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Climate Change Increases the Risk of Wildfires

ScienceBrief Review **September 2020 update**

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This ScienceBrief Review is part of a collection on Critical Issues in Climate Change Science, relevant to inform the COP26 climate conference to be held in Glasgow (2021). Eds: Corinne Le Quéré, Peter Liss, Piers Forster.
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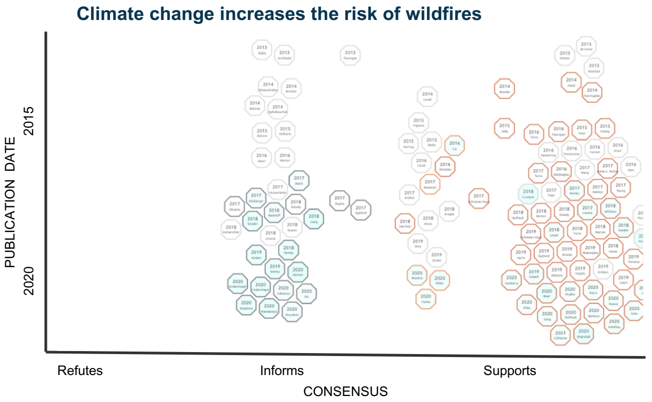
Approach. We undertook a ScienceBrief Review on the link between climate change and wildfire risk in January 2020, reviewing 57 scientific articles. 116 scientific articles are now available. This update focusses on articles relevant to the wildfires ongoing in the western United States, new findings relevant to the wildfires that raged southeastern Australian during the 2019-2020 season, and new findings since January 2020. **The full Brief and all publications can be viewed here:** https://sciencebrief.org/topics/climate-change-science/wildfires/explorer

Summary. New scientific publications reviewed since January 2020 strengthen the evidence that climate change increases the frequency and/or severity of fire weather – periods with a high fire risk due to a combination of high temperatures, low humidity, low rainfall and often high winds – in many regions around the world. The western United States is among the regions where the trends in fire weather have been most pronounced in the past at least 40 years. Fire activity is influenced by a range of other factors including land management practices. However, land management alone cannot explain recent increases in wildfire extent and intensity in the western US or southeast Australia because increased fire weather amplifies fire risk where fuels remain available.

The new analysis shows that:

- Well over 100 studies published since 2013[1] show strong consensus that climate change promotes the weather conditions on which wildfires depend, enhancing their likelihood.
- Natural variability is superimposed on the increasingly warm and dry background conditions resulting from climate change, leading to more extreme fires and more extreme fire seasons.
- Land management can enhance or compound climate-driven changes in wildfire risk, either through fuel reductions or fuel accumulation as unintended by-product of fire suppression. Fire suppression efforts are made more difficult by climate change.
- There is an unequivocal and pervasive role of climate change in increasing the intensity and length in which fire weather occurs; land management is likely to have contributed too, but does not alone account for recent increases in wildfire extent and severity in the western US and in southeast Australia.



Snap shot of the Brief on climate change and wildfires showing the high consensus among the 116 scientific publications examined (81 support, 0 refute). Click here to visit the Brief.

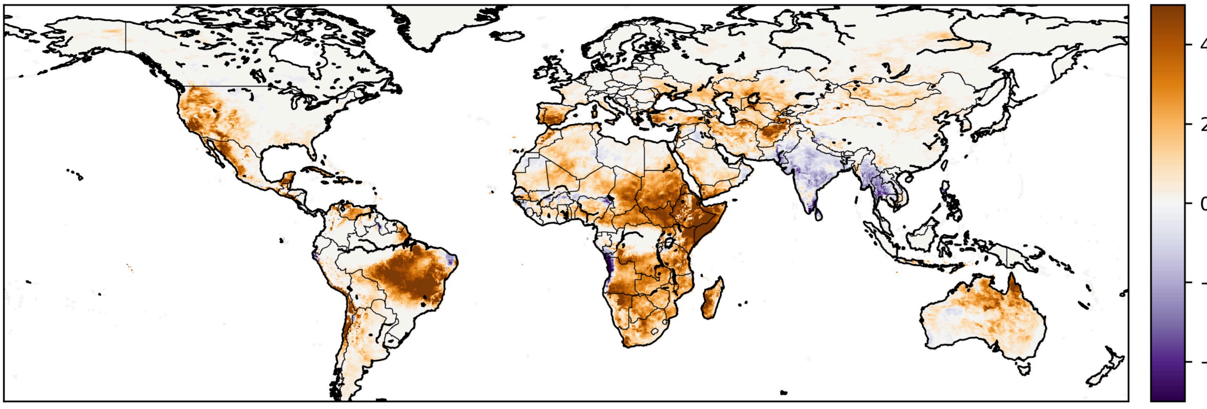
Background

Human-induced climate change promotes the conditions on which wildfires depend, enhancing their likelihood and challenging suppression efforts. Although the global area burned by fires each year is declining, the majority of this trend is explained by conversion of natural savannahs and grasslands to agriculture in Africa (Andela et al. 2017). In contrast, the area burned by forest wildfires is increasing in many regions, including in the western US and southeast Australia. Here we focus on the impacts of climate change on "fire weather", which affects the likelihood of fires occurring and the severity of fires when they do occur.

"Fire weather" refers to periods with a high likelihood of fire due to a combination of high temperatures, low humidity, low rainfall and often high winds. A number of indices are used to track fire weather based on the meteorological information available, and these indices broadly quantify the risk of fire based on weather conditions at any given time and place. "Fire weather season length" refers to the number of days per year of fire weather. Fire weather season length is on the rise globally, signalling a rising risk of wildfires in many regions (see Figure).

[1]Only studies published since the release of the last assessment report of the Intergovernmental Panel on Climate Change (IPCC), in 2013, were examined here.

Change in the length of the fire weather season (1979-2019: days per year)



Change in the length of the fire weather season between 1979 – 2019 as seen in meteorological data (figure produced by M. Jones and J. Abatzoglou following Jolly et al. (2015); data from Vitolo et al., 2020, using the ERA5 dataset).

Human-induced warming has already led to a global increase in the frequency and severity of fire weather, increasing the risks of wildfire. Rising global temperatures and more frequent heatwaves increase the frequency of fire weather by promoting hot and dry conditions, despite an increase in global mean precipitation which falls more sporadically. Fire weather seasons have significantly lengthened across 25% of the Earth's vegetated surface, with detectable climate change impact above natural variability over a similar extent (Abatzoglou et al., 2019). These impacts will become increasingly pervasive and intense with each added degree of warming. While there are regional exceptions, the global picture is of a hotter world that supports longer and more extreme fire seasons (see Figure).

Land management can ameliorate or compound climate-driven changes in wildfire risk. Prescribed burning during the cooler season can reduce available fuel and therefore reduce the likelihood or intensity of subsequent fires. Fire suppression and increased residues from logging can enhance the intensity of wildfires when they occur. Fuel reductions or the maintenance of fire breaks around population centres can help to avoid the worst direct impacts of wildfire on communities, and is particularly effective around populated centres. Fire management is highly sensitive to local climate and landscape conditions, both of which have changed in recent decades due to climate change and other factors, such as population growth.

Wildfires can have broad impacts for human health and wellbeing and for the natural environment. Impacts include deaths directly from fire and indirectly from associated air pollution, loss of property, accelerated thawing of permafrost, amplification of climate change, and biodiversity loss.

Climate Change and Wildfire in the Western US

The western US is exposed to greater wildfire risks than it was before humans began to alter the global climate. The legacy of fire suppression and exclusion of indigenous land stewardship have increased vegetation density in the region thereby contributing to recent wildfires.

Fire weather has become more frequent and intense in western US forests. Fire weather has become more frequent and intense in recent decades, lengthening by 8 days between 1979 and 2019 on average globally (Jolly et al., 2015; Figure 1). The US is among the regions where the frequency and severity of fire weather has shifted beyond the natural conditions seen in the pre-industrial period (Abatzoglou et al., 2019). Goss et al. (2020) found that climate change is increasing the likelihood of extreme autumn wildfire conditions across California with a doubling of such days over the past four decades. Williams et al. (2019) also found that warming is enhancing the potential for large wildfires in autumn, which typically occur during strong, dry offshore winds and when winter precipitation is delayed. Khorshidia et al (2020) finds that megafire days (confluence of dry fuels/strong winds) in southern California has increased by 3x over this same period. Finally, Crockett et al. (2018) finds that extreme wildfires happen more frequently during droughts, compounding the effects of climate trends and climate variability. Overall, climate change is bringing hotter, drier weather to the western US and the region is fundamentally more exposed to fire risks than it was before humans began to alter the global climate. Recent trends in fire weather are projected to continue under a warming climate, with a 25% increase in extreme autumn fire days projected for California by the late 21st century, even for a medium scenario of future emissions (RCP 4.5; Goss et al., 2020).

Fire weather is driving more wildfire activity in western US forests. Hotter, drier weather means forests are being primed to burn more regularly, and this has led to an increase in fire activity in recent decades. Williams et al. (2019) found that Californian forests experienced an eightfold increase in summer forest-fire extent during 1972–2018, and that nearly all of the increase could be explained by increased fuel dryness in the context of contemporary fire management. In the wider western US forests, Westerling et al. (2016) found that annual burned area increased tenfold between 2003–2012 and 1973–1982. Increases in summer wildfire area have occurred principally due to increased fuel dryness under a warming climate that has been accompanied by reduced summer precipitation (Halofsky et al., 2020; Williams et al., 2019; Abatzoglou & Williams, 2016;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Holden et al., 2018), in the context of modern land management and fire suppression practices.

Demographic factors alone cannot account for the magnitude of the observed increase in wildfires in the western US, but increased population leads to greater impacts. In addition to climate change, the increased population at the wildland-urban interface (WUI) is contributing to greater impacts of wildfires, with more people, property and infrastructure at risk (Syphard et al. 2019, Hanberry, 2020; Radeloff et al., 2020). Strader (2018) found that there was a >100–fold increase in homes built in high fire risk zones during 1940–2010, while 97% of US wildfires in the WUI result from human ignition (Mietkiewicz et al., 2020). Observations reveal weaker climate–fire relationships where human populations are higher, due to both ignitions, land fragmentation, and suppression (Syphard et al., 2017). While studies from elsewhere in the world have shown that a rising rural population leads to higher human ignitions, especially along new highways (Oliveira et al., 2017), studies in California have not revealed such an effect where the number of ignitions has declined slightly over the past four decades (Keeley and Syphard, 2018).

Land management practices are contributing factors, but cannot alone explain the magnitude of the observed increase in wildfires extent in the western US forests in recent decades. Prescribed burning is one mechanism for removing the most flammable excess fuels from the forest floor. However, negative perceptions towards the practice and a closing window of opportunity to conduct the burns safely each year mean that these prescribed burns are conducted less regularly than desired in some regions (Miller et al., 2020). Limited fuel management through hazard reduction fires has been suggested by some (Kolden, 2019; Miller et al., 2020; Moreira et al., 2020) as a contributing factor to the increasing scale and impact of wildfires in the western US (and other regions with Mediterranean–type climate). A long history of fire suppression has also contributed to elevated wildfire risk because fuel stocks are out of sync with their natural dynamics. Increased forest residues from reduced frequency of low–intensity fires enhance the likelihood of fires being highly impactful when they do occur (Moreira et al., 2020). Likewise, the implementation of widespread fuel treatments reduce the proportion of high–severity fires (Liang et al., 2018) under future climates in the Sierra Nevada. The influence of land–management practices on fire activity is ecosystem–dependent; for example, fire suppression practices may have little bearing on changes in burned area in sub-alpine ecosystems with climate change (Hansen et al., 2019). However, Goss et al. (2020) concluded that “the broad geographic extent of increased burned area in California and the western US suggests that demographic and forest management factors alone are insufficient to explain the magnitude of the observed increase in wildfire extent over the past half–century”.

Climate Contribution to the 2019–2020 Australian Bushfires

Extreme heat and drought in Australia during the fire season of 2019–2020 (and prior years of drought) led to an unprecedented fire season in the forests of the southeast of the country. The weather conditions were partly a result of human–driven climate change. Long term accumulation of fuels as a result of fire suppression and logging practices likely contributed to the severity and extent of fire activity.

The scale of the 2019–2020 bushfires was unprecedented. A globally unprecedented 21% of the Australian temperate and broadleaf mixed (TBLM) forest biome burned during the 2019-2020 bushfires. This is believed to be due to record low levels of moisture in the leaf litter layer, which propagate TBLM fires, following a period of record-breaking heat and extended drought, coupled with windy conditions in early September 2019 (Boer et al., 2020). While this period of elevated fire weather is consistent with predictions of climate change, formal attribution studies for the 2019–2020 Australian wildfires are still in progress.

Fuel management through prescribed burns and improved logging practice cannot fully mitigate increased wildfire risk due to climate change. Recent analysis found 36% of the 2019–2020 burned area in Victoria had been burned twice or more in the previous 25 years, (Lindenmayer & Taylor, 2020) suggesting limited effectiveness of prescribed burns to mitigate wildfires in these areas. Lindenmayer et al. (2020) identified that, in addition to climate change, logging residues from poor forestry practices in Victoria contributed to the intensity of the 2019–2020 megafires. However, Di Virgilio et al. (2020) demonstrate that in southeastern Australia, climate change has reduced the window for safe use of prescribed burns to manage forest fuel loads, limiting future effectiveness of this tool. Extended fire–season length in other regions would mean this also applies elsewhere. To prevent future extreme or catastrophic fires in forests, using fuel management alone, Clarke et

Extreme weather and Pyroconvection are projected to increase wildfire risk under future climate change in southeastern Australia. Research published before the 2019-2020 bushfires revealed that surface fire weather conditions and atmospheric instability can interact during major fires, as heat and moisture are released (Dowdy & Pepler, 2018; Di Virgilio et al., 2019; Dowdy et al., 2019). Known as pyroconvective circulation, temperature and humidity changes above the fire and can develop thunderstorms and pyrocumulonimbus clouds, resulting in catastrophic wildfires that are even more dangerous, because wind speed and direction changes erratically (Dowdy & Pepler, 2018). Reanalysis data (1979–2016) for southeast Australia, show pyroconvection risk increased over time, especially during spring and summer, due to worsening surface fire weather conditions (Dowdy & Pepler, 2018). Future projections (2060–2079) suggest that climate change may continue to increase the risk of pyroconvection in southeastern Australia, compared to 1990–2009. This increase is notable in November (spring) and to a lesser extent during December (summer), though a trend was not clear for all regions of the country (Di Virgilio et al., 2019; Dowdy et al., 2019).

New Evidence from Elsewhere in the World

Scientific evidence that climate change is causing an increase in the frequency and extent of fire weather, contributing to extreme wildfires around the world, continues to mount.

In the **Mediterranean region**, anthropogenic climate change signal has been detected separately from natural variability in southern France and was responsible for 50% of the increase in fire weather (Barbero et al., 2020). Fargeon et al. (2020) report that under a high emissions scenario (RCP 8.5) for the future, climate change signal emerges from natural variability in most of France after 2060. Positive temperature, negative humidity and zonal wind anomalies in the Iberian Peninsula correlate with large fires (Vieira et al., 2020) that are projected to increase in the number of extreme days and normalised burned area by 2071–2100, under both a medium (RCP 4.5) and a high (RCP 8.5) emissions scenario (Calheiros et al., 2021). For the Mediterranean region as a whole, fire weather is projected to increase 14–30% by the late 21st century, depending on future emissions scenarios. In **Central Asia**, fire weather is projected to increase by 63–146% and burned area by 3–13% by 2071–2099, depending on future emissions scenarios (Zong et al., 2020).

The full Brief and all references to publications can be viewed and explored here:

https://sciencebrief.org/topics/climate-change-science/wildfires/explorer

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