

Economic Impact of Fire Weather Forecasts

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Abstract—Southeastern Australia, where the State of Victoria is located is regarded as one of the most fire prone areas in the world. The Australian Bureau of Meteorology provides fire weather services in Victoria as part of a national framework for the provision of such services. These services range from fire weather warnings to special forecasts for hazard reduction burns. Fire weather services are important inputs into the decision-making processes of fire management authorities that enable effective decision-making at various stages of fire management. The key beneficiaries of these services are the general community through better information provided to fire management authorities. This paper discusses the fire weather service that is provided by the Bureau of Meteorology and makes an attempt to measure the economic impact of such services for bushfires in Victoria focusing on both costs and benefits. The overall costs will relate to the direct and indirect cost of supplying the fire weather services, the cost of the fire mitigation and management efforts implemented as a consequence of these fire weather services and the cost of fire fighting and relief/recovery initiatives. The benefits will relate to minimization or avoidance of damage to timber assets, private property and public infrastructure, of agricultural production losses, of disruption to other economic activities, of human injury and fatalities; of damage to recreational sites and public amenities, of adverse ecological and environmental impacts, and of adverse effect on public health and general visibility due to smoke dispersion. Some of these benefits will have market values and the others non-market values. The benefit-cost comparisons can provide useful information for improvement of existing fire weather programs and also assist in making decisions on future investments in specific activities.

Introduction

Since mid 1960's Australia has experienced 20 to 25 major bushfire events. According to the Center for International Economics (CIE) (2001), this equates to one major bushfire event in approximately every one and half years. In addition to these large-scale major bushfires, every year many small-scale bushfire incidents occur across Australia, which cause damage to property and in some instances the loss of human life. CIE (2001) analysis based on State agency statistics indicated that average annual area burnt due to bushfires nationally in Australia (excluding Northern Territory) is around 440 000 hectares. (In Northern Australia, large areas burnt due to large-scale grass fires can distort the overall areas burnt and hence fire damages per area burnt.) In the state of Victoria, it is estimated that the average annual area burnt due to bushfires is around 110 000 hectares (CIE 2001). This means that 25 percent of the area burnt in Australia (excluding Northern Territory) due to bushfires generally takes place in Victoria.

Under the Meteorology Act 1955 among the functions of the Australian Bureau of Meteorology (Bureau) is “the issue of warnings of gales, storms and other weather conditions likely to endanger life or property, including weather conditions likely to give rise to floods or bush fires.” These functions are to be carried out in the public interest generally and in particular for the purpose of assisting persons and authorities engaged in primary production, industry, trade, and commerce”.

The provision of fire weather services to the fire agencies and the community is mainly through the Bureau's distributed service delivery structure. The Bureau operates a Regional Office in the capital city of each State and Territory in Australia, except in the case of the ACT, where a smaller satellite office is operated under the guidance of the NSW Regional Office in Sydney. Within the structure of each Regional Office, there is a Regional Forecasting Centre (RFC), which carries overall responsibility for forecast production and dissemination. Day to day operational output from each Region is the responsibility of the Senior Meteorologist who works

under the general direction of a senior line manager. Each Regional Office is operated under the guidance and direction of the Regional Director.

Fire Weather Services

The Bureau provides two broad categories of fire weather services. The first category is the services provided to the general public. These services include:

- Routine forecasts of fire danger during the fire season by way of public weather forecasts.
- Public fire weather warnings when the fire danger is expected to exceed a certain critical level.

The second category is the services provided to fire management authorities, civil defense organizations, police and other emergency services. These services include:

- Detailed routine forecasts during the fire season.
- Warnings when the fire danger is expected to exceed a certain critical level.
- Operational forecasts to assist in combating ongoing fires.
- Special forecasts for prescribed burns.
- Advice regarding the installation and operation of special meteorological stations operated by fire authorities.
- Consultative advice and climatological information to assist with assessment of risk, development of fire prevention strategy and other aspects of fire management.

In addition to the routine services provided each day during the fire season (November to May), the Bureau provides the following services when extreme fire danger is expected and/or when fires are burning. These include:

- Fire weather warnings issued on a District basis when the fire danger is expected to reach extreme. These are issued publicly and are used by the Country Fire Authority (CFA) as a key input into decisions about the declaration of a total fire ban.
- Wind change charts. These are issued to the fire agencies on days of significant fire risk when a wind change is expected to affect the State. These charts show the current and expected future position of the wind change and are used by fire agencies when developing operational fire management strategies and tactics.
- Spot fire forecasts. These are highly detailed fire weather forecasts that are issued for specific locations in which a fire is burning or where a controlled burn is planned. They include information on the expected wind, temperature, relative humidity and other

meteorological factors such as the timing of any wind changes. They are provided to the Incident Controller of the fire agency that is dealing with the specific fire and are also sent to the central fire control centres of both the CFA and the Department of Sustainability and Environment (DSE), in the case of Victoria. The spot fire forecast is broken up into three sections: the first section contains the general weather scenario and weather conditions for a specific location at +3 hours, +6 hours, +9 hours, +12 hours, and +24 hours. The second section contains a possible alternative weather scenario, to allow the fire agencies to undertake contingency planning. The third section is utilized by fire agency staff for the provision to the Bureau of observations of actual fire site weather conditions – this is valuable information that greatly assists the forecasters in making accurate predictions.

- On request, the Bureau can provide a forecaster at CFA Headquarters on critical days and, for large on going fires, a forecaster may be “outposted” to a fire incident control centre.
- Regular consultation is maintained between Bureau forecasters and the fire agencies. Bureau staff provides detailed briefing to fire chiefs, senior operational personnel and participate in operational briefings, both in person and by teleconference.

Direct Cost of Fire Weather Services

The provision of the meteorological information including fire weather forecasts is based on three essential processes: first, observing and monitoring the current state of the atmosphere and ocean; second, understanding the physical mechanisms of weather and climate forming processes in order to formulate numerical models of the atmosphere and ocean; and third, feeding the observed ‘initial’ data into these models, in real time, to predict the future evolution of the atmosphere as a basis for providing a wide range of forecast, warning and advisory services (Zillman 2002). Generally speaking, in many countries including Australia, these three processes are funded by the national governments. In other words, the basic meteorological infrastructure, data collection and basic research are taxpayer funded. Furthermore, their overall costs spread across a wide range of forecasts, warnings, and advisory services, given the economies of scale, scope and size of meteorological service provision. In this paper these costs are not considered and are assumed to be sunk costs for the provision of routine fire weather services by the Bureau.

The key focus here is on the direct costs of the additional fire weather services made available to fire and emergency authorities above and beyond what is available to the general public by the Victorian Regional Office of the Bureau. The following is an annual average estimate of these various direct costs that are incurred by the Victorian Regional Office. These estimates are based on standard accounting procedures and charging rules adopted by the Bureau. These estimated direct costs add up to around \$0.40 m per year.

- Three fire weather forecasters provide operational support to the fire agencies on a daily basis during the fire season (November to May) (\$ 0.2 m).
- One to two forecasters are outposted as onsite weather forecasters during major bush fires in specified locations or two forecasters are outposted as on site weather forecasters during major bush fires in specified locations (on average this would happen about 2 weeks per year although there is variation from year to year). Training is a significant component, probably about 4 weeks per year for one person (\$ 0.009 m).
- Cost of providing computing and administrative support (\$0.007 m).
- Cost of telecommunication services. This covers the cost of receiving extra observations from Automatic Weather Stations (AWSs) at high frequency during the fire season, and in particular during high risk fire weather days (\$0.008 m).
- Cost of research support into smoke plume modeling (\$ 0.05 m).
- Other related costs including balloons (\$0.001m).
- Cost of operating additional AWSs and other equipment (including depreciation costs). The CFA has in the past operated its own AWS network of 8 across the State of Victoria (\$0.064m).
- Cost of operating eight portable AWSs on behalf of the CFA and three AWSs on behalf of the DSE (including depreciation costs) (\$0.031m).

The Bureau is currently using additional resources allocated as part of the extra funding from the newly established Cooperative Research Center (CRC) for Bushfires to finance the efforts to improve the fire weather services in Australia. Those additional funds amount to around \$0.4 million per year for 7 years, which commenced in 2003-04 (that is, \$2.8 million over 7 years). These additional funds are treated as the additional cost of improving the accuracy, timeliness and the nature of the enhanced fire weather services provided by the Bureau. It is expected that these improvements will enable the Victorian Regional Office to enhance the fire weather services that it currently provides to the fire management authorities, civil defense organizations,

police and other emergency services, and hence to the general community.

Benefits for the Users

Assessing the benefits of fire weather information to the users is not an easy task. It is not appropriate to start from a situation where no fire weather information is available (see Sol 1994) because there is routine information on fire weather available to the general public in an ongoing basis. Hence, the purpose here is to focus on the benefits of additional information made available to fire and emergency authorities over and above what is available to the general public.

The benefits to the users of fire weather information can be assessed in the form of reduced losses from better use of fire weather services provided by the Victorian Regional Office of the Bureau. The potential benefits or reduced losses could be wide ranging depending on the location and circumstances of the specific bushfires cases. The potential benefits of reduced impact of bushfires can be viewed from the perspective of economic/commercial, social and environmental outcomes. The economic and/or commercial outcomes may involve reduced damage to timber assets, property and infrastructure, buildings, fences and vehicles, farm production, activities of businesses, personal belongings, etc. The social outcomes could range from reduced human fatalities, injuries and illnesses, psychological trauma, and destruction of personal memorabilia. The environmental outcomes may include reduced damage to native flora and fauna, water quality, amenity values, and reduced greenhouse gas emissions (see CIE 2001). Failure to reduce the impact of bushfires means a range of costs on the community and the economy. Some of these costs have market values (tangible) and can be easily quantifiable while others have non-market values (intangible) and may not be easily quantifiable.

Using the analysis presented by CIE (2001) based on data and information from Emergency Management Australia and various electronic records held by State land management agencies in Australia, Gunasekera and others (2004) have calculated the damage costs due to minor and major bushfires (table 1). As described earlier, it is estimated that the average annual area burnt in Victoria due to bushfires is around 110 000 hectares. Assuming a damage cost per area burnt of \$133 000 for every 1000 hectares burnt (table 1), this amounts to \$14.6 m per year. Furthermore, the damage cost due to major bushfires in Australia is estimated to be around \$90 m per year based on the analysis of CIE (2001) and Bureau of Transport Economics (BTE) (2001) (table 1). On the

Table 1. Summary of estimated damage costs due to minor and major bushfires in Australia.

Type of cost	Estimated cost
Minor bushfires	
Damage costs per area burnt	\$133 000 for every 1000 hectares burnt by bushfires
Major bushfires	
Insured losses (e.g. to property, assets and agricultural production)	\$70 million per year
Damage to timber assets	\$7.3 million per year
Cost of human fatalities	\$8.3 million per year
Cost of serious human injury	\$3.5million per year

Source: Based on CIE (2001), BTE (2001), and Gunasekera and others (2004).

basis that 25 percent of the area burnt in Australia due to bush fires generally takes place in Victoria, it could be inferred that 25 per cent of overall damage cost per year due to major bush fires in Australia of \$90 m per year, that is \$22.5 m per year, will also occur in the state of Victoria. Although the extent of bushfire damage impact discussed here is an approximation, it provides a broad indication of the likely average damage costs over time based on the best available information and plausible assumptions.

Hence, the bushfire damage costs in Victoria based on historical estimates imply an estimated \$14.6 m of damage cost due to the area burnt and an additional damage cost of around \$22.5 m due to insured losses, damage to timber assets, and losses due to human fatalities and serious injuries. Overall, this amounts to an estimated \$37 million per year.

There are several key areas of savings (or benefits) that have not been taken into account explicitly here. These relate to potential savings to fire and emergency agencies as a result of efficient use of fire weather information that will enable them to better pre-position their resources including the relocation/deployment and mobilization of staff and equipment. For example, fire agencies deploy their resources including ground systems and airborne fire fighting operations based on the nature and intensity of various bushfires. Aircraft used in fire fighting operations are stored in locations least likely to be affected by smoke, thus maximizing the likelihood that they can take off safely early each morning near large fires. These are the costs that have to be borne as part of fire management. If specialized meteorological information provided by the Bureau help save the use of some of these resources or assist in better using those resources, that may lead to a reduction in the cost of operation of fire and emergency management in certain circumstances.

Another area of potential savings is due to prevention of fires through effective prescribed burning which could

result in improved fuel reduction and reduced incidence of high intensity fires with extensive spread. Prescribed burning can be regarded as an important method by which the impact of bushfires can be reduced (Victorian Government 2003). There is a renewed emphasis on fuel reduction programs including prescribed burning, following the major bushfires in the recent past. If the fire prevention measures help avoid at least a single fire of 1000 hectares each year, the savings or reduced losses could be considerable. There is also the possibility of a prescribed burn escaping and becoming a large bushfire negating any accrued benefits of the program, and possibly increasing the costs.

Concluding Remarks

One of the primary objectives of providing and using fire weather information in prevention and mitigation of bushfires is to ensure that the potential and actual threats to human life, property and other assets due to bushfires are reduced or, to the extent possible, avoided. There is widespread recognition of the importance of fire weather services in understanding and dealing with the effect of weather and climatic conditions on the impact of bushfires.

Based on the information provide in this paper, the cost of providing fire weather information to fire agencies in Victoria is around \$0.8 m per year. This includes the direct cost of operations with respect to the provision of fire weather services in the Victorian Regional Office of around \$ 0.4 m and the additional cost of \$ 0.4 m of improved fire weather services as a result of research sponsored through the Bushfire CRC. This compares with an estimated damage cost per year due to major bush fires in Victoria of \$37 m.

It is assumed here that the improved fire weather services by the Bureau will lead to a modest reduction in the impact of bushfires and the related damages and losses culminating in, for example, a 5 to 10 percent reduction in overall damages that can be expected, over a medium term time period (5 to 10 years), (for example, over a 7 year period). As discussed earlier, the estimated overall damage cost due to bushfires in Victoria is around \$37 m per year on average, which is around \$260 m over a 7-year period. An assumed 5 to 10 percent reduction in overall damages due to the better use of improved fire weather services is expected to lead to a \$13 m to 26 m reduction in overall damage costs over a 7-year period.

Comparing the costs of providing the additional enhanced information (\$5.6 m over a 7-year period) to the potential savings illustrated here (\$13 m to \$26 m

over a 7-year period) would allow us to determine if the cost of additional information is worth incurring. The results here show the investment on additional enhanced information is worth making as it results in savings 2 to 5 times larger than the investment over a 7-year period. We have neither annualized nor discounted to the present the cost and benefits associated with this additional fire weather services program. This benefit – cost comparison is based on a key assumption that the provision and use of improved fire weather services is likely to lead to a reduction in the impact of bushfires and the related damages and losses culminating in, for example over a 7 year period, a 5 to 10 percent reduction in overall damages that can be estimated. An important area of future research that is noteworthy here is a detailed examination of the applicability of this assumption.

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