Climate Change Increases the Risk of Wildfires

Rapid Response Review using ScienceBrief.org
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Search keywords used for the Rapid Response Review: "Climate Change" AND "Fire" (also "Fire Weather" OR "Fire Danger")

Matthew W. Jones [1] , Adam Smith [1] , Richard Betts [2,3], Josep G. Canadell [4] , I. Colin Prentice [5] , and Corinne Le Quéré [1]

[1] Tyndall Centre for Climate Change Research, School of Environmental Sciences, University of East Anglia (UEA) [2] Met Office Hadley Centre, Exeter [3] College of Life and Environmental Sciences, University of Exeter [4] CSIRO Oceans and Atmosphere, G.P.O. Box 1700, Canberra, ACT 2601, Australia [5] Leverhulme Centre for Wildfires, Environment and Society, Imperial College, London

Approach. We undertook a Rapid Response Review on the link between climate change and fire risk. 57 scientific articles were gathered and evaluated using ScienceBrief. This document synthesises the key points that emerged from the findings. Our review focuses on papers published since the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), with its cutoff date of March 2013. The papers can be viewed on https://sciencebrief.org/topics/climate-change-science/wildfires. All papers show linkages between climate change and increased frequency or severity of fire weather, though some note anomalies in isolated regions. None of the papers support a widespread decrease in fire risk.

Summary. Human-induced climate change promotes the conditions on which wildfires depend, enhancing their likelihood and challenging suppression efforts. Human-induced warming has already led to a global increase in the frequency and severity of fire weather, increasing the risks of wildfire. This signal has emerged from natural variability in many regions, including the western US and Canada, southern Europe, Scandinavia and Amazonia. Human-induced warming is also increasing fire risks in other regions, including Siberia and Australia. Nonetheless, wildfire activity is determined by a range of other factors including land management and ignition sources, and on the global-scale most datasets indicate a reduction in burned area in recent years, chiefly due to clearing of natural land for agriculture.

ScienceBrief Review

Background. The Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) published in 2013 identified several climate trends that have the potential to influence fire weather:

- Global increases in average temperature.
- Global increases in the frequency, intensity and/or extent of heatwaves (i.e. the breaching of historically extreme temperature thresholds).
- Regional increases in the frequency, duration and intensity of drought.

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. Rising global temperatures and more frequent heatwaves and associated droughts increase the likelihood of wildfire by promoting hot and dry conditions which are conducive to fire weather. Changes in rainfall and its seasonality complicate trends in fire weather, and so reductions in fire weather are possible in some regions. Nonetheless, wildfire occurrence is moderated by a range of factors including land management practises, land-use change and ignition sources. At the global-scale, burned area has decreased in recent decades, likely due to clearing of natural land cover for agriculture and increased fire suppression.

The impact of anthropogenic climate change on fire weather is emerging above natural variability.

Quarrie Photography

Jolly et al. (2015) use observational data to show that fire weather seasons have lengthened across ~25% of the Earth's vegetated surface, resulting in a ~20% increase in global mean fire weather season length. By 2019, models suggest that the impact of anthropogenic climate change on fire weather was detectable outside the range of natural variability in 22% of global burnable land area (Abatzoglou et al., 2019). Regional studies corroborate these global findings by identifying links between climate change and fire weather, including in the following regions with major recent wildfire outbreaks:

- **Amazonia.** Models suggest that the impacts of anthropogenic climate change on fire weather extremes and fire season length emerged in the 1990s (Abatzoglou et al., 2019). Drought-induced fires may be partially offsetting reductions in Amazonian deforestation fires since ~2000 (Aragão et al., 2018). Climate-driven changes in fire weather are exacerbated by landscape fragmentation caused by deforestation (Alencar et al., 2015; Aragão et al., 2018; Brando et al., 2013).
- **Southern Europe/Mediterranean.** Models suggest that the impacts of anthropogenic climate change on fire weather extremes and fire season length emerged in the 1990s (Abatzoglou et al., 2019). Several articles identify an emerging link between heat waves, drought and fire in Southern Europe (e.g. Ruffault et al., 2017; Parente et al., 2018; Koutsias et al., 2013).
- **Scandinavia.** Models suggest that the impacts of anthropogenic climate change on fire weather extremes and fire season length emerged in the 2000s (Abatzoglou et al., 2019). Krikken et al. (2019) found that the 2018 fires in Sweden were ~10% more likely in the current climate than in the pre-industrial climate and that a greater increase in fire weather is likely in the future.

- **Western US and Canada.** Models suggest that the impacts of anthropogenic climate change on fire weather extremes and fire season length emerged in the 2010s (Abatzoglou et al., 2019; Williams et al., 2019; Abatzoglou & Williams, 2016). Yoon et al. (2015) similarly predicted the occurrence of extreme fire risk would exceed natural variability in California by 2020. Kirchmeir-Young et al. (2017) found that the 2016 Fort McMurray fires were 1.5 to 6 times more likely due to anthropogenic climate change, compared to natural forcing alone. Westerling et al. (2016) found that burned area was >10 times greater in Western US forests in 2003-2012 than in 1973-1982. The 2015 Alaskan wildfires occurred amidst fire weather conditions that were 34-60% more likely due to anthropogenic climate change (Partain et al., 2016).

Climate change also affects fire weather in many other regions, although formal detection does not yet emerge from natural variability. Abatzoglou et al. (2019) suggest that the anthropogenic climate change signal will be detectable on 33-62% of the burnable land area by 2050. Other global studies agree that the effect of climate change is to increase fire weather and burned area once other factors have been controlled for (e.g. Huang et al., 2015; Flannigan et al., 2013). Regional modelling studies corroborate these global findings by projecting how climate change will affect fire weather:

- **Siberia.** Both the number of forest fires and the extent of the burned area increased during recent decades (Ponomarev et al., 2016). Models suggest that the increased frequency and severity of fire weather will be most pronounced in the northern boreal region, including Siberia (Flannigan et al., 2013; de Groot et al., 2014). Impacts of anthropogenic climate change on fire weather extremes and fire season length are projected to emerge above natural variability in the 2020s (Abatzoglou et al., 2019).

- **Australia.** Observational data suggest that fire weather extremes are already becoming more frequent and intense (Dowdy, 2018; Head et al., 2014). However, the divergence between anthropogenic and natural forcing signals is weaker, and more challenging to diagnose than in other regions, due to strong regional and inter-annual variability in the effect of the El Niño–Southern Oscillation on fire weather (Dowdy, 2018; Sharples et al., 2016). Other important regional weather patterns, such as the Indian Ocean Dipole (IOD) and the Southern Annular Mode (SAM) also contribute to natural variability in fire weather, but their effects are increasingly superimposed on more favourable background fire weather conditions. Impacts of anthropogenic climate change on fire weather extremes and fire season length are projected to emerge above natural variability in the 2040s (Abatzoglou et al., 2019).

- **Continuing trends in regions where an anthropogenic signal has already emerged.** Models project that the length of fire weather season will increase by more than 20 days per year in the northern high latitudes by the end of this century (Flannigan et al., 2013). Models also indicate that current “100-year” fire events, in terms of burned area, will occur every 5 to 50 years across Europe by the end of the century (Forzieri et al., 2016). Modelling of Alaskan fire risk indicates a four-fold increase in the 30-year probability of fire occurrence by 2100 due to climate change (Young et al., 2017).

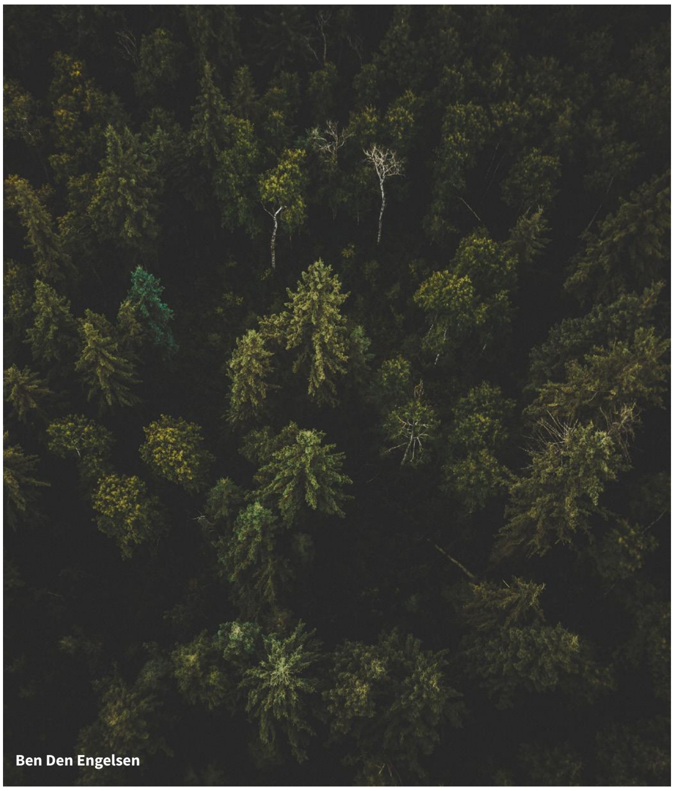
Paleo records also support increased wildfires during warmer periods. Sedimentary charcoal records and other indicators of fire activity have been used to extend records of fire throughout the Holocene period (the past 12,000 years) and beyond, enabling assessment of long-term interactions between climate and biomass burnt (Marlon et al., 2013, 2016). Other model–data comparisons reveal robust correspondence between fire and climate during the Holocene in most regions, though this correspondence can break down in regions with significant direct human control via fire ignition and suppression, including in Europe (Brücher et al., 2014). Harrison et al (2018) later used model–data comparison to demonstrate that biomass burning has increased with rising temperature over the past 1500 years. In Australia, charcoal production correlates with temperature during major historical climate transitions and the role of direct human activities is not evident (Williams et al, 2015). Overall, the 57 papers reviewed clearly show that human-induced warming has already led to a global increase in the frequency and severity of fire weather, increasing the risks of wildfire.

Future risks posed by wildfires may be significantly reduced by limiting temperature increase to well below 2ºC. Several studies have investigated the impacts of limiting global warming to 1.5ºC, 2ºC and/or 3ºC above pre-industrial levels. Globally, the area with a detectable impact of anthropogenic climate change on fire weather is twice as large at 3ºC than at 2ºC (Abatzoglou et al., 2019). These changes in fire weather may translate to increases in burned area. For example, Turco et al. (2018) find that a 1.5ºC temperature increase above pre-industrial in the Mediterannean leads to a 40% increase in burned area, whereas a larger temperature gain of 3ºC leads to a doubling of burned area. Burton et al. (2018) investigated the impact on fire weather of limiting global warming to 1.5ºC and 2ºC above pre-industrial levels, where a 2ºC limit is achieved by applying substantial and rapid greenhouse emissions reductions and a 1.5ºC limit is achieved by also including solar radiation management (stratospheric SO_2 injection). The results indicate that a 1.5ºC limit reduces fire weather globally compared with a 2ºC limit, however solar radiation management may in fact worsen fire weather in some regions and must therefore be carefully considered.


Steve Slater

Fire weather only translates to fire activity and burned area if natural or human ignitions occur, and hence the sensitivity of burned area to changes in fire weather varies regionally (Bedia et al., 2015; Archibald et al., 2013). Correlation between fire weather and burned area is strongest in the boreal and tropical forests, where fire weather is the main limitation to fire. On the other hand, burned area is insensitive to fire weather in regions where fuel stocks or human suppression are the key fire limitations.

Humans can directly affect wildfire occurrence by managing fuel loads and also suppressing ignitions during fire weather. Globally, humans have reduced the global extent of burned area in recent decades (Andela et al., 2017; Forkel et al. 2019; Doerr and Santin, 2016; Bestinas et al., 2014), and probably the last century (Arora et al., 2018). Nonetheless, direct human effects on burned area show significant regionality. While the conversion of savannahs to agricultural land has been the principal driver of the reduced global burned area in recent decades, burned area has increased in closed-canopy forests and is associated with rising population, cropland and livestock density (Andela et al., 2017; Arora et al., 2018). As a regional example, Syphard et al. (2017) find that climate influences on fire weather in the Mediterranean have been countered by direct suppression of fires since ~1970.



Ben Den Engelsen

This independent ScienceBrief review is consistent with the "Fire and Climate Change" summary of the 2019 IPCC Special Report on Climate Change and Land, which states that:

- Climate change is playing an increasing role in determining wildfire regimes along-side human activity , with future climate variability expected to enhance the risk and severity of wildfires in many biomes such as tropical rainforests.
- Fire weather seasons have lengthened globally between 1979 and 2013
- Global land area burned has declined in recent decades, mainly due to less burning in grasslands and savannas.

Full report: https://sciencebrief.org/briefs/rrr-heat-waves

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