California Wildfires:

A Demographic Time Bomb That Has Exploded

TransRe

We value risk.

March 2020

Insight Into Wildfire

The wildfire exposure of the Western United States (California, Oregon, Colorado and Nevada) has increased as the population in the wildland-urban interface has grown. This paper focuses on how demographic changes and climate changes impact one state, California.

Approximately 90% of US wildland fires are caused by people (according to the U.S. Department of Interior). The other 10% are started by lightning, lava etc. Several environmental factors affect wildfire behavior – including atmospheric conditions, fuel supply and topography. The factors are highly variable, but when combined they create dangerous conditions that make wildfire behavior difficult to predict.

We observe Californians relocating from expensive, urban areas to more rural locations. Whether due to cost of living, or quality of life, this population shift means greater human development around a natural catastrophe exposure.

In addition, California's average temperature remains consistently above historical averages. Elevated temperatures bring extended droughts. Droughts kill vegetation (brush and trees). Dead vegetation fuels fires. Extended dry seasons overlap with seasonal winds to fan those fires. Westward winds then push the fires through exposed areas faster.

Wildfires are a global, not just national issue. Changing climate conditions and human development trends remain key factors in wildfire generation and impact. Further study of the implications of these changes is required to improve the responses to the issue.

Proactive Wildfires Exposure Management

2019 conditions still favored wildfires, and there were many ignitions.

In October 2019, PG&E took preventive measures and de-energized its grid, to avoid arcing and equipment failures during high wind events.

PG&E cut power to ~800,000 electric and gas customers in nine counties (all except San Francisco) of the Bay Area and in 34 counties in total.

Source: San Francisco Chronicle

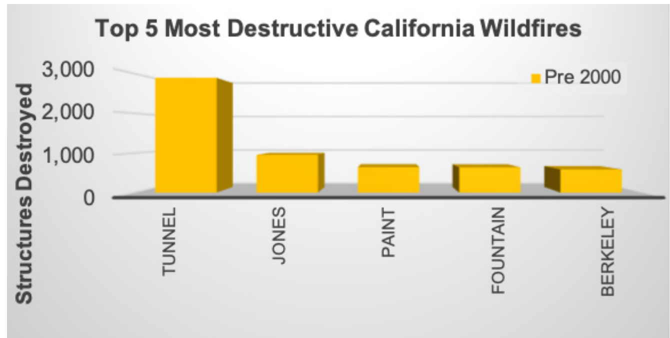
California’s Wildfire History

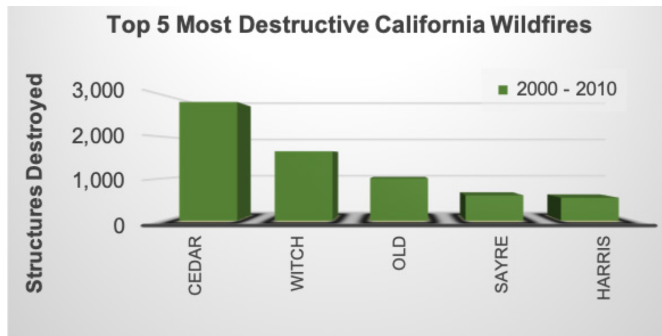
The Western US is prone to wildfires. In general it receives enough precipitation to support the growth of vegetation, but also extended warm, dry summers. This combination delivers an ample growing season to accumulate fuels and then dries them out.

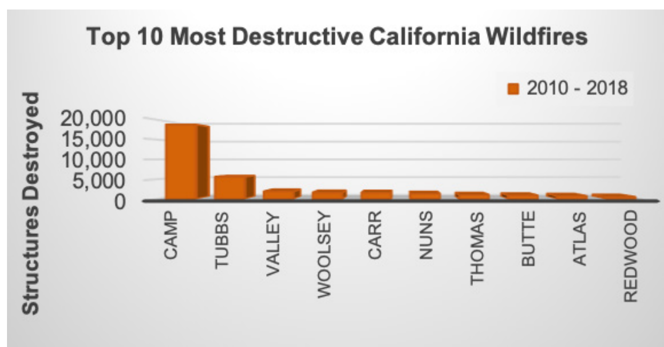
The region’s mountain ranges also produce strong wind patterns that fan the flames and spread the fires.

The fires are not new, but the noted change of average temperature and the changes to human habitation have increased the values exposed and the losses experienced:

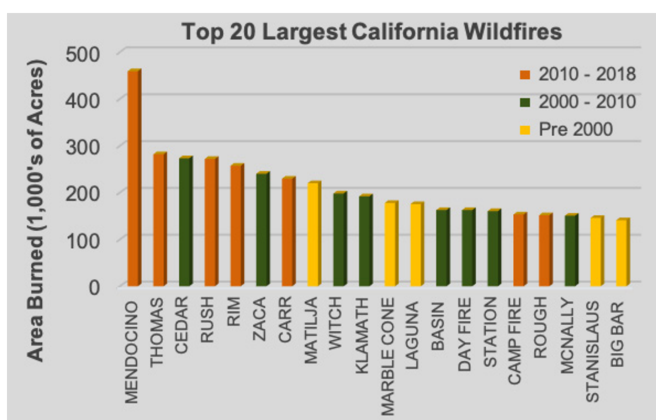
- The 1936 wildfire season ranks 3rd in acres burned, but total damage was ~6% of the 2018 season.
- The 2018 season surpassed 2017 in total acres burned, and structures destroyed.
- Eight of the most destructive fires occurred in the last two years.
- Seven of the 10 most destructive fires have occurred since 2009.
- Given recent data, we estimate likely average annual damage will be $2 billion per year.







Source: [Top 20 Most Destructive California Wildfires]



Source: [Top 20 Largest California Wildfires]

California's Recent History

The extreme drought from 2011-15 killed many trees. The 2016-17 winter was the rainiest for 100 years, which led to additional vegetation growth.

That intense wet season was followed by another intense drought in 2017-18, which included a number of record-breaking heat waves. The dry season extended deeper into fall, which meant an overlap with the wind season. New vegetation died back and added "fuel" to the fires.

Intense Winter Rains = Accelerated underbrush growth ▶ **Dry/Hot Summer = Vegetation dies, extra fuel** ▶ **Long Dry Season = Overlap with wind season**

Cal Fire reports that 260,000 acres burned in 2019, compared to 1,670,000 acres in 2018, although the number of ignitions increased slightly.

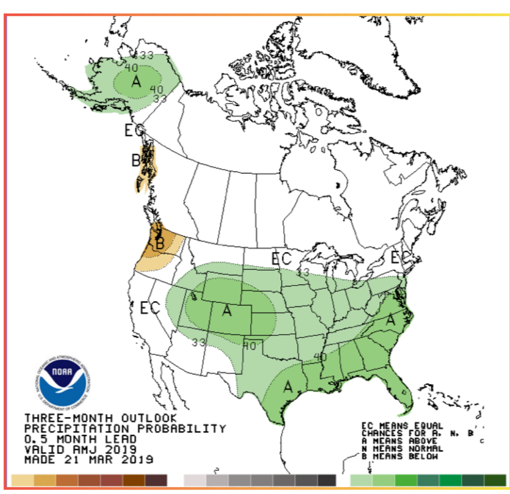
Source: [CAL Fire]

2019 US Precipitation & Temperature Forecast

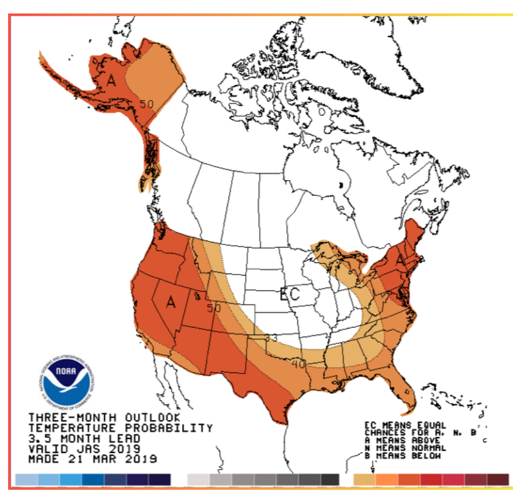
- Above average rainfall during winter 2019
- California had average rainfall in spring 2019
- Summer 2019 was hot and dry

One rainy season grows fuel for a few years' worth of wildfires

Spring Precipitation



Summer Temperature



Source: [NOAA National Weather Service, Climate Prediction Center]

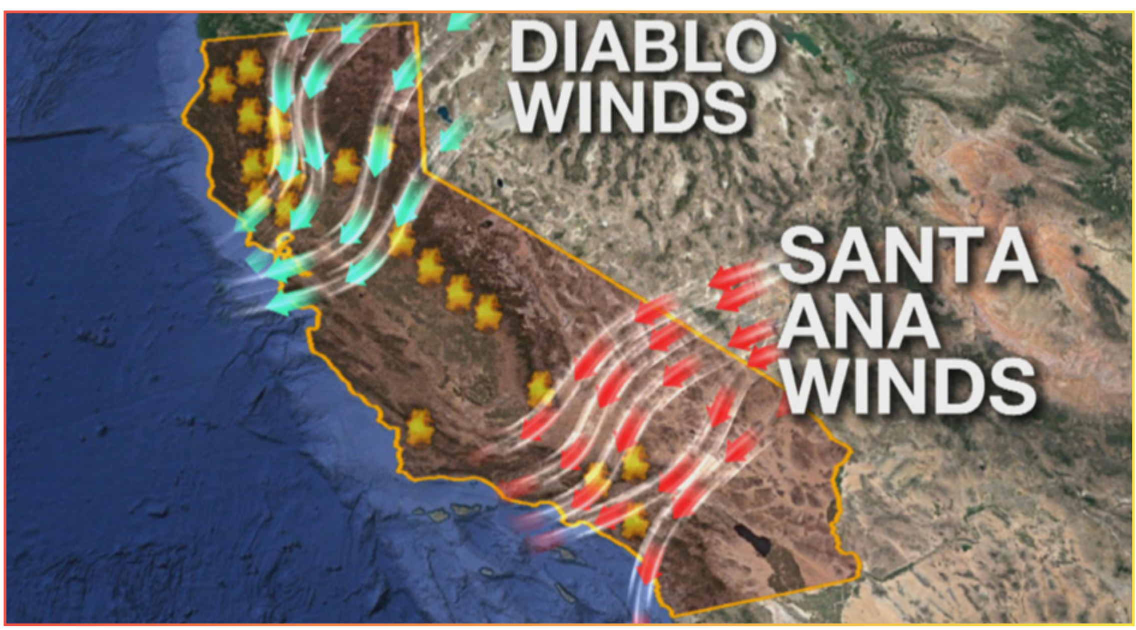
The Impact of Diablo & Santa Ana Winds

Summer fires (June-September) can occur anywhere in the state but typically target more wild and remote areas where summer temperatures have dried out accumulated woody debris. These fires also tend to burn more slowly.

Diablo and Santa Ana wind-driven fires (October-April), strike more developed areas along the coast (San Diego, Los Angeles, San Francisco Bay Area, Santa Barbara, Napa, etc.) and tend to burn faster. These type of fires can be economically devastating.

- Diablo winds occur during spring and fall and impact Northern California
- Santa Ana winds occur during fall and impact Southern California
- Both are westward – they push warm, dry air down from the mountains toward the coast. This fans the flames for fast-growing fires, as they hit already dry areas and carry fires forward.

Over the past 100 years, the summer and wind-driven fires have increased in frequency and severity. This suggests that climate changes have made an already warm, dry California more conducive to fires.



Source: CBS News

Exposure and Climate: Case Studies

Fire	Acres Burned	Destroyed Structures	PCS ($bn)
Tubbs (2017)	36,807	5,636	8.5
Hanley (1964)	53,000	156	N/A

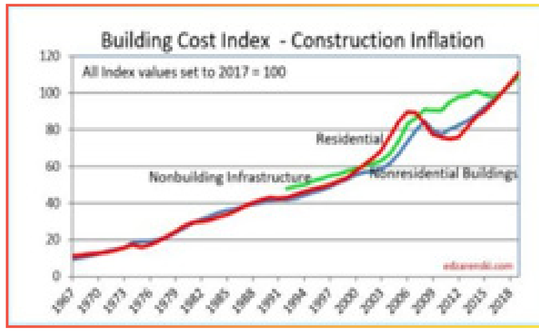
Source: Top 20 Most Destructive California Wildfires
Source: Marin County Fire History

Exposure Growth
1964 vs. 2017 Case Study

The Hanley Fire (1964) occurred in the same area of Northern California as the Tubbs Fire (2017).

- Hanley's burn scar was 43% larger than Tubbs.
- However, because of lower population density, fewer buildings were affected.

In the last 50 years, hundreds of thousands of homes have been built in the area. The result is a much more significant reconstruction cost.



Source: Construction Inflation

Exposure growth and climate change are key ingredients for wildfires

Climate Impact
1985 vs. 2017 Case Study

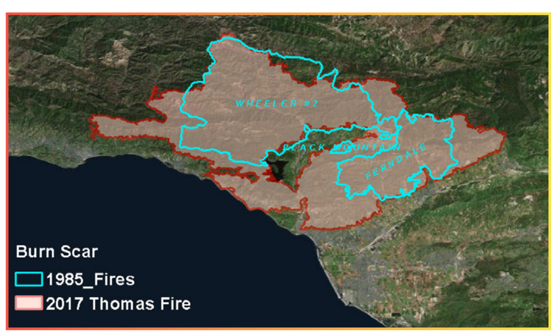
The Thomas Fire (2017) demonstrates the impact of a warmer climate.

In 1985, three fires occurred in the same area as the Thomas Fire, but yet the acres burned (in a three months span) was less than from the Thomas Fire. Why?

- Early end to rainy season disrupts wildland management
- Extended dry season limits controllable fire
- Extended dry, hot weather into fall overlaps with Diablo and Santa Ana wind seasons, which allows fire to spread faster

Fire	Acres Burned	Destroyed Structures	PCS ($bn)
Thomas (2017)	281,893	1,063	2.2
Wheeler #2 (1985)	126,854	124	N/A
Wheeler #2 (1985)	1,250	N/A	N/A
Ferndale (1985)	46,724	N/A	N/A

Source: Top 20 Most Destructive California Wildfires
Source: Remembering the 1985 Normal Heights fire



Source: TransRe
Source: Monitoring Trends in Burn Severity (MTBS)

Lack of Rainfall Increases Wildfire Risk

California has had eight periods of drought in the past 100 years (highlighted in lighter blue/orange in the graphs below). Three of those drought periods have occurred in the past 20 years.

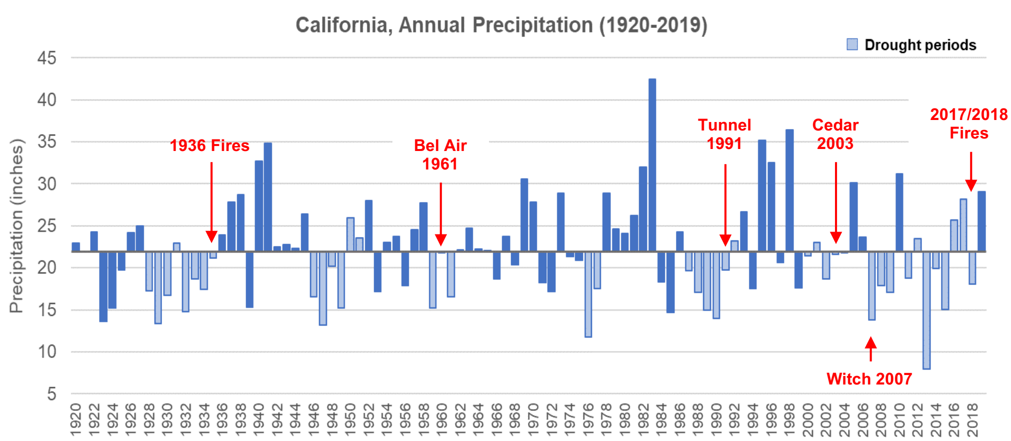
A majority of these events transpired after few consecutive years of below average rainfall.

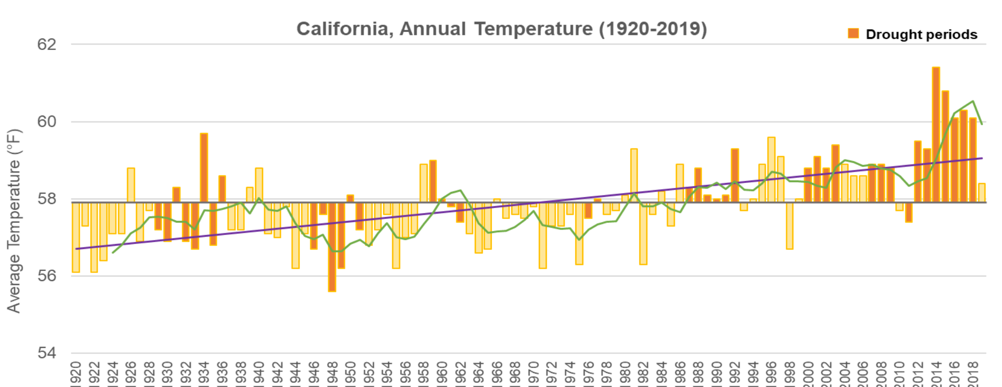
Period	Average Precipitation	Average Temperature
1920-2019	21.9 in	57.9° F
1980-2019	22.4 in	58.3° F
2000-2019	20.9 in	59.2° F

Data from below graphs **Source: TransRe**

Wildfire Facts

- Temperature and moisture are strong predictors of wildfire risk variability
- The lack of precipitation defines drought duration and severity
- Temperature has amplified drought severity in the past 20 years – California sees much hotter and drier temperatures
- There has been a 2.3% increase in average temperature since 1920





Source: [NOAA National Centers for Environmental information, Climate at a Glance]

California's Wildland-Urban Interface (WUI)

WUI is where development meets (interface) or is intermingled with (intermix) wildlands.

Traditionally wildfires impacted intermix areas.

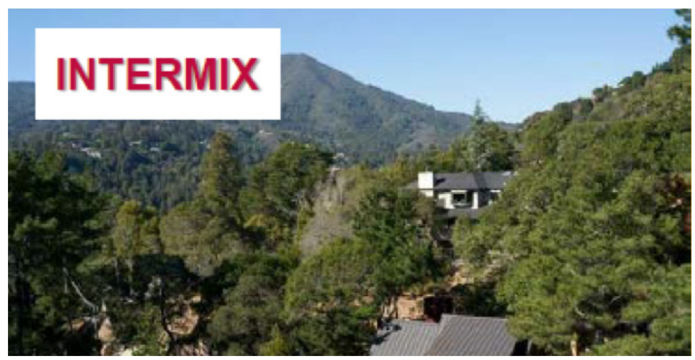
Today we see more interface fires, which can cause more urbanized damage.

California's WUI housing growth was more than 40% between 1990 and 2010. In Northern California that tends to be more interface exposure, whereas Southern California tends to have high-value properties intermixed in the WUI.

Communities in areas prone to wildfires must proactively prepare for wildfires, to protect lives, homes and infrastructures.

Source: PNAS

Source: Georgia Forestry Commission



Source: FIREsafe Marin

Based on 2010 Census, approximately 30% of all housing units in California are in WUI areas.

Source: U.S. Census Bureau

Region	% in WUI
Northern California	35%
Southern California	28%
Overall	31%

Source: TransRe

WUI Category	Risk count
Interface	84%
intermix	16%

Source: TransRe

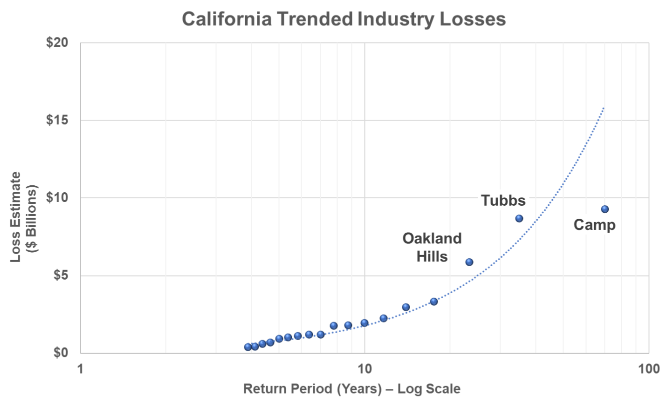
WUI Category	Density	Risk count
Interface	Low	1%
	Medium	27%
	High	57%
Intermix	Low	5%
	Medium	10%
	High	1%

Source: TransRe

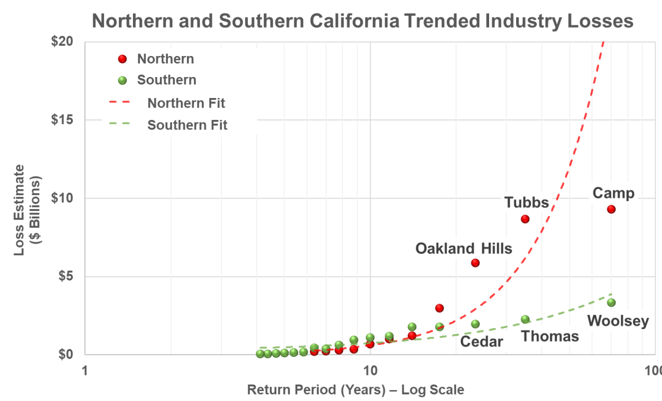
California's History of Wildfire Losses

The North and South suffer separately, with Northern fires (Camp, Tubbs, Oakland Hills) dominating the tail. The different topography can impact fire suppression.

Northern California also has more WUI interface exposure.



Source: TransRe



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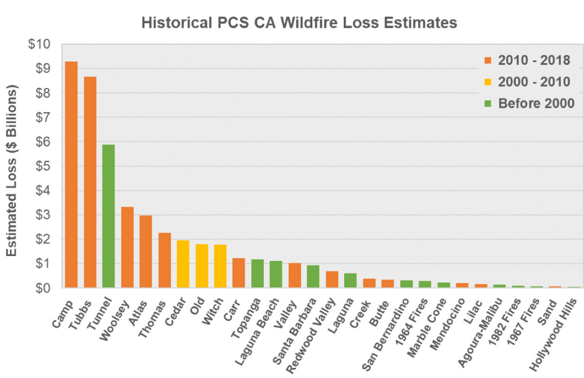


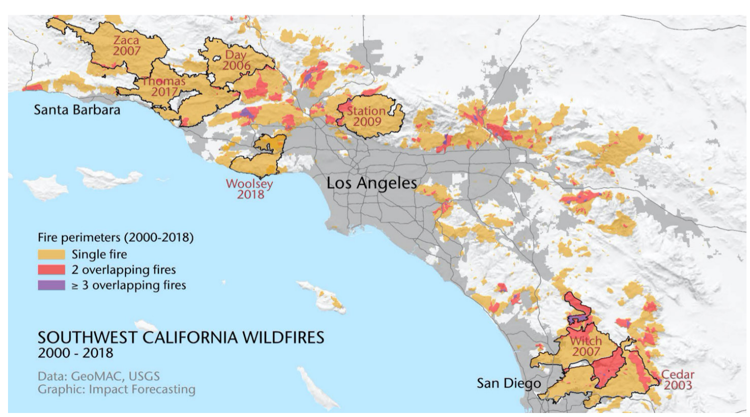
Source: TransRe

Before 2017, the Oakland Hills Fire (1991) was considered an outlier. Recent events have shown that is no longer the case.

Southwest California's Wildfire History

Although NorCal's fires are considered more destructive, Southwestern California is also very susceptible to wildfires, as the history of fire burn scars shows.

- Expect exposures to grow further into WUIs in the future
- Expect longer dry seasons to overlap with Santa Ana wind season more often



Source: Steve Bowen, Director & Meteorologist I Head of Catastrophe Insight at Aon

Current Models and Market Concerns

TransRe's View of the Models

The US Forest Service developed physical models (FSim) to provide realistic depictions of fire behavior and loss potential.

A simulation system developed by the USFS generates thousands of years of wildfire parameters across the US – both fire intensity and likelihood. The models need to be adjusted to better address urban conflagration, smoke and ember risks.

Vendor models use these USFS models as a base for their views of risk. It captures realistic patterns of burn severity, the impact of different fuel types (fine vs. coarse) and fire activity.

Differences between the vendor models include:

- Event definition (fire cluster, hours-clause, radius)
- Capturing the intricate movement of fire through the WUI
- Modeling fire spread (ember and smoke risks)

Source: [Department of Forestry and Fire Protection, Local Responsibility Area (LRA)]

Case Study: Camp Fire – A Unique risk?

Northern California's Camp Fire (November 2018) burned for over two weeks and destroyed over 150,000 acres. It is the deadliest and most destructive wildfire in California to date.

Based on relative building footprint exposure (shown below) a study by RisQ on municipal securities shows that 400 California cities are at risk of a Camp Fire-equivalent.

There is a 7% annual chance of an event as devasting as the Camp Fire.

If California's long drought continues, that probability will grow.

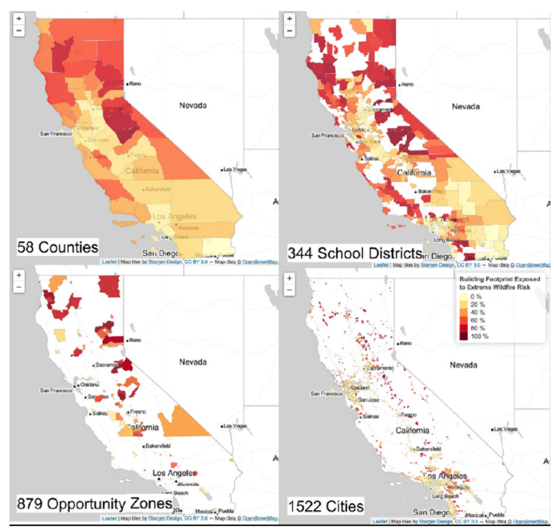


Figure 1- Building footprint exposed to extreme wildfire risk comprehensively for four different spatial jurisdiction types.

Source: [The Bond Buyer]

The map to the left indicates the areas where fire hazard is highly severe (in red) to moderately severe (in pale yellow).

TransRe's
Key Takeaways

The Wildfire Risk Landscape is Changing

- **Exposure changes (e.g. WUI growth and density)**
- **Hazard (e.g. forest vulnerability due to drought cycles)**
- **Weather volatility is increasing due to changing climate**
- **Changes in wildland fire management policies**

Our Challenges

- **Anticipating the effects of climate change is very difficult (wind remains a primary driver of fast moving fires)**
- **Manage volatility, but avoid biases**
  - **Determine if the 2017 and 2018 wildfires are anomalous, or do they indicate a new climate pattern/shift**
- **Capture physical correlation of risk**
  - **Use tools that can capture small to medium scale hazards**
  - **Persistent drought, fuel accumulation, pattern driving wind events, etc.**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