NSW Bushfire Risk Management Research Hub

Predicting pollution from hazard reduction burns

Bushfires and hazard reduction burns (HRBs) produce pollution. The NSW Bushfire Risk Management Research Hub investigated the intensity and spread of particulates from active and historic bushfires and HRBs. The Hub considered smoke plumes and ground-level pollution and is developing models to help fire managers better plan HRBs.

Smoke plumes and pollution

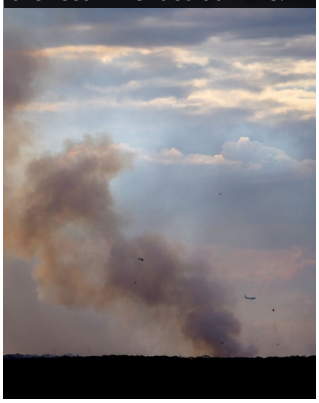
The Hub investigated 91 plumes which occurred between 2015 and 2020, which were large enough to be observed on satellite imagery and passed over Department of Planning and Environment monitors. These included plumes from 69 bushfires and 22 HRBs. The Hub compared particulates in the day and the following evening with a baseline from the previous day.

Throughout this document '**particulate**' refers to particulate matter of 2.5 micrometres (PM 2.5), **a known health hazard**.

What we learned

Most plumes from HRBs and bushfires remain aloft (above the ground). Only about 8% of the plumes investigated exceeded pollution standards as they passed over monitors, including 22 bushfires and four HRBs. Even so, poor air quality events were twice as likely when a plume was overhead.

Mobile air quality monitors are recommended at HRBs.



What's next?

- Work continues to model how weather influences particulates under plumes.
- More or better-located monitors are recommended. Of 1,003 plumes observed on satellite imagery, only 115 reached a monitor. Plumes are generally small and NSW air quality networks often fail to capture them. Deploying mobile monitors at HRBs may provide more accurate data.

Smoke plume: When a plume is directly overhead, air quality is twice as likely to be rated poor.

How much smoke and where does it go?

The Hub sampled smoke from **18 HRBs** in the Sydney region using low-cost monitors. The average burn size was **217 ha**.

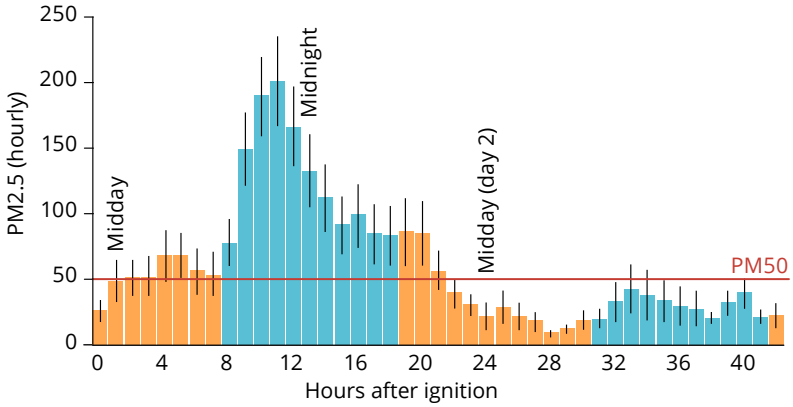
What we learned

- On the day of the burn, particulates exceeded air quality standards up to **2–7 km** from the fire, but only **downwind** of it.
- In the evening, they spread up to **8–20 km** from the fire, including **upwind**.
- Particulate levels were higher in **still and cool** weather.
- Particulate levels were higher when fires burned **into the night**.
- Larger HRBs caused higher particulate levels.

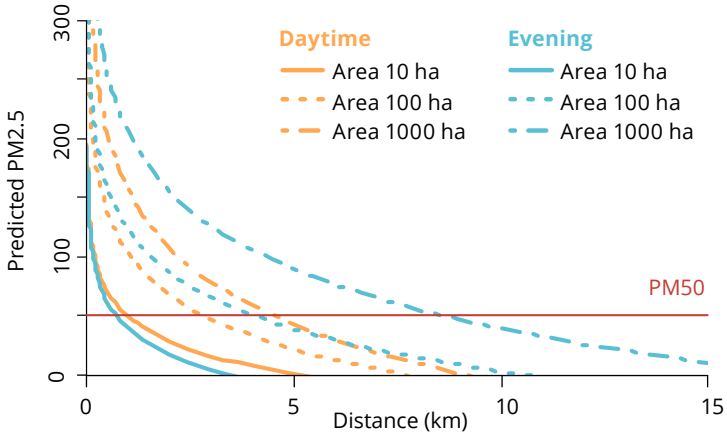
Predictions

- The Hub's models predicted that in the evening, at winds of 5 km/h and temperatures of 10°C, poor air quality would **extend up to 20 km** from the fire.
- Burns of 1,000 hectares would lead to poor air quality extending over about **100,000 hectares – 100 times larger** than the HRB.

Trade-off: Research shows the safest burning weather leads to more pollution.



Build-up: From about 7 pm, particulates built up, peaking at 10 pm and then gradually dropped.



Pollution spread: Particulates spread further in the evening and from larger fires.

What should fire managers consider?

- A daytime burn can pollute an area up to **2–7 km downwind**.
- Stable, still and cool weather – when a fire is least likely to escape – is also when a nearby community is most likely to be affected by smoke pollution.
- Fires that burn **into the night** are particularly bad, with pollutants dispersing further and **upwind**.
- A burn of 1,000 hectares could pollute an area 100 times larger.

Researchers also know from related studies that **more moisture means more smoke**. Burning dead eucalypt leaves at 15% moisture produces double the emissions of those burnt at 5% moisture. This suggests HRBs produce more particulates per kilogram of fuel consumed.

What's next?

Occasional large smoke events (spreading up to 50 km from the fire) are associated with a low inversion layer (planetary boundary or mixing height), still air, warmer weather (above 20°C), and night burning. However, these events remain difficult to predict. Work continues to improve models predicting where and when particulates will concentrate.

What do NSW monitors tell us about past HRBs and bushfires?

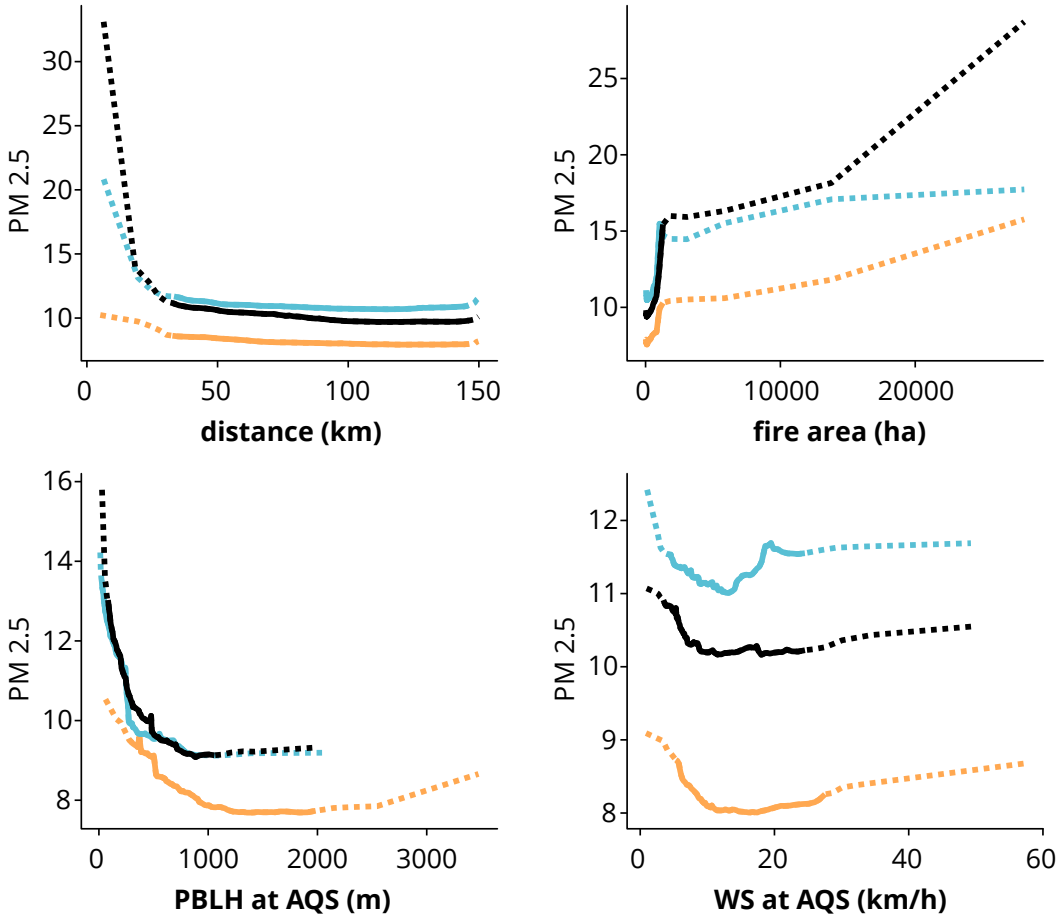
What was burning?

The Hub investigated HRBs and bushfires which occurred within 150 km of NSW air quality stations (AQS) between 2012 and 2021. Researchers used fire history and satellite hot spots to identify days when there was only one HRB or bushfire in the study area.

What we learned

- Larger fires produced far more particulates.
- Particulate levels decreased with distance from the fire, usually to background levels **within 15 km**.
- A lower inversion (boundary) layer (less than 500 m) led to higher particulate levels, especially during the morning and night.

Intense: Smoke from a HRB at Cataract in 2015. Larger fires mean more pollution.



Particulate levels: Predicted effects of fire distance, fire area, planetary boundary layer height at the air quality station (PBLH at AQS) and wind speed (WS) on particulate levels for daytime (orange), night (blue) and the following morning (black).

"Smoke and its impact on communities is inevitable, but a guide to reduce its influence on the public and firefighters' health will ensure best practice is considered in HRBs."

Leigh Nolan, NPWS team leader

Tools for fire managers

The Hub's findings mean HRB managers can better target pollution warnings, based on

- how far and in what direction smoke is likely to disperse
- hours when pollution is likely to be worse

They can also warn of conditions likely to increase pollution:

- an inversion layer below 500m
- a low inversion layer, combined with still air, warm weather, and a night burn
- moisture
- multiple HRBs
- larger HRBs

For instance, night burns are likely to pollute **up** and **downwind** of HRBs. HRBs in the Blue Mountains, under the combined effects of light westerly winds and coastal breezes, are likely to pollute Western Sydney.

What's next?

A Sydney-region model is planned to warn of high-risk pollution days, based on HRB site, size, weather and inversion layer.

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Associated article

- Smoke patterns in HRBs (https://bit.ly/HRBsmoke)

More information

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The **NSW Bushfire Risk Management Research Hub** (www.bushfirehub.org) is a partnership between researchers at the University of Wollongong, Western Sydney University, the University of NSW, the University of Tasmania, supported by the NSW Department of Planning and Environment and the NSW Rural Fire Service.

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