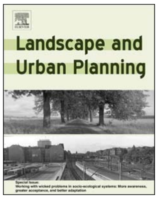
Landscape and Urban Planning 167 (2017) 267–274

Contents lists available at ScienceDirect

Landscape and Urban Planning

journal homepage: www.elsevier.com/locate/landurbplan



Research Paper

Electrically caused wildfires in Victoria, Australia are over-represented when fire danger is elevated

Claire Miller[a], Matt Plucinski[b,*], Andrew Sullivan[b], Alec Stephenson[a], Carolyn Huston[a], Kay Charman[c], Mahesh Prakash[a], Simon Dunstall[a]

[a] Data61, CSIRO, Clayton, VIC, Australia
[b] Land and Water, CSIRO, Canberra, ACT, Australia
[c] Department of Environment, Land, Water and Planning, Melbourne, VIC, Australia

ARTICLE INFO

Keywords:
Wildfire occurrence
Electricity distribution
Wildfire ignition
Fire danger

ABSTRACT

Electricity distribution infrastructure causes fewer wildfires than most other sources of ignition. However, these fires have been associated with more severe consequences than those from other causes. This paper examines whether fires caused by faults in electricity distribution infrastructure occur more often during periods of elevated fire danger, thereby increasing their consequence. The occurrence of wildfires caused by electricity distribution infrastructure were compared to those attributed to other causes during periods of elevated fire danger across the State of Victoria, Australia, where historically such fires have had significant impact on lives and assets of value. The results provided strong evidence that fires caused by electrical faults are more prevalent during elevated fire danger conditions and that they burn larger areas than fires ignited by most other causes. As a result the consequences of fires caused by electricity infrastructure are worse than fires from other causes. This knowledge highlights the importance of mitigating ignition-causing faults in the electricity network, particularly on days of elevated fire danger.

1. Introduction

Electrical distribution lines and associated infrastructure have been associated with the cause of many wildfires around the world including in the United States, Spain, and Australia (e.g. Collins, Penman, & Price, 2016; Curt, Fréjaville, & Lahaye, 2016; Martinez, Vega-Garcia, & Chuvieco, 2009, Syphard & Keely 2015, Xu, Zhang, Chen, Wu, & Li, 2016). The State of Victoria, Australia, has a long history of numerous large-scale wildfire events attributed to the electricity distribution network with the majority occurring on days with extreme fire weather conditions. Examples include the February 12, 1977 (McArthur, Cheney, & Barber, 1982) and "Ash Wednesday", February 16, 1983 (Country Fire Authority, 1983). More recently, six of the major fires on "Black Saturday", February 7, 2009, were caused by faults in the electrical distribution network (Gray 2015; Teague, McLeod, & Pascoe, 2010). These wildfires collectively burnt over 270 000 ha, caused the death of 159 people and destroyed 1832 homes (Teague, McLeod, & Pascoe, 2010). In the aftermath of many of these incidents, inquiries have recommended improvements to the way electrical infrastructure is managed, particularly on days of peak fire danger (e.g. Teague, McLeod, & Pascoe, 2010; Gray 2015). With the impact of climate change expected to increase the frequency and severity of peak fire danger days around the world (e.g. Flannigan, Krawchuk, de Groot, Wotton, & Gowman, 2009), understanding the factors that influence the occurrence of such fires is critical to reducing their impact, particularly in landscapes not previously prone to such fires.

Electricity infrastructure can ignite wildfires through arcs, molten and combusting metal particles that are expelled when vegetation contacts wires, and from burning insulation fluids in equipment such as transformers and re-closers (Coldham 2011; Russell, Benner, & Wischkaemper, 2012). When these small but very hot sources come in contact with fuel, such as grass and leaf litter, they can ignite a fire (Coldham, Czerwinski, & Marxsen, 2011; Fernandez-Pelloet al., 2015; Urban Zak, & Fernandez-Pello, 2015). If the conditions of the day are conducive to fire spread such ignitions can escalate into wildfires. These wildfires are hereafter referred to as electrical fires.

Fire danger indices are used to estimate the potential for fires to

---

* Corresponding author at: GPO Box 1600, Canberra, ACT, 2601, Australia.
E-mail addresses: claire.miller1990@gmail.com (C. Miller), matt.plucinski@csiro.au (M. Plucinski), Andrew.Sullivan@csiro.au (A. Sullivan), Alec.Stephenson@data61.csiro.au (A. Stephenson), Carolyn.Huston@data61.csiro.au (C. Huston), kay.charman@delwp.vic.gov.au (K. Charman), Mahesh.Prakash@data61.csiro.au (M. Prakash), Simon.Dunstall@data61.csiro.au (S. Dunstall).

http://dx.doi.org/10.1016/j.landurbplan.2017.06.016
Received 27 July 2016; Received in revised form 16 May 2017; Accepted 25 June 2017

start, spread and cause damage (Chandler, Cheney, Thomas, Trabaud, & Williams, 1983). In Australia, the Grassland Fire Danger Index (GFDI) (McArthur, 1966) and the Forest Fire Danger Index (FFDI) (McArthur 1967) are used to produce fire danger ratings. In each of these systems a numeric index is calculated from weather and fuel availability. Other similar systems are used in other parts of the world (e.g. Deeming, Burgan, & Cohen, 1977; Stocks et al., 1991). Categorical Fire Danger Rating (FDR) classes are assigned to defined ranges of index values. The rating classes used are Low, Moderate, High, Very High, Severe, Extreme and Catastrophic. Total fire bans are declared for days when the maximum forecast FDR has a Severe or higher rating (i.e., GFDI or FFDI ≥ 50).

The general incidence of vegetation fires from electrical sources throughout the year is low, typically 1.5-3% of all fires across Victoria (Marxsen, 2016; Mitchell, 2013), 1.6% around Perth, Western Australia (Plucinski, 2014), about 2.2% across Australia (Bryant, 2008) and 1% in California (Mitchell, 2013). However, there has been a general perception as a result of the many inquiries that electrical fires on days of elevated fire danger are much more prevalent and have greater consequences in regard to area burnt and level of destruction than fires from other sources

There has been little research investigating the effect of timing and weather on the occurrence of wildfires from specific causes, especially electrical fires. Mitchell (2009, 2013) found that the number of electrical fires increased rapidly with increases in wind speed in southern California and were disproportionately high during periods of dangerous wildfire weather compared to those ignited by other causes. This study also found that electrical fires burned considerably larger areas on average than fires from other ignition sources, and that there is an association between strong winds, powerline faults and rapid fire spread (Mitchell, 2013). Similar findings were also reported by Syphard and Keeley (2015) with regard to larger burned areas and the occurrence of electrical fires during the months of the year associated with extreme wind events.

Plucinski (2014) investigated links between fire danger and ignition sources in South-West Western Australia and found no statistically significant relationships between electrical fires and fire danger. However, this study demonstrated the importance of extreme weather conditions in explaining high occurrence rates for fires from other ignition causes with small heat outputs, such as sparks from machinery and discarded cigarettes.

The aim of this paper is to determine if the occurrence of electrical fires on elevated fire danger days is disproportionate compared to other ignition sources in the State of Victoria, Australia and to identify possible explanations if this is the case. The paper also compares the size of electrical fires with those from other sources: lightning, arson, escapes, and other accidental fires.

2. Methods

2.1. Consolidation of ignition data

Records for vegetation fires (fires ignited in landscape vegetation that could potentially develop into wildfires) across the State of Victoria, Australia, were obtained from the Country Fire Authority and the Department of Environment, Land, Water and Planning for the period from 1 January 2002 to 31 March 2013. Each fire incident report specified: the time of detection to the nearest minute, an ignition cause category, and geographic coordinates. Ignition causes were determined by trained senior firefighters. The two databases had different ignition cause categories which were revised to six major fire cause categories in a combined dataset (Table 1).

Fire incidents within urban areas were removed from the dataset as they generally did not have the potential to burn large areas and affect landscapes. For our analysis, urban areas were defined using the Australian Bureau of Statistics Significant Urban Areas spatial database (ABS, 2011). Each ignition point was also assigned to one of two broad vegetation types, forest or grassland (Sullivan, McCaw, Cruz, Matthews, & Ellis, 2012) to correspond with the application of the Forest and Grassland FDR systems. Any fires not involving landscape vegetation, for example garden, building or vehicle fires, were removed from the dataset.

2.2. Fire danger calculations

Half hourly weather data was obtained from the 78 Commonwealth Bureau of Meteorology weather stations across Victoria for the 11 years of the study and the preceding two years, which were used to allow calculated drought indices to stabilise. Fire events were linked to the closest station with data available at the time of ignition.

The data from each station were used to calculate fuel moisture content and the Forest and Grassland Fire Danger Indices (FFDI and GFDI) (McArthur, 1966, 1967). Fuel moisture content was determined using a simplified version of Matthews, Gould, & McCaw's (2010) equations, which correspond with tables presented in Gould, McCaw, Cheney, Ellis, & Matthews (2007). FFDI and GFDI were calculated using the equations given by Noble, Bary, & Gill (1980). FFDI required the calculation of the Drought Factor, which was determined using the method of Finkele, Mills, Beard, & Jones (2006). The Keetch-Byram Drought Index (Keetch & Byram, 1968) is an input for calculating Drought Factor and requires daily records of rainfall and maximum temperature. If these were not available for a station, values were sourced from SILO gridded data (Jeffrey, Carter, Moodie, & Beswick, 2001; SILO 2016). As there were no available records of grass curing levels for the calculation of GFDI, curing was assumed to follow a sinusoidal relationship with Julian day (e.g. Gill, King, & Moore (2010)) and be fixed across space using the equation

$$Curing\,(\%) = \min\left(48 \times \left(1.4 + \cos\left(\frac{y-39}{365} \times 2\pi\right)\right), 100\right),$$

where y is Julian date.

2.3. Analysis procedure

Four different approaches were used to investigate the prevalence of electrical fires during normal and elevated fire danger conditions. The first approach considered the overall prevalence of electrical fires compared to those from other causes by comparing the proportions of fires attributed to each cause. The statistical significance of the relationship between odds of occurrence for fires at different conditions were assessed using a Poisson generalized linear model (Agresti, 2002) calculated using R (R Core Team, 2014).

The second approach was to consider the occurrence of fires from different cause categories during periods of elevated fire danger, defined as times when fire danger indices were greater than 50. This coincides with the ratings Severe ($50 < \text{GFDI} \leq 100$ and $50 < \text{FFDI} \leq 75$), Extreme ($100 < \text{GFDI} \leq 150$ and $75 < \text{FFDI} \leq 100$) and Catastrophic ($\text{GFDI} > 150$ and $\text{FFDI} > 100$).

The third approach studied the weather associated with ignitions. This applied summary statistics and kernel density plots to weather conditions for each ignition type. The summary statistics reported were: median, mean, skew, and inter-quartile range (IQR). Skew indicates the asymmetry of the estimated distributions, with a positive skew implying a longer tail at the higher value end of the distribution. IQR calculates the spread of this distribution, with a higher value indicating an increased spread over the factor values.

The kernel density plots represent the estimated distribution of fires taken over each of the weather variables listed in Table 2. These density plots were truncated to show only the extreme quartile range of the data as it was found that the main differences between ignition types were in the extreme ends of each variables' distribution. The extreme