Comment

Supplementary information to:

Extreme wildfire seasons loom — science can help us adapt

A Comment published in *Nature* **634**, 1041–1044 (2024)
https://doi.org/10.1038/d41586-024-03433-y

Jennifer K. Balch & A. Park Williams

This Supplementary information comprises:

1. Method for calculation of annual area burnt
2. Supplementary method references
3. Supplementary data for the graphic 'Going up in flames' (see separate Excel file)

Supplementary Information for:
Extreme fire seasons are looming, science can help us adapt

Jennifer K. Balch & A. Park Williams

1. Method for calculation of annual area burned

We define the western United States (US) as the 11 westernmost states within the continental US: Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming. To distinguish forested from non-forested areas we use the 250-m resolution map of US forest type from Ruefenacht *et al.* (2008)[1] and produce a 1-km resolution map of forest fraction.

To calculate the annual wildfire area for the western US we produce annual 1-km maps of area burned by wildfire for 1984–2024. For 1984–2022 we use the 30-m maps of wildfire occurrence from the US Forest Services Monitoring Trends in Burn Severity (MTBS) dataset[2], excluding MTBS fires classified as prescribed (available from https://www.mtbs.gov/). We calculate annual forest-fire area by multiplying each annual 1-km map of MTBS wildfire area by the 1-km map of forest fraction. Notably, the MTBS database only represents large fires ≥404 ha. Although the vast majority of western US wildfires are smaller than 404 ha, these larger fires constitute 93% of the annual wildfire extent according to the comprehensive list of 1992–2020 wildfire occurrences developed by the US Forest Service[3].

To extend the annual burned-area record through 2023 we use the MODIS Collection 6.1 MCD64A1 burned area product[4], which provides maps of daily fire occurrence at 500-m resolution from November 2000 through near-present (available from https://lpdaac.usgs.gov/products/mcd64a1v061/). We use the MODIS data to calculate alternative records of annual total area burned and forest area burned for 2001–2023. The MTBS- and MODIS-based records of annual area burned correlate very well during their 2001–2022 period of overlap (r = 0.99 for total area burned and forest-fire area only). However, the burned area totals calculated from MODIS are approximately 50% higher than those from MTBS. This is because the MODIS product does not distinguish wildfires from other fire types (prescribed fires, incineration of waste), it includes fires of all sizes, and it has a much lower spatial resolution than that of MTBS. While the MTBS maps of burdened area can distinguish burned from unburned area at a relatively high resolution within a fire, the MODIS dataset flags an entire 500-m grid cell as burned regardless of the proportion of the actual area that burned within it. Further, the 500-m burned area dataset relies partly on 1-km maps of MODIS active-fire occurrences, so the effective resolution of the MODIS burned area product is lower than 500 m. Due to the exceptionally strong interannual co-variability between MTBS- and MODIS-based calculations of area burned, we use the linear relationship between the two time series during 2001–2022 to adjust the MODIS-based area burned in 2023 to be comparable to the MTBS-based record from 1984–2022.

To extend the burned-area record through 2024 we use the wildfire polygons provided by the Wildland Fire Interagency Geospatial Services (WFIGS) Group, accessed through the US National Interagency Fire Center (https://data-nifc.opendata.arcgis.com/pages/wfigs-page). This dataset contains wildfire perimeters within the US from 2021 to present. In 2021–2023 the mean annual area burned according to WFIGS is approximately 21% larger than the corresponding burned areas we calculated from MTBS and MODIS. This is expected because, unlike the MTBS dataset, the WFIGS polygons generally do not indicate which areas within a polygon were unburned and they also include fires smaller than 404 ha. To enhance the compatibility of the 2024 area burned with those of 1984–2023 we multiplied the WFIGS-derived calculations of total wildfire area and forest-fire area in 2024 by 0.82 and 0.83, respectively (our MTBS/MODIS-calculations of total wildfire area and forest-fire area in 2021–2023 are 82% and 83%, respectively, of those calculated from WFIGS). Notably, the WFIGS dataset only comes through 15 October 2024, so our estimates of area burned in 2024 are lower than the final value will be, but most likely only by a few percent. Based on the list of 1992–2020 wildfires provided by US Forest Service, fires ignited on or before October 15 account for 97% of total annual wildfire area in the western US (and 99% of annual forest-fire area).

Trends in annual wildfire area and forest-fire area from 1984–2024 are calculated using the Theil-Sen estimator, as this approach is less sensitive to outliers than is the least-squares approach[5]. Because of the non-normal distribution of burned areas we perform the trend analysis on log-transformed time series of annual area burned.

2. Supplementary Method References

1. Ruefenacht, B. *et al.* Conterminous US and Alaska forest type mapping using forest inventory and analysis data. *Photogrammetric Engineering & Remote Sensing* **74**, 1379–1388 (2008).
2. Eidenshink, J. *et al.* A project for monitoring trends in burn severity. *Fire Ecol* **3**, 3–21 (2007).
3. Short, K. C. Spatial wildfire occurrence data for the United States, 1992-2020 [FPA_FOD_20221014]. Forest Service Research Data Archive https://doi.org/10.2737/RDS-2013-0009.6 (2022).
4. Giglio, L., Schroeder, W. & Justice, C. O. The collection 6 MODIS active fire detection algorithm and fire products. *Remote Sens Environ* **178**, 31–41 (2016).
5. Sen, P. B. Estimates of the regression coefficient based on Kendall's Tau. *Journal of the American Statistical Association* **63**, 1379–1389 (1968).