Journal of Environmental Management 90 (2009) 2819–2822

Contents lists available at ScienceDirect

Journal of Environmental Management

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

100-years of Australian bushfire property losses: Is the risk significant and is it increasing?

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ARTICLE INFO

Article history:
Received 19 October 2007
Received in revised form
24 December 2008
Accepted 29 March 2009
Available online 1 May 2009

Keywords:
Bushfire
Property losses
Australia
Global warming

ABSTRACT

This study examines the bushfire (wildland fire) risk to the built environment in Australia. The most salient result is that the annual probability of building destruction has remained almost constant over the last century despite large demographic and social changes as well as improvements in fire fighting technique and resources. Most historical losses have taken place in a few extreme fires which if repeated are likely to overwhelm even the most professional of fire services. We also calculate the average annual probability of a random home on the urban–bushland interface being destroyed by a bushfire to be of the order of 1 in 6500, a factor 6.5 times lower than the ignition probability of a structural house fire. Thus *on average* and if this risk was perceived rationally, the incentive for individual homeowners to mitigate and reduce the bushfire danger even further is low. This being the case and despite predictions of an increasing likelihood of conditions favouring bushfires under global climate change, we suspect that building losses due to bushfires are unlikely to alter materially in the near future.

1. Introduction

The threat of bushfires (wildland fires) casts a malevolent shroud over many Australian communities. In terms of property loss, the potential is greatest at the urban–bushland interface and quantifying this threat is essential for developing rational planning regulations and fair and realistic insurance premiums. This paper examines this threat as its main focus.

Our study will draw upon Risk Frontiers' disaster database of historic building losses –*PerilAUS* – which provides a reasonably faithful testimony of national building losses from 1900. (Description of the *PerilAUS* database itself is deferred until the Methodology section.) Fig. 1 shows the annual aggregate numbers of buildings destroyed by bushfire since 1926. The average toll is 84 buildings per year, a figure compiled from years with no or few losses together with occasional extreme excursions. The episodic nature of these large event losses will be taken up in later discussion.

How important are bushfire losses in the wider scheme of things? One way to answer this question is to compare total building losses arising from bushfire with those from other natural hazards. Fig. 2 shows that, over the past century, tropical cyclones have been the most destructive, accounting for some 30% of losses, with floods and bushfires each responsible for another 20% as are thunderstorms when losses from hail, wind gust and tornado are combined (Blong, 2004). Heatwaves have been responsible for the largest number of fatalities (Coates, 1996), but this paper restricts its focus to building losses alone.

Another source of information is the Insurance Council of Australia's (ICA) database of significant insured losses (>$A10 million). The database began after the 1967 Hobart bushfires, the first year for which reliable figures for industry losses were available. These losses have been recently normalised to account for changes in inflation, population and wealth and in the case of tropical cyclones losses, changes in construction standards (Crompton and McAneney, 2008). Normalised figures estimate likely losses as if historical events were to reoccur with 2006 population exposure and societal conditions. Seventeen bushfire events are recorded on this database with one, the 1983 Ash Wednesday event, making the top ten (Table 1) 'most costly' natural disasters in Australia.

Table 1 suggests that, while historic bushfire events may have lacked the destructive power of certain tropical cyclones and hail storms, they can on occasions be significant. Of the more extreme events, some 2300 homes were lost in the 1983 Ash Wednesday fires in Victoria and South Australia; in 1967, another 1300 in Hobart, Tasmania, and, more recently, in 2003, 506 in Canberra (Fig. 1).

The raw loss statistics discussed above conceal the role individual homeowners may play in defending homes and increasing the likelihood of survival of both themselves and their homes

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0301-4797/$ – see front matter
doi:10.1016/j.jenvman.2009.03.013

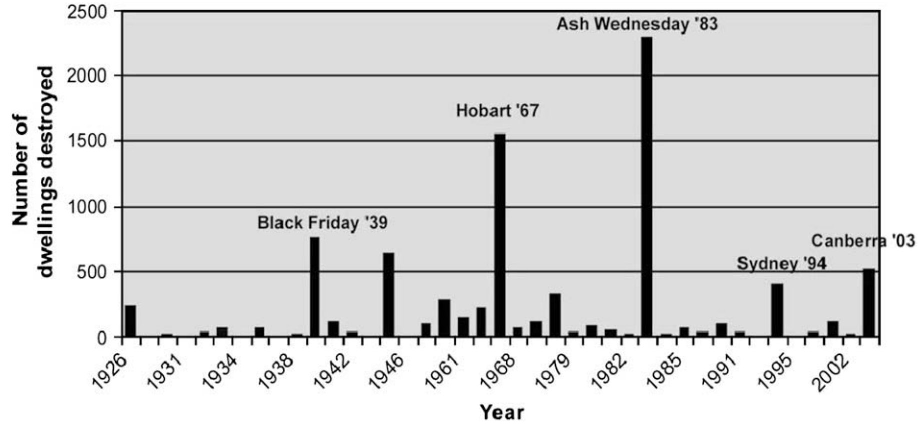

Fig. 1. Annual number of dwellings lost to bushfires since 1926.

(Wilson and Ferguson, 1984; Handmer and Tibbits, 2005; Leicester and Handmer, 2007). In fact, based on evidence that nearly all bushfire related deaths occur out in the open when people are exposed to high levels of radiant heat and smoke, often during evacuation (Haynes et al., 2008), Australian fire authorities now encourage homeowners to be either prepared to defend their homes or evacuate early, well before the fire front approaches (Leicester and Handmer, 2007; Tibbits et al., 2008). To our knowledge, this policy is unique amongst countries with significant bushfire risks and clearly puts the actions of residents as central in the protection of lives and property. This being the case, we shall also briefly consider the likely influence of the perception of the bushfire risk by those living on the urban–bushland interface in respect to how this might affect their preparedness in the face of bushfire threats.

2. Methodology

The salient conclusions are drawn from examination of the *PerilAUS* database. This database has been compiled by painstaking examination of official records and early newspapers and records amounting to nearly 5000 natural hazard events from 1900 to 2003. Data entries were derived mainly from archival searches of the *Sydney Gazette* and *Sydney Morning Herald* (dating from 1803 and 1831, respectively) (Coates, 1996; Blong, 2004). In the case of bushfire and except for some years prior to 1926 where data are incomplete, it provides the best available national record of loss events from the 1900. Although the two newspapers are Sydney/New South Wales (NSW)-based, bushfire events that took place in other states beyond NSW are also well captured by other information sources, in particular, local newspapers and official records. Certainly, we believe that few fires that resulted in significant property losses have been overlooked.

Besides the historical analyses based upon the *PerilAUS* database, we also identify current properties at risk by their distance from the urban–bushland boundary. The latest Geocoded National Address File (PSMA, 2008) compiled from Government sources and regarded as Australia's most authoritative geocoded address database was employed. It contains about ten million addresses with known latitude and longitude. Medium-resolution Landsat 7 ETM+ images were used to classify bushfire-prone vegetation – forests and pine plantations. We focused on identifying areas greater than 0.5 km^2 of continuous bushland, i.e. areas that might allow large fires to develop and, on occasions, get out of control; small, scattered and discontinuous areas of vegetation were not considered. Given the locations of all addresses and bushland, the calculation of shortest distance between them is then straightforward. A number of sensitivity tests used to validate this methodology's fit-for-purpose were described by Chen and McAneney (2005).

3. Results

It is instructive to look at how building losses have changed over time and we examine this now. The historical evidence (Fig. 1)

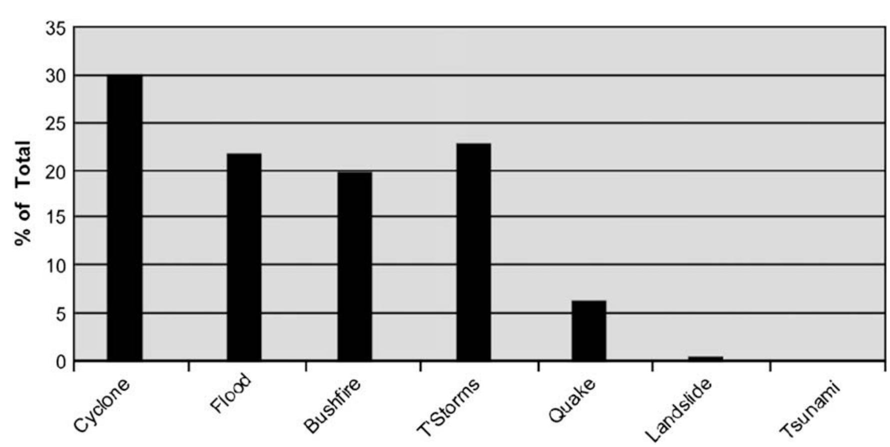

Fig. 2. Percentage of the accumulated building losses between 1900 and 2003 attributed to different perils. "T'storms" represents thunderstorms including hail, wind gust and tornadoes.

Table 1
The ten largest insurance disasters ranked by the indexed loss as if the historical event were to reoccur in 2006.

Rank	Year	Peril	Location	Original loss ($M)	Current loss (2006) ($M)
1	1989	Earthquake	Newcastle	862	4300
2	1974	Cyclone	Darwin	200	3650
3	1999	Hail	Sydney	1700	3300
4	1974	Cyclone-Flood	Brisbane	68	2090
5	1985	Hail	Brisbane	180	1710
6	1983	Bushfire	VIC, SA	176	1630
7	1990	Hail	Sydney	319	1470
8	1973	Cyclone	QLD/NT/WA	30	1150
9	1976	Hail	Sydney	40	730
10	1986	Hail	Sydney	104	710

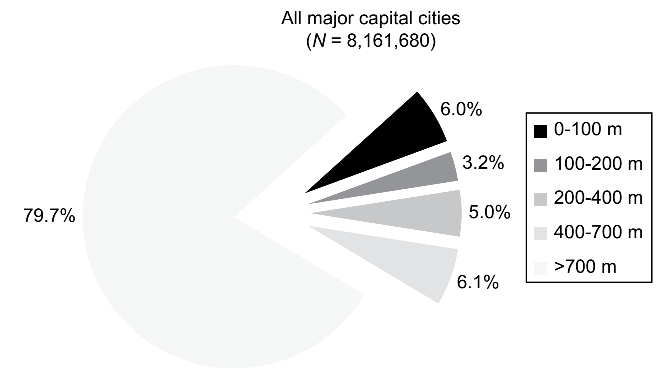

Fig. 3. Percentage breakdown of addresses by distance category from large areas of bushland.

shows no obvious trend. Table 2 lists a number of metrics drawn from *PerilAUS* related to the probability of losing homes due to bushfire. These statistics are calculated between the year at the head of each column (Table 2) and 2003. Thus the first column contains numbers calculated from 1900 to 2003, while those in the most right hand column are calculated between 1990 and 2003. 1926, 1939, 1967 and 1983 were each years with significant fires and building losses. Statistics based on years prior to 1926 were adjusted by eliminating years with missing data.

Table 2 is revealing: no complicated statistics are needed to show that the likelihood of losing homes to bushfire has remained remarkably stable over the last century with some building destruction expected in around 55% of years. This same stability is also exhibited for the bigger events with an *annual* probability of losing more than 25 or 100 homes in a single week remaining around 40% and 20% respectively. The time duration of one week has some relevance to reinsurance treaties, but is used here to identify major fire events and to filter out instances of high accumulated losses due to different fires widely spread over time and geography.

The second key result arises from categorizing addresses by distance from large areas of bushland. This is not the only variable determining bushfire vulnerability, but it is demonstrably the most important (Chen and McAneney, 2004). For this paper, we have employed five distance ranges (Fig. 3). Group 1 comprises addresses within 100 m of bushland and thus the most at-risk addresses. After adjusting for duplicates in the G-NAF street address database and for regions around major cities, we obtain a realistic upper bound on the national number of most at-risk addresses of about 550,000. The other four groups are in intervals out to and beyond 700 m from bushland, the maximum extent to which we have seen building loss in Australia (Chen and McAneney, 2004).

4. Discussion

That the statistics on home destruction (Table 2) have remained obstinately invariant over time is an intriguing and important result. We note that Australia's population has increased from around 4 to 20 million over the last century and 63% of people now live in capital cities rather than just 33% in 1900 (Trewin, 2006); life for most is now an urban experience. *A priori*, we might have expected the likelihood of bushfire losses to have increased with population or at least with the population living immediately adjacent to bushlands. The fact that this is not so is in part testament to the activities of firefighters and more effective weather forecasts and communications. However the constancy of the figures over time is intriguing and still remains to be explained.

Table 2
National bushfire building loss probabilities calculated between the start year and 2003. The first row gives the frequency of any (non-zero) loss while the second and third includes only those events that have resulted in more than 25 or 100 homes destroyed within a single week.

Start year	1900	1926	1939	1967	1983	1990
Annual probability of a non-zero loss	56%	53%	48%	57%	57%	57%
Annual probability of losing >25 homes in 1 week	39%	40%	42%	41%	38%	36%
Annual probability of losing >100 homes in 1 week	18%	19%	22%	19%	19%	21%

One possibility is that resources into fire fighting and education have increased over time *exactly* in balance with the presumably increasing risk. In other words, the political processes that govern the allocation of resources have established some sort of quasi-equilibrium between inputs and outcomes. Attractive as this thesis may be, it seems implausible, especially given that in the early part of last century there was little systematic attempt to learn from fire experience (Collins, 2006). It is also difficult to point to other areas of government where resource allocation is so finely tuned.

More credible is the argument that large losses occur rarely and under extreme weather conditions when fires get out of control and converge to create so-called mega-fires. This is easily demonstrated by reference to Fig. 1 where we see that just five such events have accounted for the majority of losses in the last 75 years. Once a fire exceeds a certain scale, there is very little that can be done to stop it until it either runs out of fuel or weather conditions change. A banal conclusion might be that large event losses can only be avoided if every fire that has the possibility of impacting a populated area is extinguished while still small enough to be manageable. In practice, however, there is a limitation to the most generous of resources.

As mentioned already, the risk is particularly high at the edges of towns or cities where suburbs adjoin bushland and where there is the potential for large numbers of homes to be destroyed. This being the case, building losses will be a function of the width of the fire front and if and how this front intersects populated areas, the disposition of homes vis-à-vis the bushland and whether or not homes are defended (McAneney, 2005). In short, we can regard building losses as a random variable.

Given that the average number of homes destroyed annually is 84 and having already assessed the number of the most at-risk addresses within 100 m of large areas of bushland at 550,000, we are now in a position to estimate the annual probability of a random home being destroyed by bushfire front. The result is roughly 1 in 6500, a figure that assumes the risk to be spread uniformly over the entire urban–bushland boundary.

In reality, the actual risk will vary widely from the average due to local conditions – position, slope and aspect in relation to dangerous wind directions – and occupier behaviour. Nonetheless the number can be compared with other risks commonly averaged over the population such as: the annual chances of having a motor vehicle stolen (∼1 in 200), being the victim of a robbery (∼1 in 1200) or dying in a traffic accident (∼1 in 11,000) (Trewin, 2006). The average annual ignition frequency of structural house fires is 1 in 1000 although most of these fires are confined to a single room (SCRCSSP, 2006). We explore the implications of these figures in the following discussion.

Despite often obsessive media focus on bushfires, the risk of a home near the urban–bushland interface being destroyed by bushfire is about a sixth of the risk of a structural fire and half the risk of a random person being killed in a traffic accident. That this risk seems low compared with other risks that society tolerates may explain why advice on how individuals can reduce their bushfire risk is often ignored. Additionally it has been demonstrated that other benefits that accrue from certain decisions, in this case living near bushland, can reduce perceptions of risk (Slovic et al., 2004). While the effect of this will vary depending on the knowledge and experience of individuals, there is little reason to doubt that the same mental heuristics that people employ to gauge other threats will often result in the bushfire peril being misjudged, or at least judged differently from experts (Slovic, 1987, 1999). Regardless of how individuals regard the risk, the prospect of thousands of destroyed homes and potentially dozens of fatalities – 60 civilians were killed in the 1983 Ash Wednesday bushfires – remains unpalatable from community and political perspectives; it is this concern that underpins ongoing efforts to control and mitigate bushfires. Insurers take a similarly jaundiced view about the prospects of large correlated losses.

Global climate change adds a further level of uncertainty to the above picture, both by increasing the likelihood of conditions that lead to bushfires (Pitman et al., 2007) and through unknown influences on the El Niño – Southern Oscillation cycle that affects Australian climate and weather (Powers et al., 1999). Nonetheless we believe that the near future impacts of global climate change are unlikely to be as dramatic as the combined changes of all of the other factors that have so far failed to materially affect the likelihood of building losses from bushfire over the last century. This is not to ignore the threat posed by global climate change but, at least in the case of fire in Australia, the main menace will continue to be the extreme fires. This threat can only be diminished by improved enforcement of planning regulations that restrict where and how people live with respect to distance from bushland. If all buildings were located at distances of 700 m or more from large areas of bushland, the likelihood of building losses would become vanishingly small. However, this is a political choice that must be made in the knowledge that the risk, even for those living at the urban–bushland interface, is relatively low on average.

5. Conclusions

This paper extends previous efforts to estimate the risk to the built environment from bushfires in Australia. The historical record shows very clearly that most building damage occurs during infrequent extreme events. Such extreme loss events will occur for a variety of reasons that will vary from one situation to another: worse droughts, high fuel loads, limited resources, failure of owners to mitigate their individual risk, poor decision-making or even poor outcomes to good decisions given the uncertainties of conditions in the field (McAneney, 2005).

The actual loss in a bushfire is a random variable that depends upon a host of variables including whether or not it intersects a populated area, the disposition of threatened houses and human intervention. Of special concern is the urban–bushland interface where the potential always exists for large losses. People enjoy living close to the greenery and will continue to do so despite the bushfire risk. We estimate the average annual likelihood of a random home on this urban–bushland interface being destroyed by bushfire is around 1 in 6500. This relatively low average probability of a household being impacted means that fire services will often struggle to make homeowners take this threat seriously. The recent Canberra fires provide a stubborn reminder that fire catastrophes will continue to occur and the stability of the probability of building losses over the last century gives little hope that another Ash Wednesday can be avoided.

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