



[4] US wildfires: anthropogenic climate change and risks for utilities in fire-prone areas

Given the collapse in PG&E stock in the wake of two severe wildfire seasons, we wanted to assess risks that such catastrophic events recur in the future. In other words, were 2017 and 2018 anomalous fire seasons, or are such risks something that investors need to be mindful of in the future? Based on the latest research, owning utilities in fire-prone areas looks to be fraught with risk that isn't going away.

PG&E's market capitalization after two years of wildfires

US\$ billions

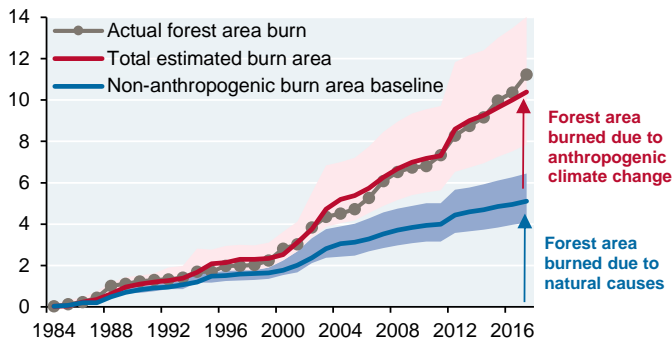


Source: Bloomberg. March 13, 2019.

Recent wildfire research attempts to identify the degree to which man-made climate change contributes to forest fire activity. The approach: use historical data to determine a “non-anthropogenic baseline”, which is the amount of hectares that would probably have burned anyway absent any climate change, and due to natural causes. One recent example comes from a 2016 paper from researchers at Columbia’s Lamont Doherty Earth Observatory and the University of Idaho. Their “natural burn area” baseline is shown in blue; the gray dots show the actual amounts burned; and the red line shows the estimated total burn area. As you can see, **total hectares burned were roughly double their “natural” baseline estimate.**

Climate change responsible for a doubling of burn area

Millions of hectares of US forest fires, cumulative

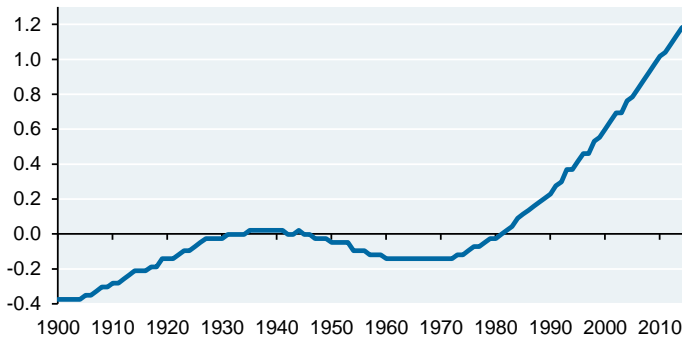


Source: Abatzoglou and Williams. 2016. Shaded areas are 95% confidence intervals.



Here’s another look. The first chart shows an estimate of the increase in temperature in Western forest regions due to human activities. The recent temperature increase corresponds to an increase in the “**fuel aridity**” of Western forests (fuel aridity is a blend of different combustibility measures that rise as climate impacts intensify²⁴). As the fuel aridity of Western forests rose, the hectares of US forests that burned in wildfires rose as well, and by an exponential amount as the Y axis is in log scale (second chart). These charts illustrate the connection many forestry scientists see between man-made climate change (which drives up fuel aridity) and wildfire severity.

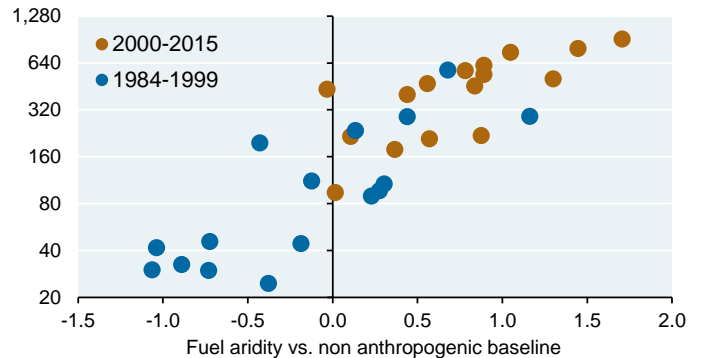
Estimated temperature change in Western forest region due to human activities, Degrees Celsius



Source: Abatzoglou and Williams. 2016.

US forest fire area versus fuel aridity by year

Forest fire area, thousands of hectares



Source: Abatzoglou and Williams. 2016.

Climate change is not the only way that humans affect wildfire severity; humans also start a lot of fires, whether intentionally or not. When looking at the numbers of fires and at the number of hectares burned, humans account for 84% of the former and almost half of the latter. Natural causes such as lightning account for the rest. The table below is for the period 1992-2012; fire frequency peaked around 1980, and has been declining since due to fewer instances of arson, fewer controlled burns becoming uncontrolled, and fewer cigarette ignitions.

Humans start most fires and account for almost half of all forest area burned

	Number of fires			Area burned (hectares)		
	Human	Lightning	Human %	Human	Lightning	Human %
Mediterranean California	87,274	2,855	97%	2,143,282	253,210	89%
Northern Forests	61,673	2,574	96%	302,561	82,721	79%
Eastern Temperate Forests	815,499	44,859	95%	3,827,045	829,293	82%
Marine West Coast Forests	14,586	925	94%	19,251	27,291	41%
Great Plains	134,944	17,586	88%	3,992,557	2,564,955	61%
Southern Semiarid Highlands	7,504	2,167	78%	340,873	254,418	57%
Tropical Wet Forests	4,832	1,917	72%	357,150	350,477	50%
North American Desert	55,422	52,044	52%	2,394,677	8,880,691	21%
Northwest Forested Mountains	76,735	94,017	45%	1,895,622	5,731,733	25%
Temperate Sierras	13,607	26,502	34%	754,393	1,152,064	40%
Total Continental US	1,272,076	245,446	84%	16,027,412	20,126,852	44%

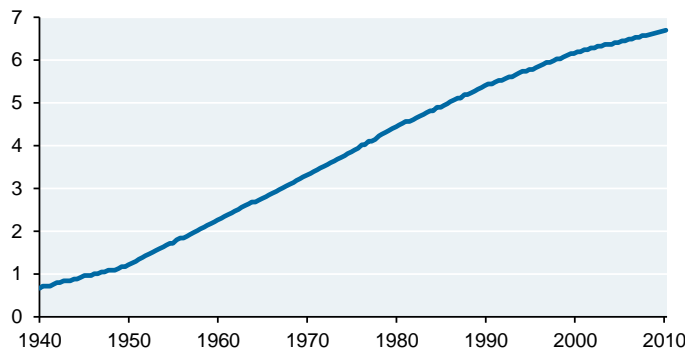
Source: Balch et al University of Boulder, January 2017, for the period 1992-2012.

²⁴ **Fuel aridity** is a composite based on 8 measures of potential forest fire risk and intensity: the energy release component, the Fire Weather Index, the vapor pressure deficit, the climatic water deficit, the Palmer drought severity index, the Forest Fire danger index, the Keetch–Byram drought index and reference potential evapotranspiration.



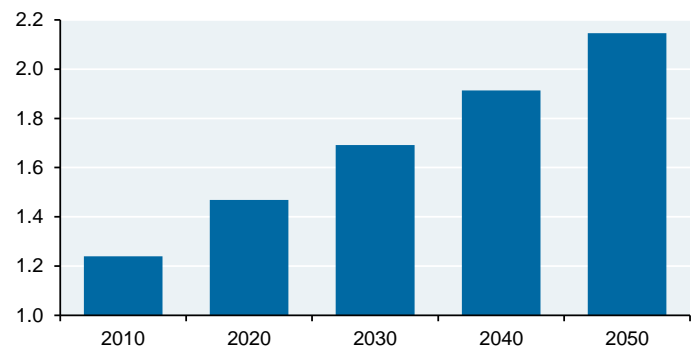
Part of the reason for the increase in wildfires and the resulting economic damages: **increased housing growth in fire-prone areas, and an increase in fire suppression policies.** The number of US homes and land area prone to wildfire impacts has increased by nearly 1350% since 1940. The first chart shows the number of homes in the Western US deemed to have “medium to very high” fire risk. A recent study looked at California specifically and future housing settlement in fire prone areas. The authors estimate that California’s residential development will replace nearly 12 million acres of forests and agricultural lands by 2050, increasing the number of houses in “very high” wildfire severity zones by nearly 1 million.

Total homes located in "medium to very high risk" wildfire zones in western US, Millions of homes



Source: Strader (Villanova), *Natural Hazards*. 2018.

California homes located in "very high risk" wildfire zones Millions of homes

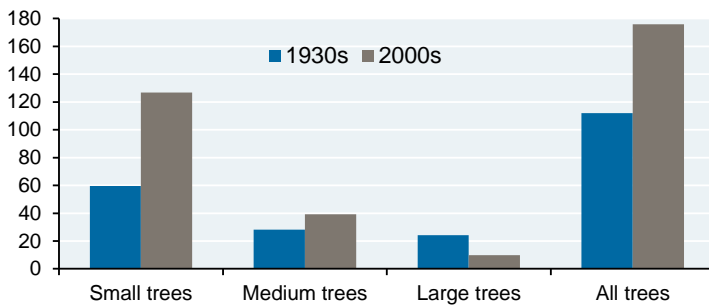


Source: Mann et al. 2014. Chart depicts "Rural Growth" scenario.

On **fire suppression**: in some fire suppressed ecosystems, certain shade-intolerant and more fire-resistant species such as Ponderosa pine can be outcompeted by shade-tolerant and less fire-resistant species such as Douglas fir. The result: a less fire-resistant forest. And by contributing to buildup of woody debris, these ecosystems are at risk of high-intensity “catastrophic” fires and soil erosion. As shown below, some forests in Northern California have become much denser since the 1930’s, reflecting *in part* the impact of fire suppression approaches. To be clear, the 1940-1980 cool/wet period in the West also contributed to denser forests of smaller trees since there were fewer wildfires and more moisture for tree regeneration²⁵.

California Headwater forests have become denser

Trees per acre



Source: Public Policy Institute of California, UC Berkeley. 2017. Survey regions include Sierra Nevada highlands and southern Cascade ranges. Trees are categorized as small if they are 4-12 inches diameter at breast height, medium at 13-24 inches and large over 24 inches.

²⁵ Ponderosa pine and western larch may suffer 50% of their circumference damaged by fire and survive whereas other tree species such as Douglas fir may die with only 25% of their circumference damaged. Sources for this section include the University of Montana College of Forestry and Conservation, and the Montana State University Forest Ecology and Management department.



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