered but is not yet built.

This RPS dataset is the foundation for the summaries of wildfire risk to homes found in Section 4. It incorporates spatial data regarding the fire environment—fuel, weather, and topography—as well as spatial and temporal data regarding historical wildfire occurrence. The fuelscape dataset used for this assessment includes the effects of wildfires that occurred through 2019, so it represents conditions as they existed at the beginning of the 2020 fire season.

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<sup>7</sup> <http://pyrologix.com/reports/Contemporary-Wildfire-Hazard-Across-California.pdf>

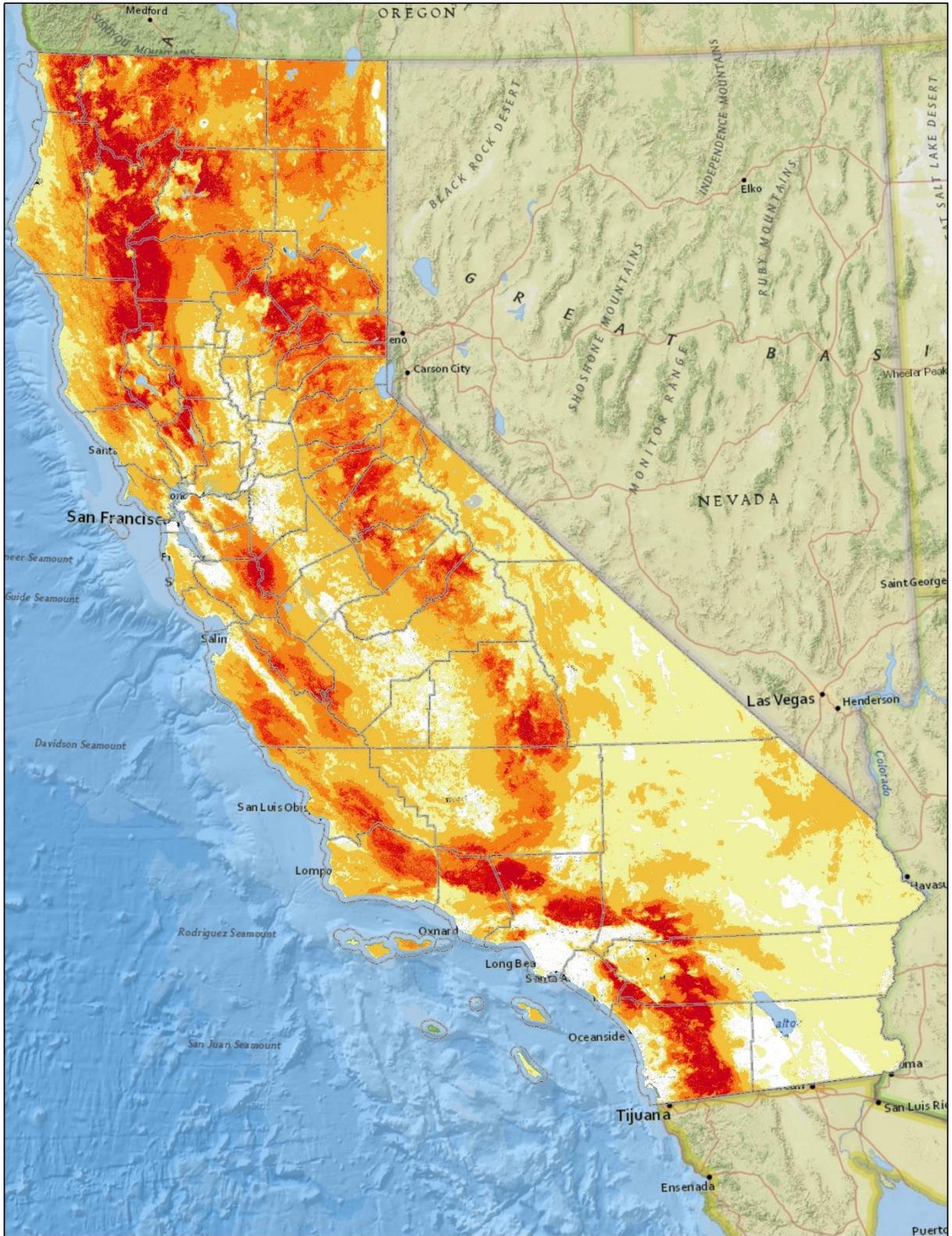


Figure 2. Circa 2020 Risk to Potential Structures across all land in California. Areas represented in white are not exposed to wildfire (more than 900 m from burnable land cover). All lands are included in this map, whether or not homes are present.

## 3 HOUSING-UNITS AND COMMUNITIES

### 3.1 HOUSING UNITS

A spatial dataset of housing-unit density<sup>8</sup> covering the nation was produced by the Wildfire Risk to Communities Project ([www.wildfirerisk.org](http://www.wildfirerisk.org)). Housing-unit density (HUDen) was generated using population and housing-unit count data from the U.S. Census Bureau, building footprint data from Microsoft, and land cover data from LANDFIRE. Building footprints were assigned population and housing-unit counts based on the population estimates of the Census block unit, then smoothed to create raster data at 30-m resolution. The nationally available HUDen raster was modified slightly for California (Figure 3) to match the projection of the hazard data and to correct an omission of building footprints in the Microsoft dataset<sup>9</sup>.

We converted housing-unit density values to housing-unit count for a summary in this assessment. Summing the housing-unit (and population) count values for all locations in a named community provides an estimate of the total number of housing units (and population) in the community.

For this assessment, housing units were considered *directly* exposed to wildfire if they were located on burnable land cover<sup>10</sup>. Housing units were considered *indirectly* exposed to wildfire if they were located on nonburnable land cover (other than open water and ice) but within 900 m of burnable land cover.

### 3.2 CALIFORNIA COMMUNITIES

We wished to summarize wildfire risk to homes within named communities across California. For these summaries, we defined a “community” as a geographic area (and the population and housing units contained within it) defined by proximity to a U.S. Census Bureau Populated Place Area (PPA). PPAs consist of incorporated places (cities and towns) plus unincorporated Census Designated Places (CDPs). There are 1,521 PPAs across California (32% are cities and towns; 68% are CDPs).

The U.S. Census Bureau maintains a polygon dataset representing both incorporated places and CDPs. The CDP polygons are generally drawn to capture areas of locally concentrated population, but they omit most outlying homes that may otherwise be considered part of the “place”. We refer to the U.S. Census PPA delineation as the community “core”.

To include the population and housing units surrounding the PPAs, Bunzel, and others<sup>11</sup> used a travel-time analysis to delineate the land areas closest by drive-time to each PPA core, up to a

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<sup>8</sup> Scott and others 2020

<sup>9</sup> Building footprints were missing from the available dataset for an area near Lompoc, California. To correct this, we generated HUDen for the areas of missing building-footprint data by assuming that population and housing units were uniformly distributed within census blocks in this area.

<sup>10</sup> Burnable and nonburnable land cover is characterized by the LANDFIRE Remap 2016 FBFM40 data layer ([www.landfire.org](http://www.landfire.org)), with minor calibration edits informed by local expert knowledge. Burnable land cover includes land covered by grasses, forbs, shrubs, tree litter, understory trees, or logging slash. Nonburnable land cover includes urban areas, irrigated agricultural land, permanent snow or ice, bare ground, and open water.

<sup>11</sup> Bunzel and others 2021

maximum of 45 minutes travel time (Figure 4). Approximately 99.9 percent of California's total housing-unit count (as estimated by HUDen) can be found within these expanded community boundaries. Less than 0.1 percent of California's housing units are not within a community boundary (that is, they are more than 45 minutes of drive-time from any PPA).

Eight communities were removed from the final summary spreadsheet due to the very low estimated population count (less than 4 persons). The low population counts did not permit accurate measurement of hazard and risk to exposed population/housing units.

Although this document refers only to this dataset of named communities, we also generated summaries of wildfire risk to homes in:

- Counties
- County subdivisions
- ZIP codes

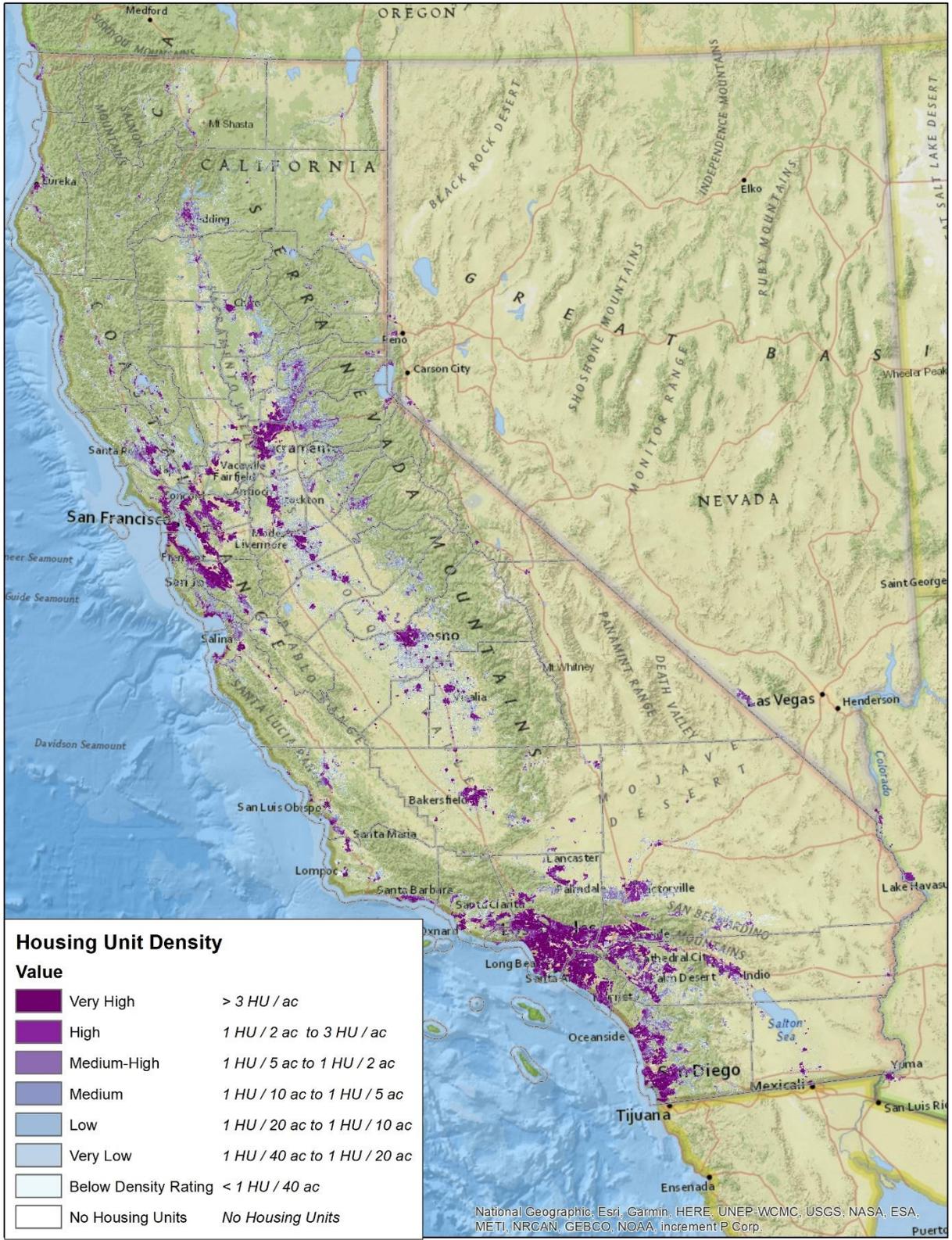


Figure 3. Housing-unit density across California.

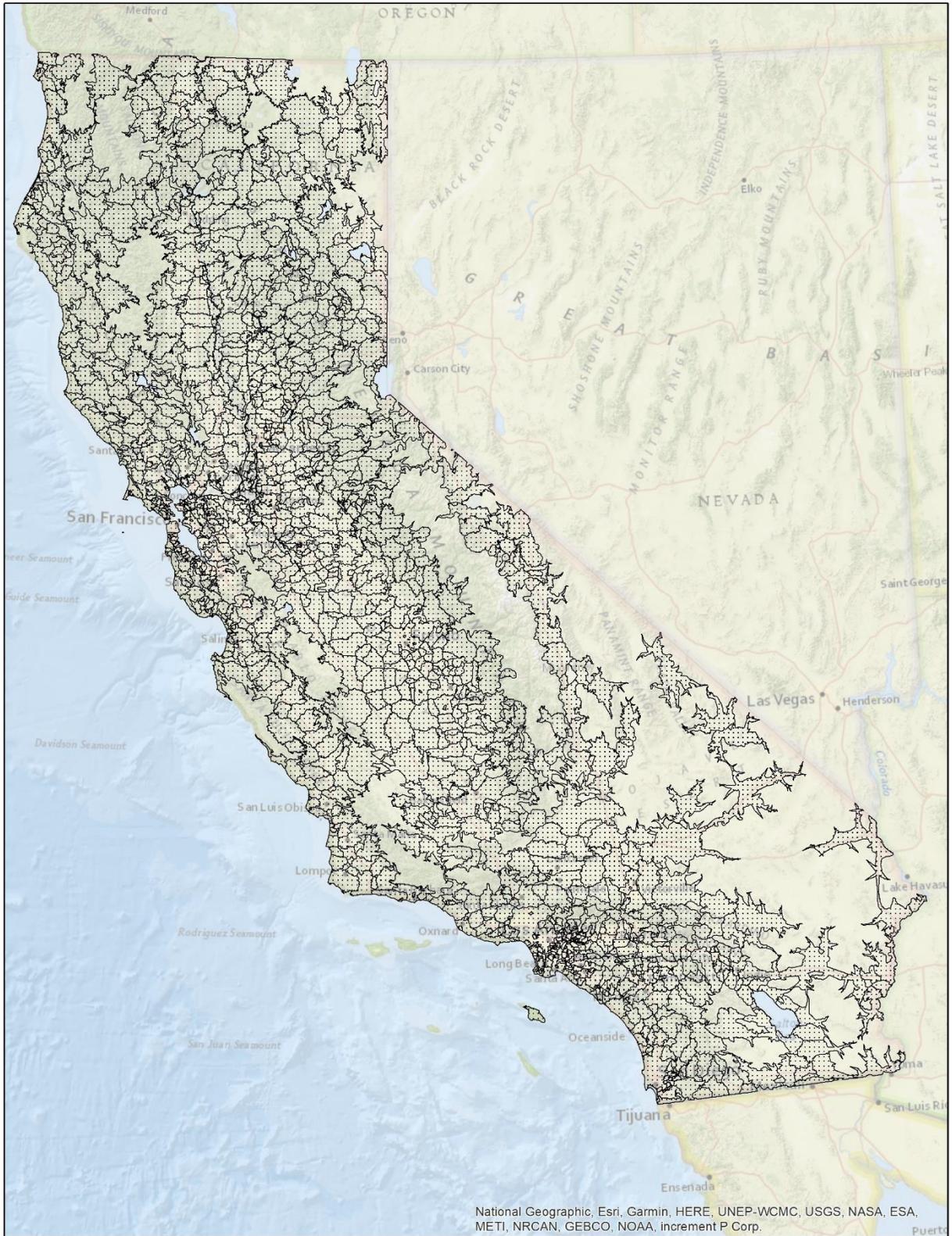


Figure 4. "Expanded" community polygons across California. Less than 0.1% of California housing units are found outside one of these community polygons.

## 4 WILDFIRE RISK TO EXISTING HOMES

Section 2.3 describes the methods used to map Risk to Potential Structures across California (Figure 2). For summarizing risk to existing homes, we masked out all areas of the state with no wildfire exposure or no housing units present (Figure 5). This dataset indicates where homes are exposed to wildfire, and their relative wildfire risk.

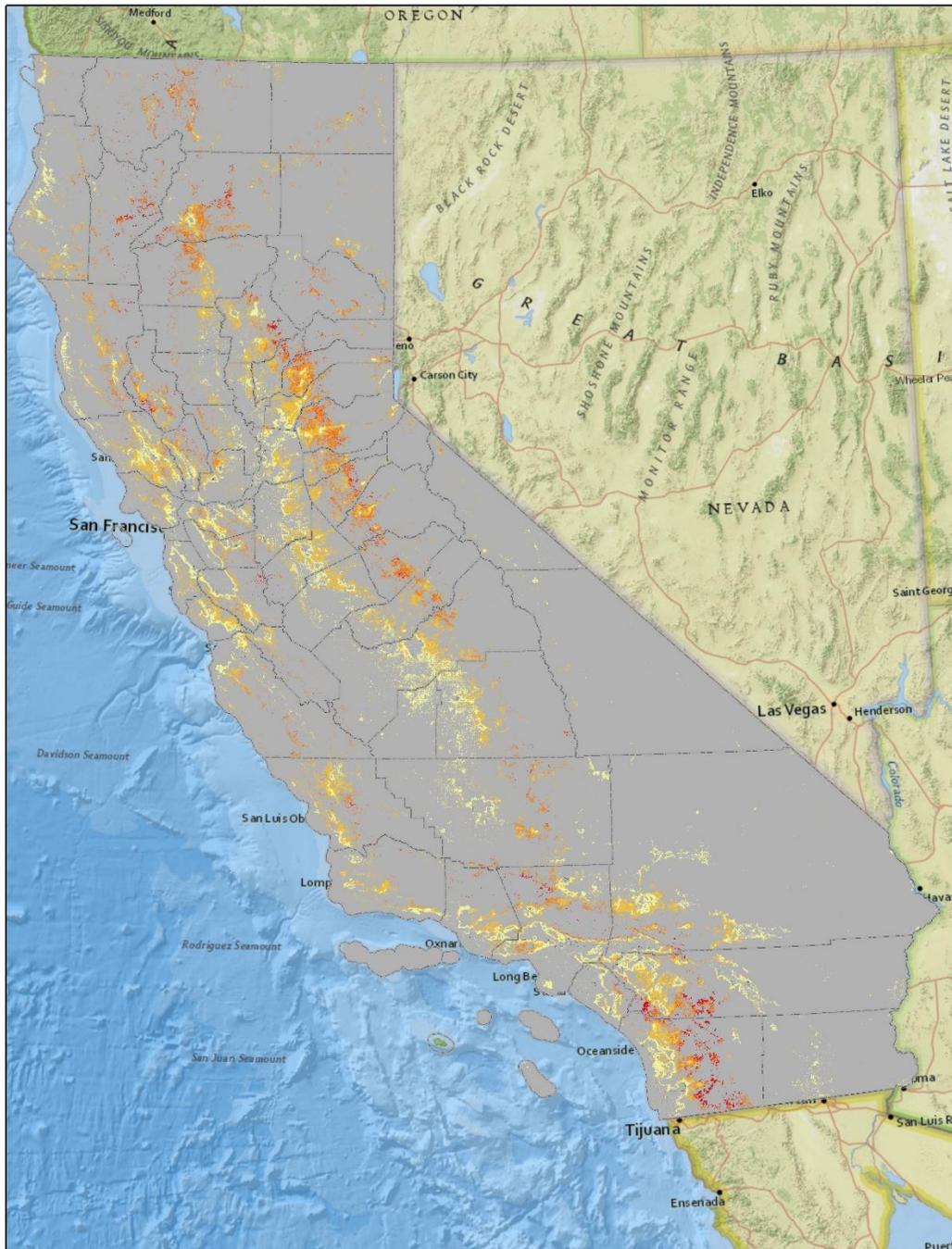


Figure 5. Risk to Potential Structures (RPS) map for California, showing where homes are present (housing-unit density is greater than zero).

#### 4.1 MEAN RPS WHERE HOMES EXIST

We calculated the mean RPS where exposed housing units are located within each community (as defined in Section 3.2). Nonexposed housing units—typically within the urban core of a community—were not included in the calculation of mean RPS. This measure represents the mean risk—likelihood and consequence—in the populated areas of a community. The higher this value, the greater the risk an average housing unit within the community will experience. Mean RPS where homes exist is not a cumulative measure for a community, so it does not necessarily increase as the population or number of housing units increases. Instead, this measure is sensitive to the general location of a community within the RPS map and the populated areas within each community.

Ranking communities by Mean RPS highlights the communities with the greatest average potential for wildfire losses but does not consider the population or number of housing units residing in the community. The rating provides information useful in prioritizing mitigation efforts, i.e. this community is at greatest risk of loss. But without the magnitude of wildfire impacts, the scope of needed mitigation is unknown.

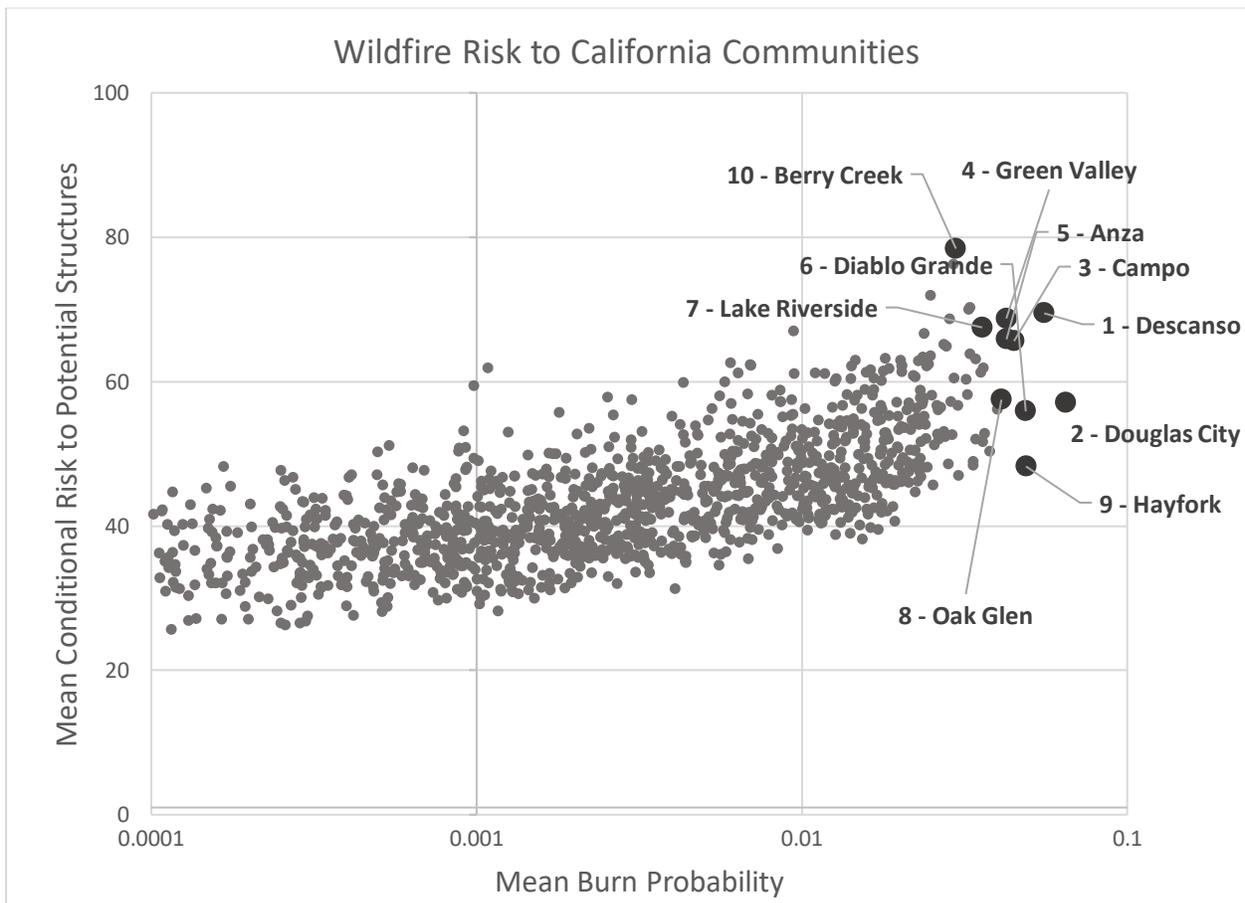


Figure 6. Semi-log plot of Mean Burn Probability and Mean Conditional Risk to Potential Structures - the components of mean Risk to Potential Structures.

Figure 6 graphically displays the ranking of RPS in terms of the component variables BP and cRPS. Descanso, a Census Designated Place in San Diego County, is the community whose mean risk to homes is highest, even though other communities have a higher BP or a higher cRPS. For example,

Douglas City, ranked 2<sup>nd</sup> for overall risk to homes, has the highest average BP of all communities. Berry Creek, ranked 10<sup>th</sup> for overall risk to homes, has the highest average cRPS.

A complete tabulation of the top 25 most at-risk communities as measured by Mean RPS is found in Table 2 below.

## 4.2 CUMULATIVE ANNUAL WILDFIRE RISK TO HOUSING UNITS

The product of housing-unit count and RPS is called annual wildfire risk to housing units, or just housing-unit risk (HURisk). This raster layer incorporates all of the risk elements, including burn probability and fire intensity, as well as structure susceptibility as characterized by the response function (Table 1) and exposure by identifying where homes are along with an estimated count in each pixel (Figure 3). It takes *both* the presence of non-zero burn probability and intensity and the presence of housing units to have a value of HURisk greater than zero.

Summing HURisk within each community polygon provides a measure of cumulative wildfire risk to each community. Because HURisk includes housing-unit count in addition to RPS, it is in part dependent on the “size” of a community—the population or number of housing units (Figure 7).

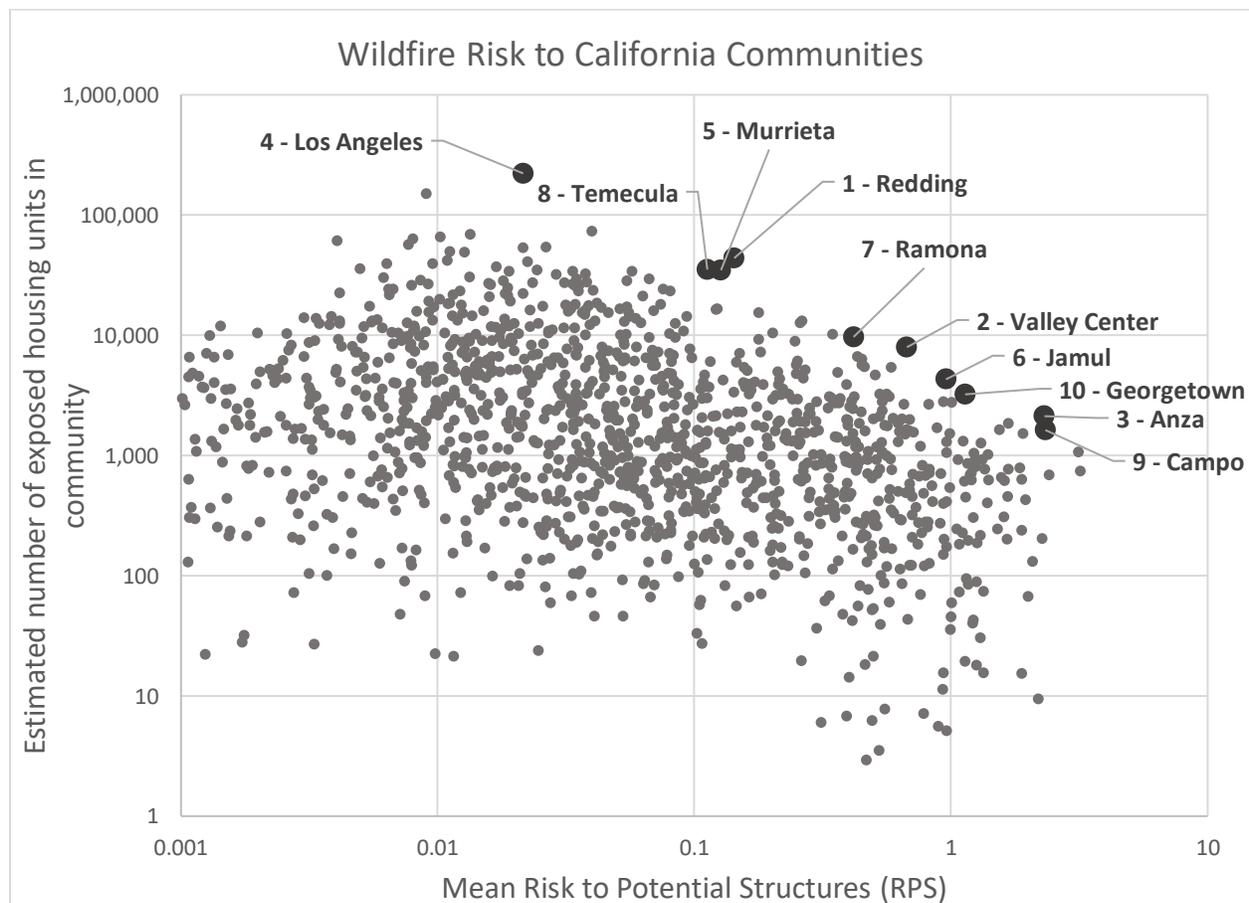


Figure 7. Log-log scatterplot of Mean Risk to Potential Structures (RPS) and number of exposed housing units per community.

The expanded zone around Redding, an incorporated city at the northern end of the Sacramento Valley, has the greatest cumulative wildfire risk to homes of any Populated Place Area in California (Table 3), despite not having the highest Mean RPS or number of exposed housing units (an estimated 48,482 exposed housing units). For example, the City of Los Angeles, ranked 4<sup>th</sup> for cumulative housing-unit risk, has only moderate Mean RPS but the greatest number of exposed housing units of any community in California (an estimated 1,453,466 exposed housing units). Likewise, Campo, a CDP in southeastern San Diego County and ranked 9<sup>th</sup> for cumulative housing-unit risk, has among the highest Mean RPS scores of any community, but is of modest size (1,627 exposed housing units).

A complete tabulation of the top 25 most at-risk communities as measured by Mean RPS is found in Table 3 below.

Table 2. The top 25 communities as ranked by greatest mean Risk to Potential Structures (RPS) near where structures are found in the community.

Community Name	HU count	Fraction HUcount directly exposed	Fraction HUcount indirectly exposed	Fraction HUcount not exposed	Exposed HU count	Mean RPS all exposed	Rank Mean RPS (of 1513)	Percentile Mean RPS	Expected annual HU risk	Rank Expected annual HU risk	Fraction direct expected annual HU risk	Fraction indirect expected annual HU risk
Descanso	1077	85.9%	14.1%	0.0%	1,077	3.85	1	100.0%	3,375	13	88.0%	12.0%
Douglas City	750	86.7%	13.3%	0.0%	750	3.69	2	100.0%	2,384	28	86.5%	13.5%
Campo	1627	78.8%	21.2%	0.0%	1,627	2.94	3	100.0%	3,797	9	80.6%	19.4%
Green Valley	430	65.8%	34.2%	0.0%	430	2.91	4	99.9%	838	132	69.3%	30.7%
Anza	2124	87.0%	13.0%	0.0%	2,124	2.80	5	99.9%	4,914	3	87.9%	12.1%
Diablo Grande	307	98.8%	1.2%	0.0%	307	2.72	6	99.9%	375	290	98.6%	1.4%
Lake Riverside	797	88.4%	11.6%	0.0%	797	2.41	7	99.9%	1,469	54	89.4%	10.6%
Oak Glen	779	87.4%	12.6%	0.0%	779	2.35	8	99.9%	1,301	66	87.8%	12.2%
Hayfork	1855	80.6%	19.4%	0.0%	1,855	2.35	9	99.8%	3,094	16	85.8%	14.2%
Berry Creek	693	99.1%	0.9%	0.0%	693	2.33	10	99.8%	1,666	44	99.2%	0.8%
Robinson Mill	205	98.7%	1.3%	0.0%	205	2.30	11	99.8%	462	244	98.7%	1.3%
Tobin	9	67.7%	32.1%	0.0%	9	2.27	12	99.8%	21	964	67.2%	32.8%
Pine Valley	812	64.6%	35.4%	0.0%	812	2.23	13	99.8%	1,011	101	65.7%	34.3%
Julian	1657	83.4%	16.6%	0.0%	1,657	2.23	14	99.8%	2,552	25	87.0%	13.0%
Alleghany	67	94.2%	5.8%	0.0%	67	2.22	15	99.8%	134	523	93.9%	6.1%
Lakeland Village	5535	31.1%	68.6%	0.3%	5,519	2.16	16	99.7%	2,535	26	53.4%	46.6%
Aguanga	1526	85.5%	14.5%	0.0%	1,526	2.15	17	99.7%	2,901	18	85.6%	14.4%
Potrero	658	78.8%	21.2%	0.0%	658	2.09	18	99.7%	1,032	97	79.2%	20.8%
Montgomery Creek	241	95.2%	4.8%	0.0%	241	1.94	19	99.7%	454	248	95.7%	4.3%
Round Mountain	638	95.3%	4.7%	0.0%	638	1.92	20	99.7%	1,199	74	95.8%	4.2%
Coffee Creek	202	87.3%	12.7%	0.0%	202	1.92	21	99.6%	333	318	89.4%	10.6%
Coulterville	309	86.8%	13.2%	0.0%	309	1.89	22	99.6%	495	234	89.3%	10.7%
Kennedy Meadows	16	97.5%	2.5%	0.0%	16	1.87	23	99.6%	29	900	97.6%	2.4%
Groveland	458	86.1%	13.9%	0.0%	458	1.85	24	99.6%	758	149	88.2%	11.8%
Downieville	228	73.5%	26.5%	0.0%	228	1.79	25	99.6%	252	370	74.2%	25.8%

Table 3. The top 25 most at-risk communities as ranked by expected annual housing-unit risk.

Community Name	HU count	Fraction HUcount directly exposed	Fraction HUcount indirectly exposed	Fraction HUcount not exposed	Exposed HU count	Mean RPS all exposed	Rank Mean RPS (of 1513)	Percentile Mean RPS	Expected annual HU risk	Rank Expected annual HU risk	Fraction direct expected annual HU risk	Fraction indirect expected annual HU risk
Redding	51,674	36.8%	57.0%	6.2%	48,482	1.143732	178	92.6%	6,271.58	1	76.1%	23.9%
Valley Center	7,951	84.3%	15.7%	0.0%	7,951	1.725129	100	96.0%	5,353.65	2	88.5%	11.5%
Anza	2,124	87.0%	13.0%	0.0%	2,124	3.919739	5	99.9%	4,914.45	3	87.9%	12.1%
Los Angeles	1,453,466	4.6%	17.1%	78.3%	315,130	0.486861	425	80.0%	4,780.89	4	46.1%	53.9%
Murrieta	44,229	19.7%	75.8%	4.6%	42,213	2.455077	36	98.4%	4,421.45	5	65.3%	34.7%
Jamul	4,296	67.2%	32.8%	0.0%	4,296	1.970994	75	96.9%	4,107.95	6	86.4%	13.6%
Ramona	9,691	60.3%	39.7%	0.0%	9,691	2.097573	60	97.5%	4,046.75	7	84.3%	15.7%
Temecula	50,377	21.4%	61.8%	16.8%	41,905	1.317036	150	93.7%	3,947.65	8	66.0%	34.0%
Campo	1,627	78.8%	21.2%	0.0%	1,627	4.314169	3	100.0%	3,796.58	9	80.6%	19.4%
Georgetown	3,223	94.1%	5.9%	0.0%	3,223	1.142984	180	91.9%	3,658.58	10	95.7%	4.3%
Diamond Springs	10,310	77.6%	22.4%	0.0%	10,310	0.759487	296	86.6%	3,553.07	11	93.6%	6.4%
Wildomar	13,357	35.2%	64.8%	0.0%	13,357	3.300740	13	99.7%	3,477.95	12	68.3%	31.7%
Descanso	1,077	85.9%	14.1%	0.0%	1,077	4.219531	4	99.9%	3,374.60	13	88.0%	12.0%
Red Bluff	13,224	45.6%	54.4%	0.0%	13,224	0.840590	264	89.1%	3,266.61	14	81.1%	18.9%
Cottonwood	5,438	73.3%	26.7%	0.0%	5,438	1.070950	200	91.3%	3,172.43	15	87.1%	12.9%
Hayfork	1,855	80.6%	19.4%	0.0%	1,855	3.456666	11	99.7%	3,094.48	16	85.8%	14.2%
Santa Clarita	85,933	20.4%	77.9%	1.7%	84,472	0.779982	290	86.8%	2,933.34	17	40.6%	59.4%
Aguanga	1,526	85.5%	14.5%	0.0%	1,526	3.281952	14	99.5%	2,901.29	18	85.6%	14.4%
Nevada City	6,415	83.0%	17.0%	0.0%	6,415	1.027456	214	90.5%	2,875.50	19	96.6%	3.4%
Alpine	6,670	58.8%	41.2%	0.0%	6,670	2.628624	20	99.2%	2,873.79	20	80.4%	19.6%
Bootjack	2,775	97.1%	2.9%	0.0%	2,775	0.916421	244	89.5%	2,791.09	21	97.3%	2.7%
Grass Valley	15,468	56.1%	43.9%	0.0%	15,468	0.610235	358	83.4%	2,741.13	22	86.8%	13.2%
Bella Vista	2,833	86.3%	13.7%	0.0%	2,833	1.455132	133	94.9%	2,636.38	23	88.5%	11.5%
Yreka	5,698	42.0%	58.0%	0.0%	5,698	2.009983	70	97.1%	2,557.29	24	68.9%	31.1%
Julian	1,657	83.4%	16.6%	0.0%	1,657	2.323968	42	98.3%	2,551.79	25	87.0%	13.0%

### 4.3 ADDITIONAL SUMMARY ZONES

In addition to the Community Zone polygons, we also summarized risk and exposure for the following sets of polygons:

- California Counties
- California County Subdivisions
- California Zip Codes

Summary spreadsheets for all four sets of polygons are available. To obtain these summaries, please contact Patrick Doyle (patrick.doyle@usda.gov) of the U.S. Forest Service or Joe Scott (contact@pyrologix.com) of Pyrologix.

### 4.4 FULL ATTRIBUTE LIST

This report highlights two measures of wildfire risk to homes in California Communities, but a whole host of additional metrics are provided in each of the zone summary sheets. Below is a listing of those additional attributes.

**GEOID** - unique code for joining attributes to spatial data.

**Community Name**<sup>12</sup> - the name of the Census Populated Place area within the Expanded Community zone.

**Fraction Water Area** - proportion of the zone covered by water.

**Fraction Burnable Area** - proportion of the zone covered by burnable fuel types.

**Fraction Nonburnable Area** - proportion of the zone covered by nonburnable fuel types.

**Population Count** - the sum of population count (derived from POPden) for all pixels in the summary zone.

**Fraction POPcount directly exposed** - proportion of the population located on burnable fuel types.

**Fraction POPcount indirectly exposed** - proportion of the population located on nonburnable fuel, but *within* 900 m of burnable fuel.

**Fraction POPcount not exposed** - proportion of the population located on nonburnable fuel *beyond* 900 m of burnable fuel or located on water/ice.

**Expected annual Pop exposure** - the estimated number of people likely to be exposed annually to wildfire in the zone. This is calculated as the product of POPcount and burn probability.

**Fraction annual Pop exposure directly exposed** - proportion of the population exposure located on burnable fuel types.

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<sup>12</sup> In the other polygons sets, this field is replaced with the County Name, County Subdivision Name, or ZIP code.

**Fraction annual Pop exposure indirectly exposed** - proportion of the population exposure located on nonburnable fuel *within* 900 m of burnable fuel.

**HUcount** - the sum of housing-unit count (derived from HUden) for all pixels in the summary zone.

**Fraction HUcount directly exposed** - proportion of the housing-unit count located on burnable fuel types.

**Fraction HUcount indirectly exposed** - proportion of the housing-unit count located on nonburnable fuel *within* 900 m of burnable fuel.

**Fraction HUcount not exposed** - proportion of the housing-unit count located on nonburnable fuel (*beyond* 900 m of burnable fuel or located on water/ice).

**Exposed HUcount** - the count of housing units located on directly- and indirectly exposed pixels in the zone.

**Mean BP all exposed** - the sum of burn probability (BP) on pixels with exposed housing units, divided by the number of pixels with exposed housing units.

**Rank Mean BP** - number rank of mean BP in the polygon area relative to other summary polygons (#1 means highest mean BP in the summary area).

**Percentile Mean BP** - mean BP percentile rank relative to the amount of exposed HU count with the summary area. The percentile value between communities is influenced by the number of exposed housing units in the community.

**Mean BP direct exposed** - the sum of burn probability (BP) on pixels with directly exposed housing units, divided by the number of pixels with directly exposed housing units.

**Mean BP indirect exposed** - the sum of burn probability (BP) on pixels with indirectly exposed housing units, divided by the number of pixels with indirectly exposed housing units.

**Mean cRPS all exposed** - the sum of cRPS on pixels with exposed housing units, divided by the number of pixels with exposed housing units.

**Rank Mean cRPS** - number rank of mean cRPS in the polygon area relative to other summary polygons (#1 means highest mean cRPS in the summary area)

**Percentile Mean cRPS** - mean cRPS percentile rank relative to the amount of exposed HU count with the summary area. The percentile value between communities is influenced by the number of exposed housing units in the community.

**Mean cRPS directly exposed** - the sum of cRPS on pixels with directly exposed housing units, divided by the number of pixels with directly exposed housing units.

**Mean cRPS indirectly exposed** - the sum of cRPS on pixels with indirectly exposed housing units, divided by the number of pixels with indirectly exposed housing units.

**Mean RPS all exposed** - the sum of RPS on pixels with exposed housing units, divided by the number of pixels with exposed housing units.

**Rank Mean RPS** - number rank of mean RPS in the polygon area relative to other summary polygons (#1 means highest mean RPS in the summary area)

**Percentile Mean RPS** - mean RPS percentile rank relative to the amount of exposed HU count with the summary area. The percentile value between communities is influenced by the number of exposed housing units in the community.

**Mean RPS directly exposed** - the sum of RPS on pixels with directly exposed housing units, divided by the number of pixels with directly exposed housing units.

**Mean RPS indirectly exposed** - the sum of RPS on pixels with indirectly exposed housing units, divided by the number of pixels with indirectly exposed housing units.

**Expected annual HU risk** - the cumulative exposure of housing-unit risk on an annual basis, calculated as the sum of the product of RPS and HU count raster layers.

**Rank Expected annual HU risk** - number rank of expected annual HU risk in the polygon area relative to other summary polygons (#1 means highest expected annual HU risk in the summary area).

**Fraction direct expected annual HU risk** - proportion of the expected HU risk located on burnable fuel types.

**Fraction indirect expected annual HU risk** - proportion of the expected HU risk located on unburnable fuel types *within* 900m of burnable fuel types.

## 4.5 SPATIAL INEQUALITY OF WILDFIRE RISK TO HOMES

The Pareto Principle, sometimes called the **law of the vital few**, is the notion that relatively few *numbers* of things (say, 20% of them) often account for a majority of their *cumulative effects* (like 80%). This is sometimes also called the 80/20 rule because it is often the case that 20% of *things* account for 80% of effects. This notion stems from a strongly unequal contribution of each *thing* to effects.

This concept has been applied to the distribution of income (and wealth) among the members of a nation or community. To visualize—and eventually quantify—this inequality, Max O. Lorenz developed what is now known as a Lorenz Curve, which plots the cumulative number of people on the X-axis (sorted from least wealthy to most), and their cumulative wealth on the Y-axis.

We examined whether there existed a *spatial* inequality in wildfire risk to wildfire-exposed homes<sup>13</sup> in California by plotting a Lorenz Curve with the cumulative count of housing units on the X-axis and their cumulative annual housing unit risk on the Y-axis (Figure 8). Indeed, we see a strongly unequal distribution of risk among existing homes in California—the 15% most at-risk housing units account for 85% of the total housing-unit risk. This is simply a result of inherently high spatial variability in Risk to Potential Structures.

At first glance this result could suggest an efficiency in mitigating wildfire risk to homes—if we target just those 15% of homes, we can mitigate 85% of the risk. That seems very efficient. But the 15% of homes located in the highest RPS portions of populated areas of the state tend to occur at low housing-unit densities, so the land area where these 15% of homes is large (Figure 9). Moreover, these most at-risk homes are located in all corners of the state from the Oregon border to the border with Mexico, and from near the Nevada state line to the Pacific Ocean.

In the end, despite the concentration of risk on relatively few housing units, the risk to those housing units is spatially dispersed around the state.

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<sup>13</sup> Nonexposed homes in the urban cores of large cities were not included in this graph; those would make the distribution even more unequal.

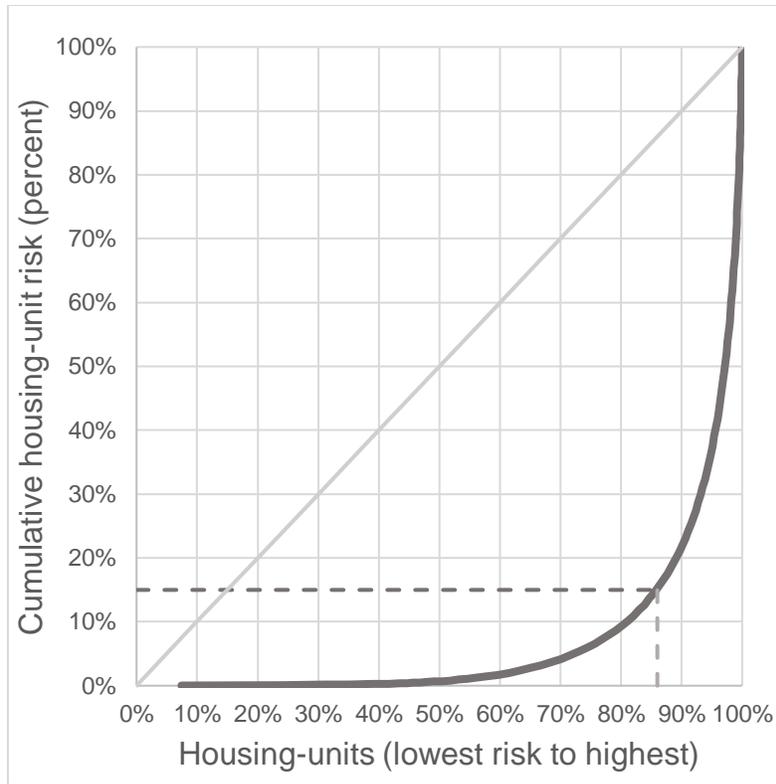


Figure 8. Lorenz Curve illustrating the spatial inequality of wildfire risk to homes in California. Locations with housing units exposed to wildfire were sorted from lowest to highest Risk to Potential Structures (X-axis). The Y-axis represents the cumulative risk to housing units with a lower risk than the X-axis. This is a “Lorenz Curve” that illustrates how a small fraction of the housing units accounts for a majority of the overall risk. In this case, 85% of the least-exposed housing units account for only 15% of the cumulative risk. The converse is also true—the 15% most at-risk housing units comprise 85% of the cumulative risk.



Figure 9. The blue-shaded areas of California represent where an estimated 85% of the cumulative housing-unit risk exists, yet only 15% of the exposed housing units. Because these housing units are relatively low density, they cover a significant fraction of the land area where exposed housing units exist.

## 5 CONCLUSIONS AND SUMMARY

The first step toward mitigating wildfire risk to homes is knowing where to start. This assessment provides foundational information that should prove useful to a variety of organizations charged with mitigating wildfire risk to homes by allowing them to prioritize the most at-risk communities and locations on the landscape. For this application, the community-mean RPS summary is best—it highlights the communities with high exposure to wildfire, even if the population is low. Moreover, the tabular datasets available include information about direct versus indirect home exposure, meaning that prioritization can be further refined based on direct versus indirect risk to homes<sup>14</sup>.

The data provided may also help in the allocation of mitigation resources. For that, the cumulative risk to homes can provide a guide because it incorporates the “size” of a community—population or housing units—in addition to its exposure to wildfire. A low-population high-priority community may not need as much mitigation effort (funding) as a lower priority but higher population community.

The wildfire hazard simulations used in this report inherently incorporate the spatial and temporal trends in fire occurrence that have been taking place in California over the period 1992-2017<sup>15</sup>. During that time, the expected annual area burned has been increasing across the state, but not uniformly. The Northern Coast mountains and Klamath region exhibited the greatest increase in fire occurrence over that time, followed by the Sierra Nevada. As a result, land in the northern part of the state now has RPS scores as high as—and higher than—southern California, which has traditionally been thought to have the greatest risk to homes in the state.

However, comparatively few homes exist in the riskiest parts of northern California, whereas many homes exist in the risky portions of southern California. These trends are reflected in the ranking of communities by mean RPS (Table 2), which now has a mix of communities in all parts of the state. Among the top 10 most at-risk communities, Douglas City and Hayfork are found in the Klamath region and Berry Creek in the Sierra Nevada, with the remainder being found south of the San Francisco Bay area.

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<sup>14</sup> The mitigation strategies differ between those two exposure types. Homes with direct exposure to wildfire may require significant fuel management in the home ignition zone in addition to home hardening against embers. Homes with indirect exposure to wildfire may need far less fuel management (they are estimated to be on nonburnable land cover) but could still require home hardening against embers or home-to-home spread.

<sup>15</sup> Please see the report “Contemporary Wildfire Hazard across California” for full details.

# THANK YOU

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