

FIRE NOTE

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SUMMARY

This research project examined factors influencing fires caused by lightning. It resulted in the first systematic examination of lightning and fires in Australia (Dowdy and Mills, 2009). Fires caused by lightning (“lightning fires”) are responsible for a large proportion of the area burnt by wildfires throughout Australia and the world. The results of this research show that the Bureau of Meteorology’s real-time computer models can forecast – with typical lead times of 24 to 48 hours – locations and times where dry lightning (lightning not accompanied by rain) is more likely, and where ignitions from that lightning are more likely to be sustained. Such forecasts would potentially enable fire services and land management agencies to reduce their response time to these ignitions, and thus reduce the damage resulting from these fires.

ABOUT THIS PROJECT

This research is from the *Fire Weather – Fire Danger* project, within the Bushfire CRC *Safe Prevention, Preparation and Suppression* program.

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For more information about this research, contact Dr Dowdy via email at a.dowdy@bom.gov.au

PREDICTING FIRE FROM DRY LIGHTNING

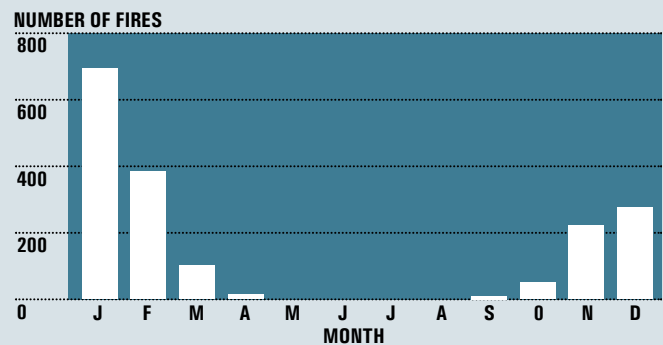


Figure 1: The number of lightning fires ignited on Victorian public land between 1 January 2000 and 31 January 2009, categorised by the month that they were first observed.

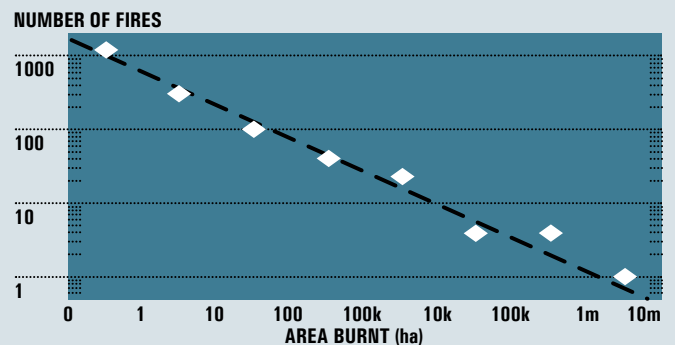


Figure 2: The number of lightning fires that occurred categorised by area burnt.

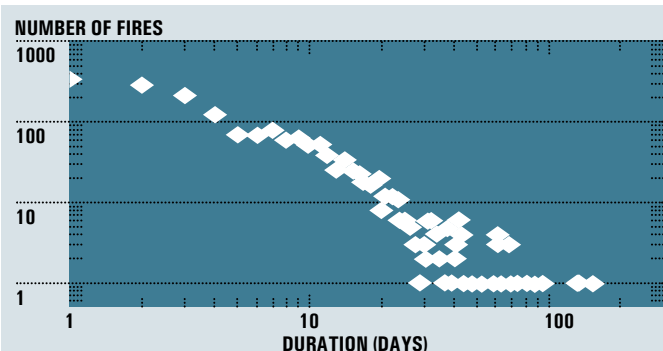


Figure 3: The number of lightning fires that occurred categorised by fire duration.

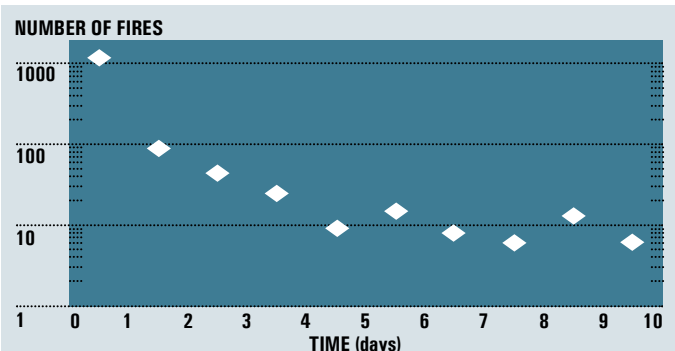


Figure 4: The number of lightning fires that occurred, categorised by the time from the lightning strike thought to have caused the fire, until when the fire is first observed.

BACKGROUND

Lightning-induced fires are the main naturally caused fires in the landscape, although it should be noted that human actions can influence lightning-fire occurrence to some extent by modifying fuel availability.

Fire occurrence information was obtained for this project from the Victorian Department of Sustainability and Environment for fires ignited on public land from 1 January 2000 until 31 January 2009.

Lightning fires were found to account for 90 per cent of the total area burnt by all fires, despite the fact that only 30 per cent of the fires were caused by lightning. This imbalance can partly be attributed to the Victorian alpine fires of January to March 2003 that burnt over one million hectares. Even without this event, lightning fires still account for a high proportion (55 per cent) of the total area burnt by all fires.

Almost all (96 per cent) of the lightning fires occurred between November and March, with January being the most common month for their occurrence (see Figure 1).

There does not appear to be a typical size for the total area burnt by a lightning fire, though smaller lightning fires generally occur more frequently than larger lightning fires (see Figure 2).

Similarly, there does not appear to be a typical duration of lightning fires, though shorter duration lightning fires generally occur more frequently than longer duration lightning fires (see Figure 3).

BUSHFIRE CRC RESEARCH

The lightning connection

Lightning data was obtained from GPATS, an Australian company that provides high technology lightning tracking devices and applications. Matching the starting time of each fire in the DSE database with the most recent lightning flash at the fire location indicates that the majority of lightning fires grow large enough to be observed less than a day after the lightning occurs (see Figure 4), with about three quarters of lightning fires being observed within three days, similar to reports from other parts of the world (Wotton and Martell, 2005).

On average, one fire occurred for every 160 lightning flashes that hit the ground. This is within the typical range of values reported elsewhere in the world (Wierzchowski, Heathcott and Flannigan, 2000). A single lightning flash, as seen by the human eye, can sometimes consist of two or more separate lightning discharges known as “strokes”. In terms of lightning strokes, it was found that one fire occurred on average for every 240 lightning strokes that hit the ground.

The time of day (or night) that lightning occurs was not found to have a large influence on the chance of a fire starting from each lightning stroke. Most lightning fires started in the afternoon, as this is when lightning most frequently occurs in Victoria. A strong seasonal influence exists, with the highest chance of fire per lightning stroke occurring during January. Lightning occurs most frequently in Victoria in January, thus compounding the problem.

Dry Lightning

Studies have shown that the chance of fuel ignition by lightning is relatively independent of fuel moisture, with some fuels igniting even though they may be very wet (Latham et al, 1997). However, the chance that an ignition is *sustained* is highly dependent on fuel moisture.

The amount of rainfall accompanying lightning in Victoria was found to have a large influence on the chance of fire per lightning stroke (see Figure 5). The likelihood of fire per lightning stroke is double the normal value when less than 2 mm of rainfall occurs, and four times the normal value with less than 1 mm of rain. If the rainfall is in the range 4-7 mm, the chance of fire per lightning stroke is about normal, with rainfall above 7 mm corresponding to a lower than normal chance of fire per lightning stroke.



▲ Bushfire CRC Project Leader Dr Graham Mills (left) and Bushfire CRC researcher Dr Andrew Dowdy are both from the Bureau of Meteorology, Victoria.

Dry lightning can occur in a number of ways, including:

- If a thunderstorm is high-based with relatively dry air at lower levels such that rain evaporates before reaching the ground (known as “virga”).
- If a thunderstorm is fast moving such that rainfall is spread thinly on the ground.
- If lightning occurs outside of the rain shaft of a thunderstorm – a phenomena commonly known as a “bolt from the blue”.

A method for predicting the likelihood of dry lightning has been developed for North American conditions (Rorig and Ferguson, 1999). The method uses two parameters: one parameter to indicate low atmospheric moisture levels (as represented by high dewpoint depression at the 850 hPa atmospheric pressure level) and another parameter to indicate high atmospheric instability (as represented by a large temperature difference between the 850 hPa and 500 hPa atmospheric pressure levels).

For Victorian conditions, it was found that high values of these two parameters indicate a higher than normal chance that lightning will be “dry” – similar to the results for North American conditions (Rorig and Ferguson, 1999), as well as a higher than normal chance that lightning will cause a fire (See Figure 6).

Fuel Moisture and Weather Conditions

An ignition is less likely to be sustained if the fuel is already wet before a lightning strike, regardless of whether the lightning is “dry” or “wet.” Fuel moisture was examined for three different classes of fuel using the Fire Weather Index System developed in Canada (Van Wagner, 1987, Dowdy et al, 2009A). The best indicator of a higher chance of fire from lightning was the moisture content of the fine fuels (see Figure 7) rather than the fuels of medium size or depth or the fuels of large size or depth. There was some indication that when one particular fuel type has high moisture content, an ignition can still sometimes be sustained by one of the other fuel types. However, it was also found that lightning fires are very unlikely to occur if the fuels of medium depth or size are very wet (as represented by the Duff Moisture Code of the Canadian Fire Weather Index System).

In terms of the weather conditions, relative humidity is better at indicating a higher than normal chance of fire per lightning stroke than temperature or wind speed. This order of importance is different to that of commonly used fire weather indices for which wind speed has the largest influence, followed by relative humidity and then least of all (contrary to popular belief) by temperature (Dowdy et al, 2009B).

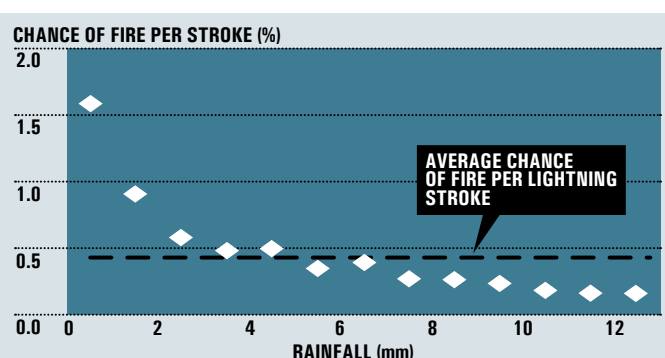


Figure 5. The amount of rainfall that accompanies the lightning, and how this influences the chance of fire per lightning stroke.

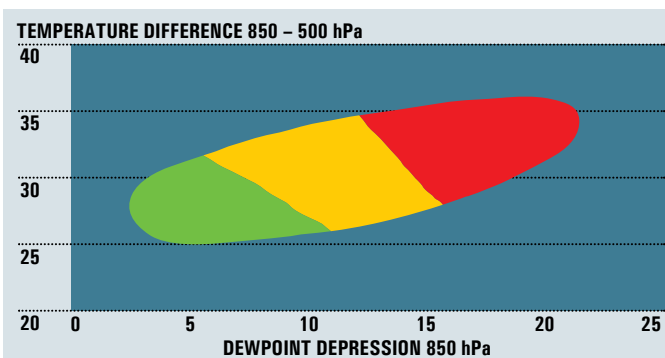


Figure 6: The chance of fire per lightning stroke: left is lower than average, middle is higher than average and right is more than two times higher than average.

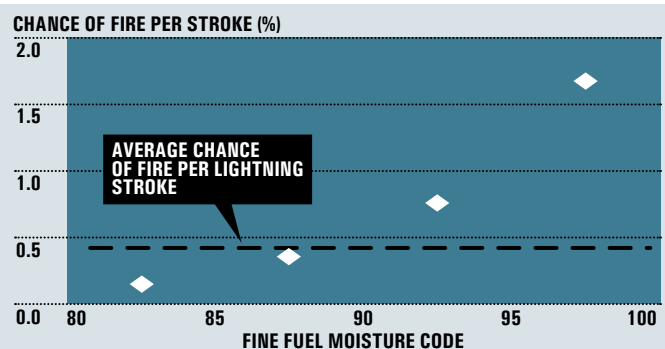


Figure 7: The chance of fire per lightning stroke shown for different values of the Fine Fuel Moisture Code of the Fire Weather Index System (higher values indicate drier fine fuels).

A higher than normal chance of fire per lightning stroke occurs for relative humidities below 38 per cent, temperatures above 26°C and wind speeds above 30 kmh⁻¹. Lower temperatures and higher relative humidities indicate a lower than average chance of fire per lightning flash, although this was not found to be the case for lower values of wind speed. This is once again different to what would be expected from fire weather indices for which lower wind speeds tend to indicate less severe fire weather conditions.

RESEARCH OUTCOMES

This research shows that the atmospheric conditions in which dry lightning occurs in southeast Australia are similar to those that have been shown to support dry lightning in the USA. This gives some confidence that the results of the research can be applied to other parts of southern Australia. In addition and for the first time, it was shown that forecasts of fine fuel moisture content indicate the probability of a lightning ignition being sustained. A forecast system based on these two components would provide an alert to those regions where lightning ignitions are more likely, with lead times of 24 to 48 hours.

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END USER STATEMENT

“This work gives us a valuable insight to lightning-caused fires. It is generally applicable to southern Australia and most of New Zealand. It also points to potential forecasting tools for enhancing fire management efforts in these areas. The research confirms similarities between North America and Australia which will encourage the uptake of overseas experiences. It also shows the utility of some of the components of the Canadian Fire Weather Index System (which has already been adapted to local conditions in New Zealand). This work boosts our capacity to manage lightning-caused fires in our variable and changing climate.”

– Mark Chladil, Fire Management Planning Officer, Tasmania Fire Service.

HOW THIS RESEARCH COULD BE USED

The characteristics of lightning fires, and the atmospheric states associated with them, show considerable similarities between different parts of the world. It is therefore likely that results obtained for Victorian conditions will have value for other locations.

It is intended that a forecasting method for lightning fires will be developed for trial in the extratropical states, based on the chance of dry lightning combined with forecasts of fuel moisture and weather conditions.

This forecasting method could potentially

be adapted to examine the influence of climate change on lightning fires. A North American study (Price and Rind, 1994) suggests a 44 per cent increase in the number of lightning fires for a doubling in atmospheric carbon dioxide level and there have been reports from other parts of the world of an increase in the number of lightning fires that have been occurring (Vazquez and Moreno, 1998). However, as yet there has not been any research undertaken into how lightning fires could be expected to change in Australia's future climate.

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AFAC is the peak representative body for fire, emergency services and land management agencies in the Australasia region. It was established in 1993 and has 35 full and 10 affiliate member organisations.