Unprecedented burn area of Australian mega forest fires

To the Editor — Between September 2019 and early January 2020, around 5.8 million hectares of mainly temperate broadleaf forest were burned in New South Wales (NSW) and Victoria (VIC) in eastern Australia by a series of mega fires. Many of the fires have exceeded 100,000 ha and continued to burn for weeks after their ignition[1]. The Gospers Mountain fire near Sydney has burned more than 510,000 ha since ignition by lightning on 26 October 2019; it is the largest forest fire recorded in Australia and continues to burn in late January 2020.

Eastern Australia's temperate broadleaf forests, dominated by eucalypts, are among the most fire-prone in the world, and major fires are relatively common[2,3], yet annually only small percentages of this forest biome burn, typically below 2% even in the more extreme fire seasons[4,5].

Are the 2019/20 forest fires unprecedented in scale, and are they the result of unparalleled fuel conditions? To address these questions, we analysed global data for remotely sensed burned area at 500 m resolution[6], covering all major global forest biomes[7] for the past 20 years (November 2000 to June 2019). We computed the annual burned area as a percentage of the continental sections of each forest biome between November 2000 and June 2019, and for the NSW plus VIC sections of the Australian 'temperate broadleaf and mixed' (TBLM) forest biome resulting from the 2019/20 forest fires. The TBLM forest biome[7] in eastern Australia covers about 27 Mha, close to the median size of other continental forest biomes (26 Mha), with about half of that forest area located in NSW and a fifth in VIC.

Our analysis substantiates that the 2019/20 forest fires have burned a globally unprecedented percentage of any continental forest biome: 21% of the Australian TBLM forest biome has so far been burned in a single season (Fig. 1). This figure contrasts sharply with annual burned area percentages for all other continental forest biomes[4], which have been well below 5%, except for the Asian and African sections of the Tropical and Subtropical Dry Broadleaf forests, for which medians of 8–9% have been recorded (Fig. 1). We note that the burned area of 21% for the Australian TBLM forest biome is an underestimate, as forest fires in Tasmania this season were not included in our analysis, and additional forest area may burn over the remainder of the fire season.

Why have the fires been so devastating this year? Fires in eucalypt forests propagate primarily through the litter layer[8], and its dryness effectively acts as the 'on/off switch' for forest fire activity. Naturally occurring firebreaks, such as moist gullies, swamps or south-facing slopes, that normally dissect the forest landscape have dried out during the current widespread drought, affecting the probability of mega forest fire events in a highly nonlinear way[9]. In 2019, predicted litter moisture content across the eastern Australian TBLM forest biome was at record low levels, and the total surface area of forest exceeding critical flammability thresholds[9] was larger and more prolonged than ever recorded in the past 30 years (Fig. 2). Thus extreme drought provided the preconditions for the unconstrained spread of fires over millions of hectares of TBLM forest, triggered by the arrival of hot dry windy

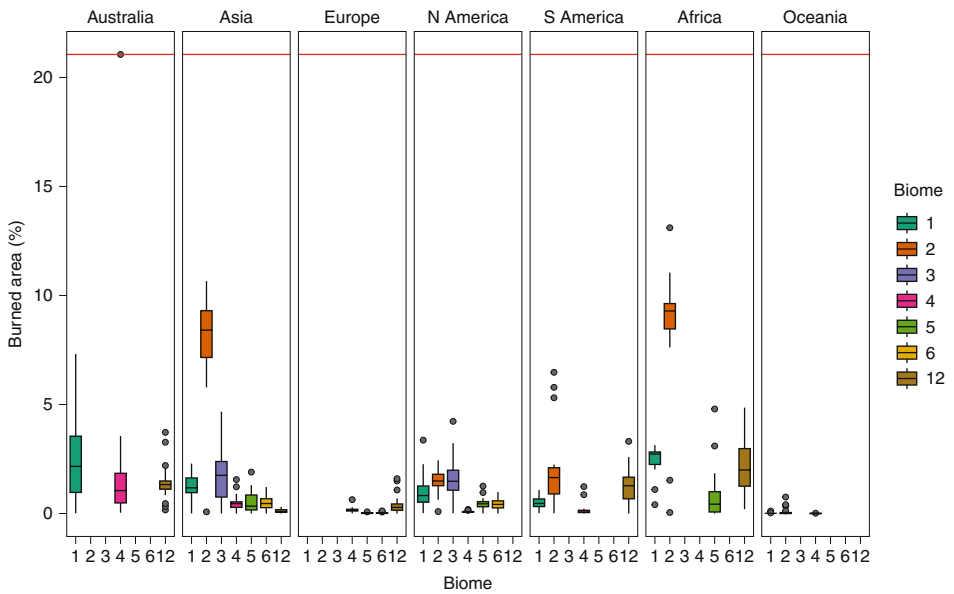

Fig. 1 | Annual burned area percentages for continental forest biomes (2000–2019). Boxplots show the median for each continent, with hinges at 25th and 75th percentiles, whiskers extending 1.5 times the interquartile range, and outliers (filled points) for seven WWF forest biomes[7]: 1, tropical and subtropical moist broadleaf forests; 2, tropical and subtropical dry broadleaf forests; 3, tropical and subtropical coniferous forests; 4, TBLM forests; 5, temperate conifer forests; 6, boreal forests/taiga; 12, Mediterranean forests, woodlands and scrub. The red horizontal line indicates the burned area of 21% observed for the Australian TBLM forest biome resulting from the 2019/20 forest fires.

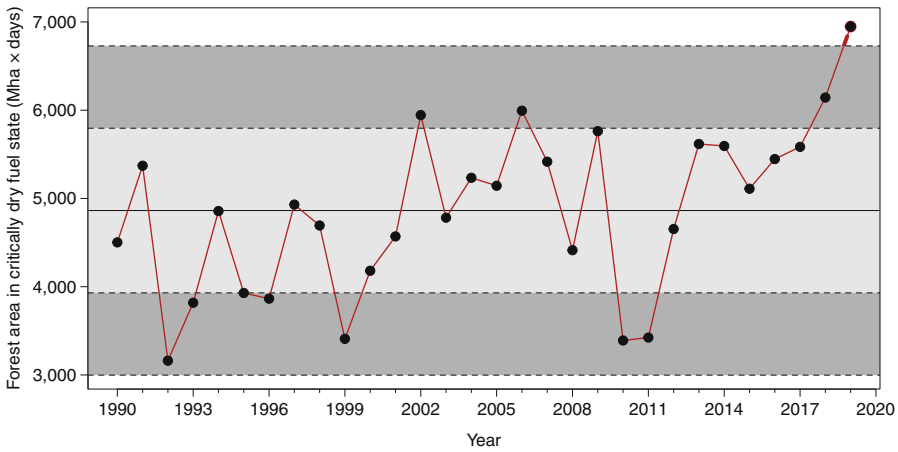

Fig. 2 | Forest area in critically dry fuel state, eastern Australia (1990–2019). Annual variation in the duration and cumulative area of large forest patches (>100,000 ha) in a critically dry fuel state. The horizontal black line indicates the 30-year mean value; light and dark grey bands indicate mean value ± 1 and 2 standard deviations, respectively. To identify forest areas in a critically dry state, spatially explicit predictions of fine dead fuel moisture content (DFMC) were based on gridded daily vapour pressure deficit, and a threshold of DFMC <10% was used[9].

weather conditions and ignitions in early September 2019 in the north and spreading south as extreme fire weather conditions continued throughout spring and early summer. The resulting large sizes of the fire complexes may prove challenging for biota that require dispersal from unburned forest for their post-fire recovery.

Given the links between the record-breaking high temperatures and widespread prolonged extreme dryness in eastern Australia and climate change[10], these unprecedented fires may indicate that the more flammable future projected to eventuate under climate change[5] has arrived earlier than anticipated. An attribution study[11] is currently under way to decipher how climate change affected the eastern Australian mega fires of 2019/20. ❐

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