Background briefings on emerging issues for fire managers from AFAC and Bushfire CRC.

bushfire CRC afac

FIRE NOTE

TOPICS IN THIS EDITION
- RISK
- NATURAL ENVIRONMENT

ISSUE 123 APRIL 2014

PREDICTING DAILY HUMAN-CAUSED BUSHFIRE IGNITIONS

▲ Fire danger ratings determine likely fire behaviour if a fire were to break out, while this study sought to predict the number and probability of human-caused fires occurring.

SUMMARY

This research developed models that predict the number and probability of human-caused bushfires per day in south west Western Australia from bushfire incident records and weather data. Significant predictor factors used in these models included fuel moisture, the number of recent bushfires, the day of the week (or type of day, such as public holidays) and rainfall.

Analysis shows that days with human-caused fires are more likely to occur on weekends and public holidays that coincide with days of low fuel moisture content, as well as days that follow periods of high fire activity.

The models performed well in regions around Perth, with reasonable accuracy of between 81 and 99% of the daily fire occurrences having daily fire counts within the predicted range. The models for these areas would be suitable for agencies to use to inform their daily operational resource planning. However, the models did not exhibit much day-to-day prediction variation in the regions along the southern coast, which experiences much fewer human-caused ignitions.

This study has relied on fire incident records, and demonstrates the importance of high quality data for allowing similar sorts of analyses and modelling.

ABOUT THIS PROJECT

This study is part of the fire load and suppression resourcing component of the *Fire development, transitions and suppression* project described in *Fire Note 94*.

AUTHOR

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CSIRO

CONTEXT

Fire danger rating systems provide an indication of the potential ignitibility, fire behaviour, suppression difficulty and damage caused by fires on a given day. While they are used to determine preparedness levels and issue public warnings, they do not explicitly relate to the probability or number of unplanned bushfires likely to occur.

Predictions of the number of bushfires likely to occur in a given area on a day would allow fire agencies to more accurately determine their resource needs, thereby helping to increase the probability of success of initial attack and managing the costs of over-preparedness against the consequences of under-preparedness.

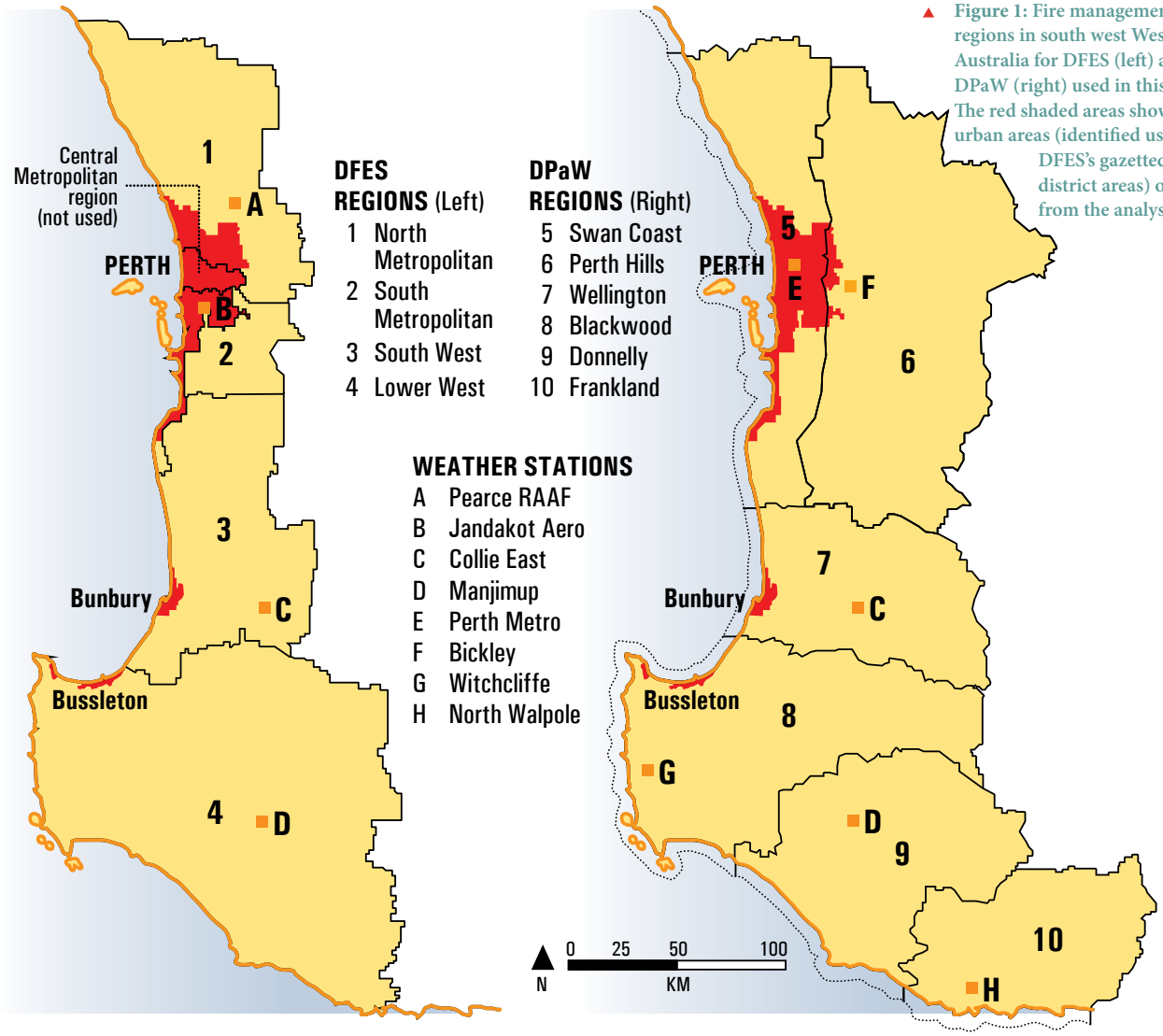
BACKGROUND

Fire agencies make daily resourcing decisions during the fire season based on fire danger ratings and the expected number of fires. Extra resources are made available, including pre-formed Incident Management Teams, and for tasks such as fire detection, arson prevention and initial fire attack on days when the fire danger or expected number of fires is high.

Daily fire occurrence models have previously been developed for regions in North America and Europe (e.g. Albertson et al. 2009, Magnussen and Taylor 2012), with some designed for operational use (e.g. Wotton and Martell 2005). These models are not readily transferrable to other locations due to differences in fuel availability and causal factors, compounded by differences in climate, vegetation, land use, fire restrictions and local culture.

These models feature factors that account for variation in fuel availability and causal agents. Fuel availability factors include inputs such as fuel moisture content and fire danger indices. Causal agents may be represented by a range of variables, such as lightning strike

FIRE MANAGEMENT REGIONS IN SOUTH WEST WA



▲ **Figure 1:** Fire management regions in south west Western Australia for DFES (left) and DPaW (right) used in this study. The red shaded areas show the urban areas (identified using DFES's gazetted fire district areas) omitted from the analysis.

density, recent bushfire activity and the type of day (i.e. weekends and school holidays, which are linked to fire cause types). For this reason most fire occurrence models are specific to fires originating from either natural (lightning) or human activity.

BUSHFIRE CRC RESEARCH

This research used fire incident data from south west Western Australia to develop models predicting the number of human-caused fires in the management regions of the two local fire agencies – the Department of Fire and Emergency Services (DFES) and the Department of Parks and Wildlife (DPaW). This region sees around 1000 bushfire ignitions per year, with more than 90% of these attributed to human activity. 70% are suspected arson (Bryant 2008). For this reason, the study only considered fires attributed to human activity. Most ignitions occur around Perth and the urbanised areas along the west coast, while the sparsely populated areas along the southern coast receive relatively few human-caused ignitions.

Human-caused bushfires were categorised as deliberate, accidental or unknown. Deliberate ignitions were those lit with malicious intent (arson). Accidental ignitions were unintentional and included fires attributed to machinery, campfires, vehicles and escapes from prescribed burns. The unknown ignition category was comprised of fires where the ignition cause could not be determined and lightning was not suspected. The research team investigated deliberate and accidental ignitions independently and developed models for these to determine if there are different factors driving them and the influence of these factors.

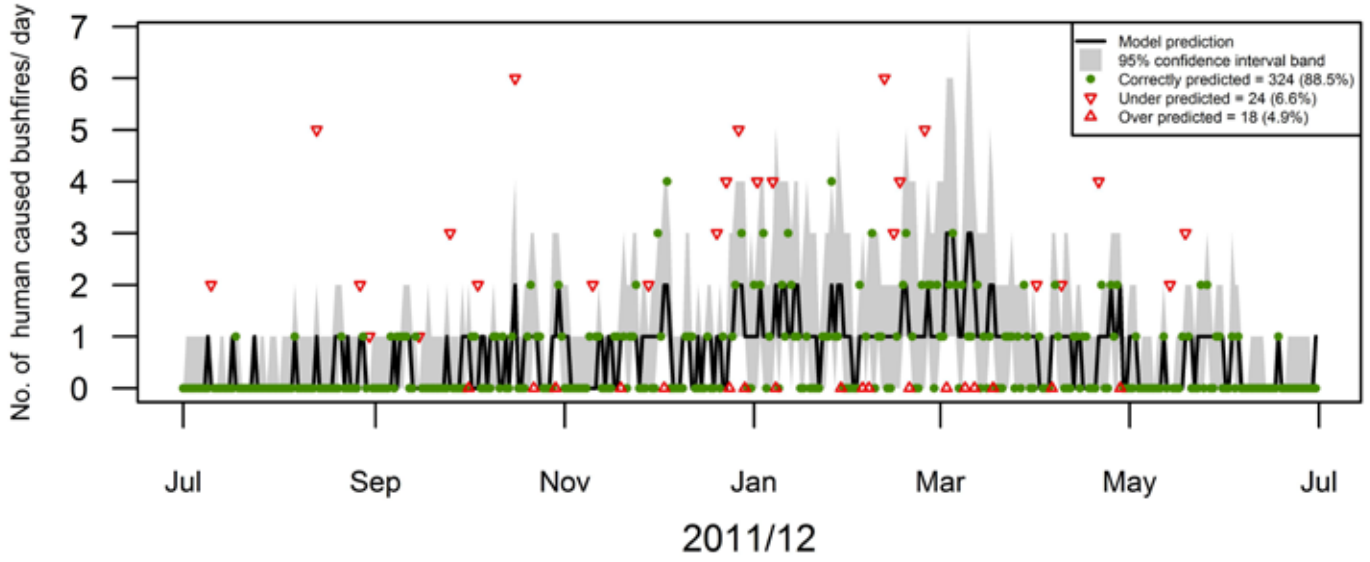
Fire incident records from DFES and DPaW were matched with weather data for the corresponding fire management regions (figure 1). The weather data was obtained from a representative station in each region and included observed air temperature, relative humidity, wind speed, rainfall, modelled fuel moisture and drought and fire danger indices. Each dataset included the total number of daily human-caused bushfire ignitions that occurred in non-urban areas within each region over four fire seasons (2008/2009, 2009/2010, 2010/2011 and 2011/2012) regardless of land tenure or responding agency.

From these datasets, models predicting the daily number of bushfires and the probability of a day having one or more human-caused bushfires were developed.

The first three years of each dataset were used for model development, while the data from the final year were reserved for model testing. A broad range of weather and day-type variables were considered during model development.

The models predicting the number of human-caused fires per day provide an estimate of the range of fires expected, based on the conditions (figure 2).

PREDICTING HUMAN-CAUSED FIRES



▲ Figure 2: Graphical examples of the model fit to the North Metropolitan DFES region during the 2011–12 evaluation season.

RESEARCH OUTCOMES

This study has relied on fire incident records, and demonstrates the importance of high quality data for allowing similar sorts of analyses and modelling. It would not have been possible without this high quality data.

The models developed in this study have reasonable accuracy, with between 81 and 99% of the daily fire occurrences in the evaluation year having daily fire counts within the predicted range. However, only those developed for areas that experience high numbers of fires showed enough day-to-day prediction variability to be of practical use. The models for these areas (Swan Coast, Perth Hills, Wellington, North Metropolitan, South Metropolitan, South West and Lower South West) would be suitable for agencies to use to inform their daily operational resource planning.

The models showed the most useful variables for inclusion in the predictive fire occurrence models were (in order of importance):

- The daily minimum fuel moisture content.
- The number of human-caused bushfires within the region over the previous two weeks.
- Day of the week (a binary variable separating weekends and public holidays from other days).
- Rainfall over the previous 24 hours.

Findings show that fuel moisture content had a better explanatory power for predicting fires than weather and fire danger variables that combine fuel availability and wind inputs. This is because the moisture content of surface litter is strongly linked to the sustainability of ignition and the availability of fuels to support combustion, whereas wind contributes more to fire spread.

END USER STATEMENT

Understanding the main factors that determine the incidence of human-caused bushfires can assist with planning for suppression response on a day to day basis. This is important in a region like south west Western Australia, where fire weather conditions can vary widely from one management area to the next, and the fire season typically extends from October to May, and can be even longer in dry years. This research has made effective use of fire report information gathered routinely by management agencies, and illustrates how fire report information can be used to better inform managers about patterns and trends in bushfire ignition.

– Murray Mitchell, Senior Fire Operations Officer, Department of Parks and Wildlife Western Australia.

Recent fire activity variables have been used for fires that have been deliberately lit and relate to crime theories. These theories suggest that recent arson fires without prosecution may indicate a low chance of copycat arsonists being caught. Additionally, the use of day type variables in the models indicates that fires are more likely to start during weekends, school holidays and public holidays. This is consistent with the findings of previous studies. Total fire bans are more likely to affect accidental ignitions than deliberate ignitions, as the latter are clearly malicious and probably done in spite of the law.

Models developed for deliberate fires and accidental fires were similar in format, indicating that these different ignition classes are most likely to occur during similar conditions. These models had poorer fits than those for all human-caused fires because of the higher frequency of days without fires in the individual cause specific subsets.

The most common problem with the fits for all models was the under-prediction on days with the highest number of fires. This is a common problem in count models developed with data sets that have high zero counts and a variety of counts occurring in similar conditions. This problem is not possible to overcome, as any model based on fire records would incur the same problem because of the randomness in the data.

The three year training dataset was shorter than many of those used in previous studies based on fire incident records (e.g. Wotton and Martell 2005; Magnussen and Taylor 2012). This study investigated the effect of the duration of the training dataset, and found very little difference in the model outcomes. This suggests that the factors driving human-caused ignition are relatively constant in south west Western Australia. As dataset length increases and data from further in the past is used, the comparability of models to current fire activity may also be affected by changes in ignition factors, such as policies related to the setting of fire restrictions, laws related to arson, changes in population distribution and density resulting from urbanisation and changes in land use.

HOW COULD THE RESEARCH BE USED?

The analysis and modelling undertaken in this project have shown that days with human-caused fires are more likely to occur on weekends and public holidays that coincide with days of low fuel moisture contents.

▲ The models developed could help agencies with daily operational resource planning.
Photo: Leigh Sage, WA Department of Parks and Wildlife

Similarly, days following periods of high fire activity are also likely to experience higher numbers of human-caused fires.

WA agencies can implement the models as decision support aids in the relevant management areas following some small system developments. The simple equilibrium fuel moisture input could be estimated from weather forecasts that provide the minimum daily relative humidity and corresponding air temperature for the days required. The rainfall input could also be estimated from weather forecasts or determined from morning observations. The number of human-caused fires in the previous two weeks could be readily determined from recent regional incident records for a current or next day forecast.

Predictions of the number of expected fires can be used in conjunction with fire danger indices to more accurately determine the daily need for fire management resources, thereby increasing the probability of initial attack success. This would help manage the cost of being over-prepared against the consequences of being under-prepared.

FUTURE DIRECTIONS

The methods developed during this project can be applied to develop similar predictive tools for day-to-day fire planning operations in other regions with suitable fire incident and metrological records. Daily fire occurrence models could be developed across Australia and be used to inform pre-emptive resource sharing between management regions.

Extension work using this dataset investigated the timing of fires from specific causes at a range of scales and in terms of weather. It also examined the effects of fire prevention measures and significant fire events on ignition rates. The results will help the targeting of fire awareness and prevention campaigns.

REFERENCES /FURTHER READING

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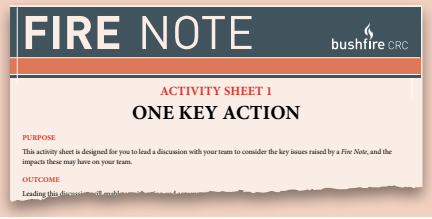
NOW WHAT?

What three things stand out for you about the research covered in this *Fire Note*? What information can you actively use, and how? Tools are available at www.bushfirecrc.com/firenotes to help, along with activities you can run within your team.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ACTIVITY SHEET 1

ONE KEY ACTION

PURPOSE

This activity sheet is designed for you to lead a discussion with your team to consider the key issues raised by a *Fire Note*, and the impacts these may have on your team.

OUTCOME

Fire Note is published jointly by the Bushfire Cooperative Research Centre (Bushfire CRC) and the Australasian Fire and Emergency Service Authorities Council (AFAC). This Fire Note is prepared from available research at the time of publication to encourage discussion and debate. The contents of the Fire Note do not necessarily represent the views, policies, practices or positions of any of the individual agencies or organisations who are stakeholders of the Bushfire CRC.

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AFAC is the peak body for Australasian fire, land management and emergency services, creating synergy across the industry. AFAC was established in 1993.