# Comment


DAVID GRAY/GETTY

**Fire-and-rescue crew attend a blaze in Sydney, Australia, in 2019.**

# Wildfires: Australia needs a national monitoring agency

**David Bowman, Grant Williamson, Marta Yebra, Joshua Lizundia-Loiola, Maria Lucrecia Pettinari, Sami Shah, Ross Bradstock & Emilio Chuvieco**

Comprehensive fire surveillance will strengthen resilience and adaptation to climate change.

Just before the COVID-19 pandemic, bush fires in Australia destroyed more than 3,000 homes and burnt millions of hectares of vegetation. The crisis exposed the nation's fire monitoring system as being unfit for purpose. Precise real-time information about the area burnt and the intensity of the fires was not available when it was needed.

Australia does not have a central system for gathering and storing essential information about bush fires. State and territory governments, and even agencies within states, have different approaches. This worked fine when fires were smaller. But those in the 2019–20 season crossed multiple state borders.

The blazes engulfed a huge geographic range and burnt for a duration and intensity that was beyond the experience of communities and fire managers[1]. Many Australians endured five months of smoke pollution that breached national air-quality standards. Usually, people would experience shorter bouts covering smaller areas[2].

The extraordinary scale and intensity of the fires were driven by climate conditions not seen in a century: three years of drought, including three consecutive, anomalously dry winters[3]. This weather is consistent with predictions that global warming will result in conditions that increase the risk of fire[4,5]. Studies have linked extreme bush-fire seasons over the past few years to anthropogenic climate change[6,7].

Debate over the cause of the bush fires became politically charged. Fire scientists and managers had to stem misinformation from politicians and the media suggesting that the fires were not unusual historically and were not linked to climate change. There were even suggestions that the fires were the result of arson, or of inappropriate land management[8–10]. Staggering environmental consequences were claimed, including greenhouse-gas emissions that were exceeded only by those in China, the United States, India, Russia and Japan, and the loss or displacement of more than one billion native vertebrates.

Such assertions can be verified or rebuked only through reliable data. The current patchwork of fire records cannot deliver that.

Here we offer a more useful picture — an analysis of satellite data related to the burning, set in the context of historical fire records. We calculate that a much smaller area was engulfed than estimates compiled from government fire records suggest. Yet we still show that nothing similar has been seen since at least the mid-nineteenth century. The geographic scale, on the back of a series of massive bush fires that have burnt southern Australian and Tasmania since the beginning of this century[1], eclipsed the worst-case scenarios designed to prepare agencies and communities.

In other words, we're navigating uncharted territory without a compass. Effective adaptation to extreme events of this sort demands much more detailed description and analysis, and that requires accurate and timely data.

We call on researchers and policymakers to build a dedicated national bush-fire monitoring agency. This is essential to provide the coherent information required for cost-effective, evidence-based fire management and mitigation. Only thus can we strengthen Australia's resilience to climate change.

## Crude patchwork

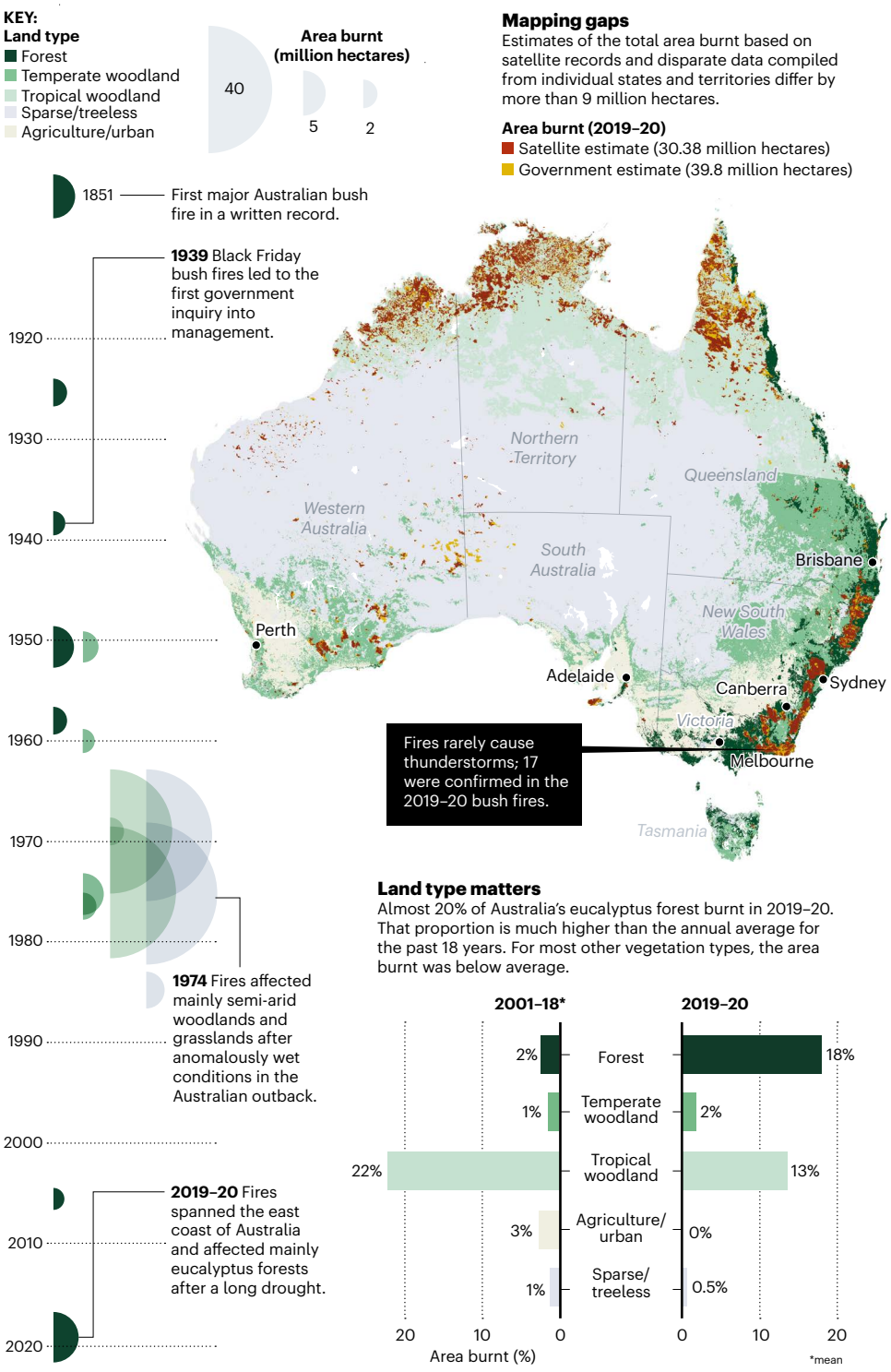
Australian state and territory governments record bush fires in a variety of ways. In the vast tropical savannahs and arid grasslands, fire mapping relies on satellite assessments. In temperate forests, fire perimeters are mapped

## EXTREME BURNING

The 2019–20 Australian bush fires destroyed millions of hectares of vegetation. The geographic extent was so immense that it exposed the nation's fire monitoring system as a thing of the past. Because individual states and territories record bush fires in different ways, there are data gaps and inconsistencies that make it difficult to accurately assess the fires' scale and environmental impact.

### Past experience

The area of eucalyptus forest burnt in 2019–20 could have been the largest since at least 1851.




### Mapping gaps

Estimates of the total area burnt based on satellite records and disparate data compiled from individual states and territories differ by more than 9 million hectares.

**Area burnt (2019–20)**
- Satellite estimate (30.38 million hectares)
- Government estimate (39.8 million hectares)

### Land type matters

Almost 20% of Australia's eucalyptus forest burnt in 2019–20. That proportion is much higher than the annual average for the past 18 years. For most other vegetation types, the area burnt was below average.




SOURCE: G. WILLIAMSON; GLCC; FIRECCI51; AUSTRALIAN GOVERNMENT; USGS

JUSTIN MCMANUS/THE AGE/FAIRFAX MEDIA/GETTY

**People in Victoria, Australia, are evacuated in January after bush fires ravaged their town.**

by ground crews, aerial surveys and satellite analysis. All regions assess severity differently.

This has led to inconsistencies and gaps in data. For example, some reports overestimate the area burnt because they include unburnt patches. Furthermore, different states and territories survey the distribution of animals, the causes of fire and the types of vegetation in disparate ways.

The lack of consistent basic data makes it impossible to accurately quantify the scale and environmental impact of fires. Moreover, extraordinary claims about the causes and consequences of bush fires cannot be scrutinized.

For example, is it true that one billion animals were killed or displaced in the last fire season? This claim hinges on estimates of the area burnt, assumes uniform fire intensity and ignores the fact that wildlife could have sought refuge in unburnt areas.

And did the fires really commit around 830 million tonnes of greenhouse gases into the atmosphere? This value depends on the type of vegetation burnt and the extent and severity of this season's fires as well as previous ones. For instance, previous research[11] has shown that a severe fire in a dry eucalyptus forest emitted 16% of the total carbon stored, yet one in a nearby area that had been subjected to prescribed burning emitted just 9%.

Disputes about the causes of the fires have also been raging, despite clear evidence that the main blame lies in anomalous weather conditions driven by climate change. Are other factors also partly responsible — the extent and effectiveness of prescribed burning[10,12] or past logging of native forests[9], perhaps? Did stopping Aboriginal fire practices make landscapes more flammable[8,13]? To what extent is arson to blame?

**"More accurate historical data are essential for charting geographic and temporal trends."**

Answering these questions requires detailed statistical analyses of consistent data that control for a range of variables, including terrain, weather, history, vegetation and land management, as well as accidental and natural causes[14].

Many research centres across the country have independently assembled new databases. This is not the solution. These simply perpetuate the problem, because they continue to be based on inconsistent data and definitions for key variables.

## Monitor at scale

Here, we illustrate why it is essential to collect national fire data by addressing two related questions. First: what area was burnt by the bush fires? Second: were the fires historically anomalous?

Using a 19-year time series of satellite data[15], we estimate that the extent of fire across the Australian continent for the 2019–20 season was 24% smaller than that estimated from a compilation of government fire records (see Supplementary Information for details).

Both approaches have strengths and weaknesses. Government records are informed by field observations, yet they often include unburnt patches within a single perimeter. Satellite-data analyses are internally consistent and repeatable, but satellites cannot reliably detect low-severity fires that leave forest canopies unscorched. It will thus be crucial to monitor fires with a method that can produce internally consistent data at the national scale, and that can be repeated many times during a fire crisis.

Our analysis shows that the area of tropical

woodland, temperate woodland, tree-less and agricultural land that burnt across Australia in 2019–20 did not differ statistically from the historical average (see 'Extreme burning'). The amount of tropical woodland (the land cover that most commonly burns in Australia) that burnt was 40% less than the average, reflecting limited fuel availability as a result of dry conditions. By contrast, almost 20% of Australia's eucalyptus forest coverage burnt — a figure more than 7.5 times higher than the annual average percentage burnt for the past 18 years (see 'Extreme burning' and Supplementary information). This satellite-based estimate is 19% smaller than that calculated in official records. Regardless, both data sources leave no doubt that the fires were anomalous in the eucalyptus forest domain.

Our calculations suggest that a fire's environmental impact cannot be reliably assessed without precise information about the area of different types of vegetation burnt.

Moreover, the 2019–20 fires were probably the largest since the mid-nineteenth century. A published compilation of all large fires recorded since the mid-nineteenth century shows that there have been 12 known seasons, with 19 individual events that burnt more than 1 million hectares[16,17]. The largest fire recorded in the temperate eucalyptus forest biome occurred in 1851, and is estimated to have burnt 5 million hectares, although the perimeter was not mapped accurately (see 'Extreme burning' and Supplementary information).

Clearly, more accurate historical data are essential for charting geographic and temporal trends, and for identifying links with anomalous weather and climate patterns. Accurately reconstructing the extent and severity of past fire events in Australian ecosystems is a substantial research challenge, and one that demands innovation and investment.

## Next steps

The Australian government has asked a royal commission to formulate a national approach to fire risk management. We call on the commission to recommend the establishment of a national fire monitoring agency. We propose that such an agency should collect the following information using nationally consistent criteria.

**Causes.** Fire scientists, criminologists, social scientists and state fire agencies[14] must work together to fully understand the relative importance of lightning, climate change and arson, among other natural and human factors, in causing bush fires. Such collaborative research can build on a 2008 national pilot study[14,18], which revealed that it is impossible to report to what extent fires are lit deliberately in the absence of a nationally consistent collection, classification and analysis of the causes of fires.

**Frequency, extent and severity.** Reliable fire mapping should be based on blending remote-sensing data from coarse- and medium-resolution satellites, aircraft and drones with field validation. Researchers must ensure that mapping is effective across vegetation types and is practical to use for fire managers.

**Biodiversity and vegetation coverage.** The national government must invest in federating existing regional data sets of ecological communities, and in mapping and field surveys to fill geographic gaps. Researchers must develop a nationally consistent classification of habitat types and plant and animal responses to fire severity. Efforts can build on the rapid assessment of wildlife species affected by the fires[19].

**Greenhouse-gas emissions.** Factors that help in determining the amount and chemical diversity of emissions as a result of the combustion of different fuel and vegetation types must be established for a wider range of Australian ecosystems. This initiative can build on the recent compilation of such factors from savannah fires[20]. This information can then be used to estimate greenhouse-gas and particulate air pollution from bush fires at a regional and national scale.

**Smoke and public health.** Air-quality epidemiologists have already called for an independent national expert committee to devise evidence-based, nationally consistent and practical means to protect the public from bush-fire smoke, including air-pollution measurements[21]. This will require close collaboration between health, education, environment, fire and emergency-management agencies.

**Economic trade-offs.** A consistent national database of fire-management expenditure, coupled with accurate mapping of fire patterns and vegetation types is needed[22]. It will enable researchers to provide policymakers with cost–benefit analyses of different management strategies.

The 2019–20 fires marked a historic crossroads. A national crisis of this magnitude, which will probably happen again, requires a national solution.

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