Socioeconomic Value of Fire Weather Services: A Case Study of Fire Weather Information for Prescribed Burning [1]

Don Gunasekera, Graham Mills, Tony Bannister [2]

Abstract Head style

Fire weather services ranging from fire weather warnings to special forecasts for hazard reduction burns are important inputs into the decision making processes of fire management authorities that enable effective decision making at various stages of fire management. For example, fire management authorities can pre-position personnel and equipment to minimise fire damage based on timely and accurate fire weather forecasts and warnings. The socio-economic value or benefit of the forecasts reflects the improvement in economic and related outcomes resulting from the use of fire weather services. The focus of this study is the socio-economic value or benefit of current and improved fire weather services aimed at prescribed burning in the Victorian region in Australia. The study has three major components. The first relates to the formulation of a conceptual framework to analyse the likely outcomes resulting from the better use of fire weather services in undertaking prescribed burning, and the associated benefits. Depending on the circumstances, these outcomes will relate to improved fuel reduction and reduced incidence of high intensity fires with extensive spread. The associated potential benefits will relate to minimisation 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. The second major component of the study relates to an assessment of the associated benefits resulting from the better use of fire weather services. Some of these benefits will have market values and the others non-market values. The final component of the study will make a comparison between the potential socio-economic benefits of the better use of fire weather services aimed at prescribed burning and the costs associated with the provision of the current and improved fire weather services. 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

Bushfires are a major phenomenon in the Australian environment, which have the potential to threaten human life and damage property, infrastructure, agricultural and forest production, livestock, biodiversity, clean air and water, and cultural heritage. Over the past three decades, Australia has been affected by between 20 to 25 major bushfires (see BTE 2001). 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

[1] An abbreviated version of this paper was presented at the second international symposium on fire economics, planning, and policy: a global view, 19–22 April, 2004. Córdoba, Spain.

[2] The authors are attached to the Australian Bureau of Meteorology, GPO Box 1289K, Melbourne, VIC 3000, Australia.

life. The risk to property and human life continues to grow as forest areas on the fringes of urban areas become more densely populated (see CIE 2001).

Bushfire management involves decision making at various stages of fire management including prevention, mitigation and response. Effective fuel reduction can play a crucial role in bushfire prevention and mitigation. Although there is a range of fuel reduction methods, prescribed or planned burning is the most common and efficient method of fuel reduction for large areas of land. There is a renewed emphasis on fuel reduction programs including prescribed burning, following the major bushfires in the recent past. Prescribed burning can be regarded as a method by which the impact of bushfires can be reduced (Victorian Government 2003). Associated with prescribed burning is the issue of the dispersion of smoke plumes produced and their potential impact on human health. Fire weather services including special forecasts for specific locations are important inputs into the decision making processes of fire management authorities who are engaged in a range of fire management activities including prescribed burning.

The process of providing and using fire weather services is resource intensive and involves challenging tasks. 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 minimized or avoided. Hence the focus of this paper is value or benefits likely to result from the use of fire weather services with a particular emphasis on fire weather services aimed at prescribed burning.

The next section will describe a conceptual framework to analyze the likely outcomes and associated benefits resulting from the use of fire weather services in undertaking prescribed burning. In the third section of the paper an attempt will be made to assess the associated benefits resulting from the better use of fire weather services using the Victorian region in Australia as a case study. A comparison of the benefits and the costs of the better use of fire weather services is attempted in the fourth section. The final section will have some concluding remarks.

Conceptual Framework

It is important to recognize that the impact of bushfires is influenced by many factors including weather and climatic conditions, the extent and condition of fuel load, forest structures, human activity, fire management and mitigation procedures etc. It is not easy to quantify the relative importance of individual factors and then clearly attribute the effect of each of these factors on the impact of bushfires. Nevertheless, it is clear that closer examination of each of these factors could provide useful insights into the management, control and reduction of the impact of bushfires. The focus in this paper is on the impact of the fire weather services provided to fire management agencies in support of fire management and mitigation.

Fire Weather Services

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. Without a clear understanding of the ‘counterfactual’ – the world without the Australian Bureau of Meteorology (the Bureau) fire weather services – it is impossible to assess the true impact that the fire weather services have had, and

continue to have, on controlling and reducing the impact of bushfires. However, given the considerable expenditure on public good meteorological services including fire weather services, it is important t As indicated earlier, the provision of fire weather services in general is funded by the Government. The question then is what does the community (and the economy) get for their money in terms of controlling and reducing the impact of bushfires?

The Bureau provides a range of fire weather services in each state including Victoria as part of a national framework for the provision of such services (Bureau of Meteorology 2004) (see *box 1*). Efforts are being made in an ongoing basis to enhance these services in order to improve the accuracy and operational utility of fire weather forecasts, warnings and outlooks. These enhanced efforts on service improvement and delivery are internally funded within the Bureau (as part of the ongoing continuous improvement process) and in some cases externally funded through a range of collaborative efforts such as the newly established Cooperative Research Center (CRC) for Bushfires.

Box 1—Fire weather services provided by the Bureau in Victoria

The Australian Bureau of Meteorology provides fire weather services in Victoria as part of a national framework for the provision of such services in accordance with the provisions of the Meteorology Act (1955).

The primary objectives of the fire weather service are:

a) To provide the public with:

- Routine forecasts of fire danger during the fire season;

- Fire Weather Warnings when the fire danger is expected to exceed a certain critical level; and

b) To provide fire management authorities, civil defence organizations, police and other emergency services with:

- Detailed routine forecasts during the fire season;

- Fire weather warnings when the fire danger is expected to exceed a certain critical level;

- Operational forecasts to assist in combating ongoing fires;

- Special forecasts for hazard reduction 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

The Routine Services

During the fire season in Victoria (normally November through April), the Bureau's Victorian Regional Forecasting Center (RFC) routinely provides the Country Fire Authority (CFA) and Department of Sustainability and Environment (DSE) with the following services:

- forecasts issued at 6.30 am each morning of weather and Forest and Grass Fire Dangers for the current day for 25 Victorian centers (plus State border areas);

- written Fire Weather Briefings issued at 10.45 am each morning that focuses on current daytime conditions and how the situation described in the 6.30 am forecast is actually evolving;

- a 4-day forecast suite issued each afternoon comprising: - forecasts of weather and Forest and Grass Fire Danger Ratings for the next two days for 25 sites around Victoria;

- longer-term forecasts of weather and Fire Danger for days +3 and +4 for 9 sites around Victoria;

- a sequence of prognosis charts and accompanying text describing the expected evolution of the weather pattern over the next 4 days.

Routine fire weather forecast information is also provided to the general community in the form of Fire Danger Ratings that are appended to District Forecasts.

Warnings and Special Fire Services

As well as routine services that are provided each day during the Fire Season, additional services are provided 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 CFA as a key input into decisions about the declaration of a Total Fire Ban;

Wind Change Chart: This is 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 change and are used by 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.

On request, the Bureau can provide a forecaster at CFA Headquarters on critical days and, for large ongoing fires, a forecaster may be 'outposted' to a fire incident control center;

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.

Outcomes of Fire Weather Services

It can be argued that the current and enhanced fire weather services from the Bureau, once incorporated into the decision making processes and the fire management activities of the fire management authorities will assist the authorities to operate in a timely and effective fashion by better mobilizing their personnel and equipment, resulting in reduced impact of bushfires and risks to personnel. There is a wide range of economic, social and environmental effects of the provision and use of current and enhanced fire weather services *(fig. 1)*. There is a common view that the community and the economy receive considerable benefits (or reduced losses) as a result of the use of fire weather services (Sol 1994). However not all of the benefits or reduced losses are easy to quantify, and those that are easy to quantify are most likely to be the benefits or reduced losses to individuals, private firms or farms and any other specific entities. Quantifying all the benefits or reduced losses is an almost impossible task.

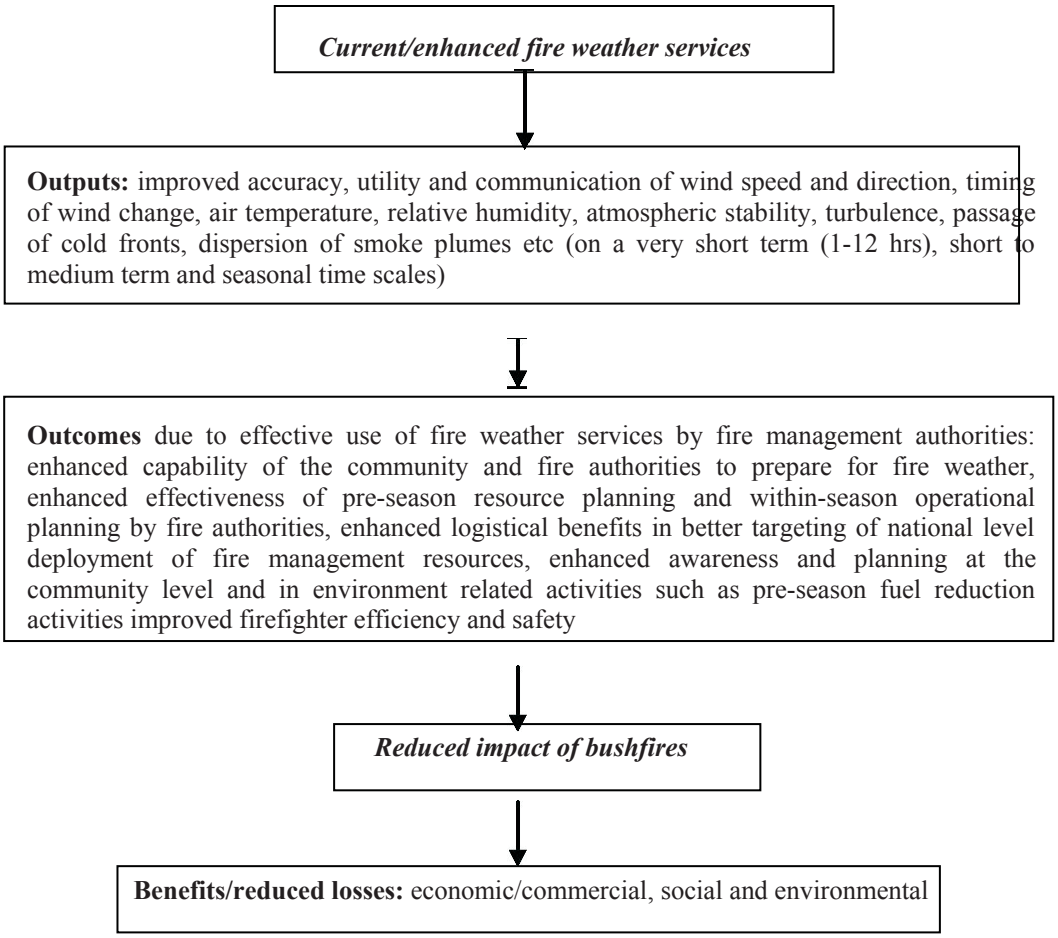

Figure 1— Summary of outputs and outcomes of fire weather services

Potential Benefits or Reduced Losses

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 and injury, 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. Based on CIE (2001) and BTE (2001), the main types of costs and the appropriate techniques for estimating each cost item are summarized in *table 1*. It is very likely that the current and enhanced

fire weather services from the Bureau, once incorporated into the decision making processes and the fire management activities of the fire management authorities do assist the authorities to operate in a timely and effective fashion by better mobilizing their personnel and equipment, resulting in reduced impact of bushfires, and hence reduced costs to the community and the economy.

Comparison of Scenarios

A plausible approach to analyzing the likely outcomes and the associated benefits resulting from the provision and use of fire weather services is to compare the outcomes emanating from a 'base line' scenario with those of an 'alternative' scenario. The 'base line' scenario can be described in the form of future expected impact of bushfires over a specified period assuming the use of *current* fire weather services in assisting the prevention and control procedures that are applied to manage bushfires. The alternative scenario is a case in which the impact of bushfires is reduced as *improved* fire weather forecasts are used in assisting the prevention and control procedures that are applied to manage bushfires. The overall or gross benefits of *improved* fire weather services can be expressed in the form of the difference in bushfire damage costs 'with' and 'without' the adoption of improved fire weather services.

The base line scenario represents the provision of the current suite of fire weather services issued by the Bureau including the extent and nature of the services aimed at assisting the fire authorities and the community to prevent and/or minimize bushfires. A plausible assumption to make is that, given other relevant factors remained unchanged, the use of the current suite of fire weather services by the fire authorities and the community will result in a continuation of the status quo level of the impact of bushfires.

An alternative scenario can reflect an improvement to the current suite of fire weather services including the improved timeliness, enhanced accuracy and better communication of the services provided by the Bureau. Under this scenario, it is expected that the fire authorities and the community will better use these improved services. Likely outcomes due to the better use of these improved fire weather services by the fire authorities may include effective prescribed burning which could result in improved fuel reduction and reduced incidence of high intensity fires with extensive spread. Also, better use of the improved fire weather services will enable the fire authorities and other emergency management service providers to better pre-position their resources including the relocation/deployment and mobilization of staff and equipment leading to reduced impact of bushfire related damages or losses. As indicated earlier, the associated potential benefits could be wide ranging depending on the location and circumstances of the specific bushfires cases. These potential 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.

The assessment of the overall benefits of *improved* fire weather services would require an estimation of bushfire damage costs 'with' and 'without' the adoption of improved fire weather services. In estimating the bushfire damage costs, CIE (2001) highlights two broad procedures: first, the importance of evaluating the *damage costs*

on a per hectare burnt basis for *minor bushfire events* and the associated timber losses; and for other cases such as injuries, fatalities and damage from *major bushfire events*, the appropriateness of basing the *damage costs on event frequencies basis* rather than areas burnt basis. Hence, according to CIE (2001) it is inappropriate to assess health and safety risks associated with a bushfire as a function of area burnt. Instead, it is more appropriate to estimate the total damage costs including the cost of injuries and fatalities by multiplying the estimated cost of an individual bushfire event by the expected future frequency of events with and without the adoption of, for example, improved fire weather services (see CIE 2001).

Table 1—Summary of the types of costs that could be reduced by effective use of fire weather services.

Cost item	Estimation technique
Market or tangible items	
Damage to timber assets	Market value
Damage to private property assets	Insurance pay-out
Farm production losses	Market value or insurance pay-out
Damage to public infrastructure	Replacement or repair costs
Disruption to businesses	Lost net income
Disruption to road freight and transport services	Delay costs incurred by affected businesses
Degradation of water quality in affected areas and catchments	Additional water treatment costs
Transaction costs (eg. legal proceedings)	Observed costs from previous events
Non-market or intangible items	
Human fatalities	Human capital approach or stated preference method
Human injury	Human capital approach or stated preference method
Loss of personal memorabilia	Stated preference method
Psychological trauma	Stated preference method
Damage to recreation sites	Stated preference or revealed preference method
Damage to native flora and fauna	Stated preference method
Greenhouse gas emissions	Estimated cost of carbon emissions under permit trading scheme

Source: Based on CIE (2001) and BTE (2001)

Assessment of Benefits or Reduced Losses

In this section a preliminary attempt will be made to assess the associated benefits or reduced losses resulting from the better use of fire weather services using the Victorian region in Australia as a case study. The idea here is to assess these benefits by making certain plausible assumptions about several key factors, namely, the current level and suite of fire weather services provided by the Bureau in the Victorian region, the efforts in terms of research and analysis, (and hence the flow on expected results) which is underway at present to improve these services in the future, and the likely consequences of the effective use of improved fire weather services by fire authorities, other emergency management service providers and the

community on the impact of bushfires. Based on the available data and information from various sources, a back-of-the-envelope analysis is undertaken to estimate the bushfire damage costs 'with' and 'without' the adoption of improved fire weather services.

Estimates of Bushfire Damage Costs

The bushfire damage costs used in this paper are based on a detailed analysis of such costs calculated by the CIE (2001) in a recent study of the anticipated benefits of reduced impact of bushfires in Australia expected to result from a research and development study carried out by the Commonwealth Scientific and Industrial Research Organization (CSIRO). The CSIRO study (Project Vesta) aimed at developing improved protocols for prescribed burning based on the research into behavior and spread of high-intensity bushfires. The results of the CSIRO study are expected to be used to: reduce the incidence of damaging forest fires by improving prescribed burning guidelines and procedures; reduce the health and safety risks to firefighters by providing improved tactical decision aids; and reduce the health and safety risks to the public by developing better early warning systems (CIE 2001). Although the CSIRO study and the Bureau's ongoing efforts to improve the fire weather services are not directly comparable, they both are aimed at reducing the impact of bushfires. In other words, in both cases the ultimate objective is to reduce the impact of bushfires. Given this and also due the paucity of information and estimates of the bushfire damage costs, this paper relies heavily on the cost of bushfire damages estimated in the CIE (2001) based on the CSIRO Project Vesta.

CIE (2001) estimates of bushfire damage costs are based on the analysis of two major sources of primary data. These sources include a database called EMATrack, which is maintained by Emergency Management Australia, and various electronic records held by State land management agencies in Australia.

Damage costs per area burnt – minor bushfires

By extrapolating the information on the cost of major bushfire events contained in EMATrack to the minor bushfire events recorded in State fire databases, CIE (2001) has estimated the unit cost associated with minor events, expressed as losses per area burnt. This amounts to a damage cost of $133 000 for every 1000 hectares burnt by bushfires. These costs relate to damage caused to property, assets and agricultural production (CIE 2001). CIE (2001) analysis based on State agency statistics indicates that average annual area burnt due to bushfires nationally in Australia (excluding Northern Territory) is around 440 000 hectares. In the state of Victoria, it is estimated that the average annual area burnt due to bushfires is around 110 000 hectares with an average annual number of fires of around 600 (CIE 2001). This means that 25 percent of the area burnt in Australia (excluding Northern Territory) due to bush fires generally takes place in Victoria.

Damage costs – major bushfires

Major bushfire events lead to various losses ranging from insured losses to property, assets and agricultural production, to human fatalities and injuries. As indicated earlier, since mid 1960s Australia has experienced between 20 to 25 major

bushfire events. According to CIE (2001), this equates to one major bushfire event in every 17 months (or approximately every one and half years) and on average each major event has caused $106 million of insured losses in present value terms. This implies that the annual insured loss due to major bushfires is around $70 million per year *(table 2)*.

The majority of Australia's forests (just over 90 percent) is regarded as non-productive, meaning that it is either protected from logging or not commercially viable for harvesting (see CIE 2001). Most of the remainder constitutes native hardwood forests, with small proportion comprising hardwood and softwood plantations (CIE 2001). These timber resources collectively are estimated to have a standing value of $10.4 billion (see CIE 2001). Based on the average area of forests affected by bushfires annually, CIE (2001) has estimated that the current value of annual timber losses is around $7.3 million per year *(table 2)*.

CIE (2001) has also calculated the economic cost of human fatalities and injuries associated with bushfires based on estimates made by the BTE (2001) in relation to economic cost of natural disasters. BTE (2001) estimates on the economic cost of human fatalities and injuries are based on the use of 'value of human capital' approach to quantifying the cost of death and non-fatal injuries. According to these estimates, the costs per human fatality and per serious injury are around $1.4 million and $0.2 million respectively (BTE 2001 and CIE 2001). According to CIE (2001) estimates based on national bushfire damage statistics, on average nine fatalities have occurred per major bushfire event. This implies that the economic cost of human fatalities per major bushfire event is around $12.5 million (or $8.3 million per year assuming that one major bushfire event occurs in every 17 months (or approximately every one and half years) as discussed earlier) *(table 2)*. CIE (2001) estimates also indicate that over the past several decades the average number of people injured due to bushfires is around 104 per event and the ratio of serious to minor injuries has been around 1 to 3, implying that the average number of serious human injury per event is around 26. Based on the estimated cost of $0.2 million per serious injury as indicated earlier, these figures imply that the economic cost of serious human injury per major bushfire event is $5.2 million or $3.5 million per year *(table 2)***.** As illustrated in *table 2* the overall damage cost per year due to major bush fires in Australia is estimated to be just under $90 million per year.

Table 2—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) and BTE (2001)

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 2),* this amounts to $14.6 million per year. Furthermore, on the 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 million per year, that is $22.5 million 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.

Baseline scenario

Under the baseline scenario, it is assumed that the provision and use of current fire weather services by the Bureau in the Victorian region in assisting the prevention and control procedures that are applied by fire authorities, other emergency management service providers and the broader community will continue. This also implies that the fire authorities, other emergency management service providers and the broader community will continue to adopt their current approaches and methods for preventing and controlling bushfires in Victoria resulting in a status quo level of bushfire impact. Hence, the bushfire damage costs in Victoria under the base line scenario will remain at their current level based on historical estimates implying an estimated $14.6 million of damage cost due to the area burnt and an additional damage cost of around $22.5 million 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 on average.

It is important to recognize the on-going continuous improvement that is likely to take place over time with respect to fire weather forecasting services, activities of the fire management authorities and the services of the other emergency management service providers. As a result of these continuous improvement of overall services aimed at managing bushfires, it is likely that there will be some reduction in expected damage costs and losses associated with future bushfires over time. Such reductions in damage costs and losses are not explicitly taken into account in this analysis.

Alternative scenario

At present the Bureau is continuing to improve its fire weather services by undertaking several projects. Some of these efforts are internally funded and the rest is externally funded through various collaborative arrangements such as the Bushfire CRC.

It is assumed under the alternative scenario that the Bureau will provide *improved* fire weather services in Victoria, assisting the prevention and control procedures that are applied by fire authorities, other emergency management service providers and the broader community. These improved fire weather services will consist of further enhancements to the current suite of fire weather services including the improved timeliness and enhanced accuracy of the services provided by the Bureau, as well as other enhanced services. Under this alternative scenario, it is assumed that the fire authorities, emergency management service providers and the community will better use these improved fire weather services. Likely outcomes due to the better use of these improved fire weather services by the fire authorities could include more effective prescribed burning which could result in improved fuel

reduction and reduced incidence of high intensity fires with extensive spread. Also, better use of the improved fire weather services will enable the fire authorities and other emergency management service providers to better pre-position their resources including the relocation/deployment and mobilization of staff and equipment leading to reduced impact of bushfire and the related damages or losses.

It is assumed here that the improved fire weather services by the Bureau in Victoria will lead to a 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 –10 years), (i.e. over a 7 year period). As discussed earlier, the estimated overall damage cost due to bushfires in Victoria is around $37 million per year on average, which is around $260 million over a 7-year period. Based on the analysis presented above, an assumed 5 to 10 percent reduction in overall damages due to the better use of improved fire weather services will lead to a $13 – 26 million reduction in overall damage costs over a 7 year period. If such improvements to fire weather services are applied across the whole country, the overall reduction in bush fire damage losses could be expected to be four times more, amounting to $50 – 100 million over a 7 year time period.

Comparison of Benefits and Costs

As indicated earlier, the Bureau is planning to use additional resources allocated as part of the extra funding from the newly established CRC for Bushfires to finance the efforts to improve the fire weather services discussed in this paper. Those additional funds amount to around $0.4 million per year for 7 years commencing 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 described in this paper. It is assumed here that the cost of disseminating and using the enhanced fire weather services is negligible as the processes involve ‘doing things better’ with existing resources (from the perspective of forecast delivery services, fire management authorities and other emergency management service providers) rather than increasing the amount of effort associated with managing the bushfires. As a result, no additional costs are added to the $0.4 million per year for 7 years (that is, $2.8 million over 7 years) in the alternative scenario analyzed here.

Assuming that the additional cost of improved fire weather services by the Bureau will be around $0.4 million per year for 7 years, and that the use of such improved services will lead to a 5 to 10 percent reduction in the impact of bushfires and the related damages over a 7 year period, the consequent reduction in losses is estimated to be around $13 – 26 million in Victoria over that period. This implies a benefit (or reduced damages) of 5 to 9 times the additional cost of fire weather services, in the case of Victoria. If such improvements to fire weather services are applied across the whole country, the overall reduction in bush fire damage losses could be expected to be four times more, amounting to $50 – 100 million, implying a benefit (or reduced damage) of 18 to 36 times the additional cost of providing enhanced fire weather services, on a national basis.

Concluding Remarks

A basic conceptual framework for analyzing the socio-economic value of fire weather services is presented in this paper. Also, a back-of–the-envelope, preliminary analysis of the potential benefits or reduced losses that could result from the use of improved fire weather services is undertaken in this paper with available data and information. The initial analysis based on best available data and plausible assumptions illustrate that likely benefits from the use of improved fire weather services can be 5 to 9 times the additional cost of fire weather services, in the case of Victoria. If such improvements to fire weather services are applied across the whole country, the overall potential benefits can be 18 to 36 times the additional cost of providing enhanced fire weather services, on a national basis. 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.

Acknowledgments

Responsibility for the views expressed rests with the authors. The authors appreciate the valuable comments and suggestions by Mike Manton, Bob Brook, Tom Keenan, John Zillman, John Handmer and Stephen Dovers.

References

BTE (Bureau of Transport Economics) 2001. **Economic costs of natural disasters in Australia,** Report No. 103, Canberra

Bureau of Meteorology 2004. **Meteorological aspects of the Eastern Victorian fires, January-March 2003,** Melbourne.

CIE (Center for International Economics) 2001. **Assessing the contribution of CSIRO – CSIRO pricing review,** prepared for CSIRO, Canberra and Sydney, http://www.bbm.csiro.au/vesta/assets/pdf/Vesta_Final_Report.PDF

Sol, B. 1994. **Economic impact of weather forecast for forest fires**, Meteorological Applications 1: 155-158

Victorian Government 2003. **Report of the inquiry into the 2002-03 Victorian bushfires,** Melbourne