Development of a Bushfire Management Business Model

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Abstract

Bushfire management is a complex task involving many elements with complex interactions between these elements. As the first stage of developing a Bushfire Risk Management Model, it was first necessary to define the Bushfire Management Business Model.

No Bushfire Management Business Model currently exists and yet bushfire management has been a major enterprise for decades in Australia. The form of fire management model currently used is based on experienced managers interacting with the community, bureaucrats, politicians, firefighters and land managers. Some aspects of the bushfire management model have been quantified, to an extent, through residential development planning guidelines, and the Model of Fire Cover - used to determine the desired level of fire response resources. However, no attempt has been made to bring all aspects of bushfire management together in a more objective manner.

This Bushfire Management Business Model project has used an interview process to quantify the relative importance of prevention, protection, response, recovery and fire regime management. Within each of these five strategies, the relative importance of different facets, and elements of these facets have been determined. A process was then run to determine how each strategy and facet of each strategy interacted with each other to achieve an acceptable level of risk. Seventeen senior fire managers from around Australia were interviewed using a standard questionnaire. The results of this survey were summarised to determine the most important elements of the Bushfire Management Model and to find how resources could be traded off against one another to achieve an acceptable level of risk. This paper presents some key components of this model.

Introduction

Fire managers need to develop methodologies that analyse both the "fire problem" and "level of risk" they have. Such methodologies may then assist in deciding what level of resources they must have available to reduce that threat. The traditional approach to doing this is termed Models or Standards of Fire Cover. This methodology has been used at least since World War II (Home Office 1985) and has been adopted in many countries of the world, including Australia. The underlying theory of fire cover is that across an agency's management area, like risk receives like cover.

As an example, the Victorian public land Model of Fire Cover (DNRE 2000) classifies the threat from each identified problem factor and mitigation limitation (e.g.

travel time) into low, medium or high risk categories. These factors are then assessed in combination to obtain an overall level of threat.

As well as using overall threat analysis, many organisations have identified the spatial distribution of threat using GIS technology under the name of Wildfire Threat Analysis (WTA). This process attempts to quantify the spatial distribution and risk levels of the factors that contribute towards wildfire risk. The typical output of WTA is a map depicting the different levels of "threat". "Threat" is determined using various mathematical summations of the specified input factors from GIS layers, in a similar fashion to non-spatial threat analysis.

Considerable investment has been made into Wildfire Threat Analysis. Most Australian state land management agencies have developed or partially developed WTA, with probably the most applied system being that used by CALM in Western Australia (Sneeuwjagt 1998). Many organisations are still developing their methodologies and attempts are being made in many parts of the world to develop nationally consistent approaches (Cameron 2001).

The Australian Standard for Risk Management (AS/NZS 4360-1999) was developed to be applicable to a wide range of industries and situations. The standard provides a generic framework for establishing the context, identification, evaluation, treatment, monitoring and communication of risk. The framework provides a rigorous and structured approach based on best practice. Since its publication, there have been some attempts to assimilate the structure into the fire management business.

(Shields 2002) developed a layout of the interaction between fire and risk management that was drawn from the Australian Standard and contemporary efforts from other authors in the field. The proposed layout uses likelihood of impact and consequence as the core elements within the design. The process requires an objective (question) to be defined by the user (fire manager) so that the model will provide an answer that is relevant to the fire manager. This last aspect has been missing in previous risk management model attempts. However, the work provided only descriptive examples of how future work on the topic could proceed.

Although both new risk assessment frameworks attempt to systematically address or calculate risk, they are inadequate when it comes to assessing management options. A critical element in any performance management framework is the need to make explicit, the logic that connects treatment delivery and outcomes. Many performance measurement frameworks simply assume implicit relationships between these two factors. A risk management model needs to incorporate how various risk treatments contribute to the achievement of risk outcomes, and to be able to determine what the best or most cost effective treatment options are. To achieve this, the bushfire management "business" needs to be modeled.

In this paper, we will present the initial results from a survey of senior fire officers around Australia. We will demonstrate how some of the elements of the bushfire management business are linked. In a simple example, we will then demonstrate how the Bushfire Management Business Model can be used to identify those areas of the business which will provide the greatest reduction in bushfire risk with the least cost.

Method

Officers from seventeen fire management agencies in six Australian states were approached to take part in a survey. Suitable people from both land management agencies and emergency response organisations were identified. The officers selected were senior in their organisation and are or have been involved in aspects of bushfire risk management.

The objective of the survey was to elucidate if managers believed there were any links or interactions between different fire management strategies. The logical first step therefore was to identify all the "strategies" and programs that are undertaken by fire management agencies. The traditional Prevention, Preparedness, Response and Recovery (PPRR) approach was amended to include Ecological Fire Regime Management (PPRRE) which is an important component of fire management in many Australian states. Functions within these "strategies" were identified as "facets". Where necessary, "elements" within each "facet" were also identified.

The first survey question that participants were asked was whether they were comfortable with our subjective listing and division of fire management strategies using the PPRRE approach.

We then asked the participants to grade their respective organisation's performance in each strategy. In order to facilitate this, we designed a classification scale based on a theoretical response curve (Fig. 1). The response curve featured a generalised and scaleless S-curve with the axes being "level of resources/effort" and "impact on risk". This curve was then divided up into five sections representing different states of strategy performance.

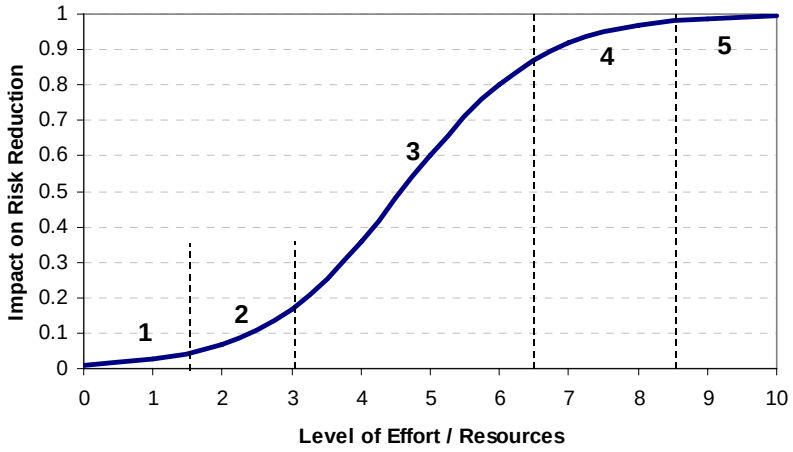

Figure 1. Relationship between the level of resources and their effect on bushfire risk reduction. 1 = limited resources and limited impact, 2 = minimal resources, some impact, 3 = moderate resources, significant risk reduction, 4 = well resourced, high level of risk reduction, 5 = ample resources, optimum level of risk reduction.

In addition, we also allowed for recording whether or not an organisation is responsible for that particular strategy. This was a frequent occurrence, for example, fire education from a land management agency's perspective.

The responses to this question told us what their agency's main responsibilities were, where the participant thought their organisation was succeeding or not succeeding, and provided a context in which to interpret their responses to the preceding questions.

The participants were then asked to estimate the notional proportion of their budget spent on the respective bushfire management strategies. Where agencies used volunteers, we also requested that they estimate the proportion of volunteer time spent on each strategy. This was so that we could ascertain the financial costs of the respective strategies, and to gain an insight into what risk management treatments the organisation placed emphasis on.

We then wanted to get an indication of how interchangeable or linked the different risk treatment strategies available to a fire manager were. In order to elucidate these relationships, managers were presented with a series of "risk matrices" to fill out. The matrices were structured so that for each fire management strategy, participants had to identify whether a 10% increase or improvement in that strategy by their organisation would a) mean that another strategy would have to be improved or increased to accommodate/facilitate this change and b) whether the perceived benefits gained from the improvement in the respective strategy would allow one to trade-off the amount of investment in another strategy. To gain an indication of how strong the link was between the two strategies, participants were also asked to indicate whether the change would be minor, moderate or major.

Participants were then asked to discuss any factors affecting the reasons why they funded strategies to those levels (budget balance) as well as the decisions they made whilst filling out the risk matrices.

The analysis of such results will always be dependant upon the context under which the answers were given. The answers provided by participants were dependant on factors such as their agency's responsibilities, controlling legislation, geographic location and the present status of their risk treatment strategies. It was therefore with extreme caution that we combined, calculated and interpreted the summary statistics of the survey results.

Results

The results presented here are only a small subset of the survey information. The intention of this paper is to give an indication of the nature of this work.

Resource Allocation Quantum

One measure of how fire agencies demonstrate their level of fire management priority is by how they allocate their funds. Budget allocations are a reflection of historical practices, political pressures to provide particular services, the inherent cost of a particular service or strategy, the perceived importance of a strategy or component of that strategy in reducing bushfire risk and how various components of the fire management strategies mutually support each other.

Table 1 summarises the proportional allocation of budgets across all fire agencies interviewed. On average, about 11% of budgets were spent on Prevention, 49% on

Preparedness, 26% on Response, 5% on Recovery and 10% on Fire Regime Management. These are long-term averages and do represent what might happen in a major fire year, such as 2003, when many times the normal budget was spent on Response and Recovery.

Preparedness normally represents about half the total budget expenditure. Of this, the greatest proportion is spent on infrastructure development and maintenance, equipment, and personnel. About 11% of total expenditure is allocated to hazard management which is about the same as the 10% allocated to Fire Regime Management.

Table 1. Average budget allocation for each fire management strategy, facet and element by bushfire management agencies around Australia.

Strategy	%	Facet	%	Element	%
Prevention	11	Legislation control	0.4		
		Enforcement	0.5		
		Community education	3.3	Fire law and regulations education	0.8
				Bushfire Behaviour and safety education	2.5
		Planning	6.5	Fire Management Planning	5.4
				Land Use Planning	1.1
Preparedness	49	Detection	3.3	Public / Other Agency detection	0.9
				Fire tower detection	1.1
				Aerial reconnaissance	0.8
				Vehicle patrol detection	0.5
				Satellites	0.1
		Hazard management	11.3	Fuel reduction burning	5.9
				Fuel break slashing/spraying/ploughing	3.9
				Other (e.g. Pruning)	1.5
		Infrastructure management	12.4	Road and track network	3.1
				Water points/plugs	0.5
				Tower maintenance	0.7
				Fire stations/depots	4.3
				Incident Control Centres	0.7
				Communications	2.8
				Aircraft infrastucture	0.2
		Resource preparedness	21.7	Crew/firefighters	7.2
				Remote Area attack crew	0.2
				Training	4.7
				Equipment maintenance	2.5
				Tankers/slip ons	4.6
				Dozers – small/large	0.9
				Fire bombers	1.1
				Reconnaissance aircraft	0.5
Response	26	Multi - Fire prioritisation			
		Response time			
		Suppression time			
		Resource combination allocation			
Recovery	5	Control line rehabilitation	1.4		
		Ecosystem rehabilitation	0.4		
		Community recovery	0.3		
		Fire fighter recovery	1.5		
		Post incident analysis/debriefs	0.6		
		Fire investigations	0.6		
Fire Regime Management	10	Landscape scale mgt	7.2		
		Local, species specific mgt.	2.4		

Budget allocations, however, vary between fire agencies depending on the nature of their organisation's objectives. Fire agencies can be classified as primarily land managers or primarily emergency response agencies. These agencies may or may not then be involved in managing fires in: rural/urban interface, native forest, plantations, and/or remote areas. Some fire agencies are heavily reliant on volunteer fire fighters and this significantly reduces a lot of fire management costs, but increases some costs such as training, equipment and tankers to support the volunteer brigades. Some land management agencies may also have a significant emergency response role.

Table 2 shows how the budget allocation of agencies with different fire management environments vary. For example, fire agencies with primarily a land management function spend significantly more on fire regime management, but significantly less on recovery than fire agencies with primarily an emergency response function. Conversely, emergency response agencies spend significantly more on preparedness than land managers due to the indirect cost of the significant volunteer workforce that emergency response agencies have.

A detailed analysis of Table 2 shows some significant differences in the budget allocations between fire agencies with different modes of operation and with different types of values at risk. These differences are important to recognise when constructing a Bushfire Management Business Model.

Table 2. Variation in budget allocation to primary fire management strategies as related to the nature of the fire management business. Blue shaded cells are more than 10% greater than the mean and fawn shaded cells are less than 10% of the mean.

Strategy	Mean	Primarily Land Mgt.	Primarily Emergency Response	Urban Interface	Significant Native Forest	Significant Plantations	Significant Remote Areas	Significant Emergency Response	Significant Volunteers
Prevention	**10.8**	10.3	11.7	11.3	12.3	7.4	8.8	10.3	10.7
Preparedness	**48.7**	44.4	56.7	49.8	47.9	62.4	37.7	52.5	56.4
Response	**26.1**	28.4	22.0	29.6	28.8	24.0	26.8	28.3	22.4
Recovery	**4.8**	3.9	6.3	4.9	5.2	3.8	4.8	5.0	6.1
Fire Regime Mgt.	**9.6**	13.0	3.3	4.3	5.6	2.2	21.8	3.9	4.3

Relationship between Resource Levels to Risk Impact Status

Survey participants rated the current level of resources being allocated to each of the identified fire management strategies, facets and elements in terms of their impact on risk reduction. This was based on the five classes described using Fig. 1. The average results are given in Table 3, with a distinction also being made between fire agencies with a primary land management function and those with a primary emergency response function.

Individual results varied widely and so the average figures mask some of the agency-to-agency variations. However, the average status reported in Table 3 still provides a basis for some preliminary analysis.

Overall, there was no particular fire management element that was consistently considered to be funded to its greatest extent. Generally speaking, the view was that most elements of fire management would result in a significant reduction in bushfire risk if additional funding or resources were applied. However, there were a few facets and elements where the current level of resources were considered to be sub-optimal.

- Law enforcement and community education (prevention strategy).
- Satellite detection, fire tower maintenance, remote-area attack crews and fuel hazard management, other than fuel reduction burning and firebreaks (preparedness strategy).
- Community recovery (recovery strategy).

The level of resources for the fire response and fire regime management strategies were considered to be adequate, even if less than optimal.

This generalised view of resourcing and risk reduction, masked some differences between fire agencies with primarily a land management role and those with primarily an emergency response role. Emergency response agencies were giving better funding to landuse planning, fire stations, incident control centres, aircraft infrastructure, fire bombers, and fire investigations. Land management agencies were giving better funding to fire towers, aerial reconnaissance, fire tower maintenance, control line rehabilitation and ecosystem rehabilitation. These differences relate to the primary objectives of the respective organisations.

Table 3. Current resource level and risk management effectiveness status as perceived by survey respondents. Status varies from 1 (low level of resources with minimal impact on risk) to 5 (high level of resources with maximum impact on risk reduction). Assessments by Land Managers (LM) and Emergency Response (ER) agencies are separated.

Strategy	Facet	Element	Status	LM	ER
Prevention	Legislation control		2.6	2.4	3.3
	Enforcement		1.9	1.9	1.7
	Community education	Fire law and regulations education	1.8	1.6	2.3
		Bushfire Behaviour and safety education	2.0	1.8	2.7
	Planning	Fire Management Planning	2.6	2.6	2.5
		Land Use Planning	2.2	1.9	3.0
Preparedness	Detection	Public / Other Agency detection	3.5	3.3	4.0
		Fire tower detection	2.8	3.1	2.0
		Aerial reconnaissance	2.8	3.0	2.0
		Vehicle patrol detection	2.3	2.6	1.7
		Satellites	1.5	1.6	1.3
	Hazard management	Fuel reduction burning	2.5	2.6	2.3
		Fuel break slashing/spraying/ploughing	3.0	3.0	3.0
		Other (e.g. Pruning)	1.3	1.1	1.0
	Infrastructure management	Road and track network	2.9	3.1	2.5
		Water points/plugs	3.2	3.3	3.0
		Tower maintenance	1.9	2.3	0.7
		Fire stations/depots	2.8	2.6	3.7
		Incident Control Centres	2.8	2.3	4.0
		Communications	3.5	3.6	3.3
		Aircraft infrastucture	2.4	2.1	3.5
	Resource preparedness	Crew/firefighters	3.2	3.2	3.3
		Remote Area attack crew	1.3	1.3	1.0
		Training	3.2	3.4	2.5
		Equipment maintenance	3.9	3.9	3.7
		Tankers/slip ons	3.6	3.7	3.3
		Dozers – small/large	3.5	3.5	3.5
		Fire bombers	2.5	2.2	3.3
		Reconnaissance aircraft	3.0	2.9	3.2
Response	Multi - Fire prioritisation		3.5	3.6	3.3
	Response time		3.1	3.3	2.5
	Suppression time		3.3	3.3	3.2
	Resource combination allocation		2.9	2.8	3.0
Recovery	Control line rehabilitation		2.8	3.2	1.5
	Ecosystem rehabilitation		2.1	2.6	0.5
	Community recovery		1.3	1.3	1.5
	Fire fighter recovery		3.4	3.3	3.8
	Post incident analysis/debriefs		3.1	3.0	3.5
	Fire investigations		2.4	2.1	3.5
Fire Regime Management	Landscape scale mgt		2.3	2.5	1.8
	Local, species specific mgt.		2.5	2.6	2.0

Realistic Resource Range (Quantum X Status)

By combining the current proportion of the fire management budget with the current status of resource effectiveness, it is possible to find the elements of the fire management business that offer the best opportunity to reduce the level of bushfire risk for the least cost. If we assume that a resource allocation status of "4.5" is near optimal levels, then the proportion of the total budget needed to be added to the current level of resourcing to reach a status of "4.5" provides a starting point to consider changes to improve fire management options. Fire management strategies or elements that can achieve an optimum status with a relatively low budget allocation are the most attractive elements to consider first. Beyond this exploration, the implications in terms of the symphysial and substitutional changes would then need to be considered.

Table 4 shows the 20 fire management facets/elements that will reduce the level of bushfire risk for the least cost. The first 10 facets/elements would require less than a 1% shift in the budget to put these elements into their optimal range. The second 10 facets/elements would require between 1% and 2% of a budget shift. The consequences of making these shifts should then be explored to find the most desirable way of optimising the overall level of risk reduction.

Table 4. Fire management facets/elements can be increased to optimal levels for the least shift in budget (without considering interaction effects).

< 1% shift in budget	**1 to 2% shift in budget**
Satellites	Vehicle patrol detection
Aircraft infrastructure	Community recovery
Remote Area attack crew	Fire investigations
Water points/plugs	Incident Control Centres
Reconnaissance aircraft	Enforcement
Post incident analysis/debriefs	Aerial reconnaissance
Legislation control	Equipment maintenance
Ecosystem rehabilitation	Fire fighter recovery
Dozers – small/large	Fire tower detection
Public / Other Agency detection	Tower maintenance

Interactions – Symphysial and Substitutional Changes

Table 5 shows an example of the symphysial and substitutional interactions between elements on a paired basis. In the process of the survey, the participant was asked: "if you increase the level of resources/effort to this element, what other elements would need to be changed to make this increase effective?" This interaction is symphysial. Conversely, the participant was asked: "if you increase the level of resources/effort to this element, what other elements could you reduce but still maintain the same level of bushfire risk?" This was the substitutional interaction.

Two of the main interactions within the "infrastructure maintenance" facet were: (1) between the utility of the road and track network and the amount of hazard reduction and response effort, and (2) the need to support any additional fire stations / depots with additional resources in coordination, communication, crews and equipment. Many other links are also highlighted in Table 5.

Table 5. Strength of interactions between bushfire infrastructure elements and other bushfire risk management strategies. "R" relates to areas where some other element is Required to be increased to make a notional increase in the specified infrastructure element effective. "RN" shows other elements that could be "traded off" but still keeping the overall fire management Risk Neutral. Shaded cells show the interactions with the greatest strength.

	Infrastructure elements to be increased by a notional 10%													
	Road and track network		**Water points**		**Fire Stations / depots**		**Fire towers**		**ICCs**		**Comm's**		**Aircraft infrastructure**	
	R	*RN*	*R*	*RN*	*R*	*RN*	*R*	*RN*	*R*	*RN*	*R*	*RN*	*R*	*RN*
Road and track network			18	6	6	6	6	0	0	0	0	0	0	0
Water points	6	-12			12	-6	6	0	0	0	0	0	0	0
Fire Station/depots	6	-6	0	0			0	6	0	-6	0	0	12	-6
Fire Towers	0	0	0	0	0	0			0	0	0	0	0	-18
ICCs	0	0	0	0	18	-12	0	6			6	-6	12	0
Communications	0	6	0	0	18	0	6	0	53	0			24	0
Aircraft infrastructure	0	-6	0	0	0	-6	0	-12	0	0	0	0		
Detection	0	0	6	0	6	0	12	-18	0	0	0	0	12	-18
Hazard management	29	-24	6	-12	6	0	-6	0	0	0	0	-6	0	-6
Resource preparedness	12	-12	18	-12	35	-6	6	0	24	0	24	6	35	0
Prevention	0	0	0	0	12	0	6	0	6	0	0	12	12	0
Response	18	-53	18	-18	24	-6	12	6	24	-6	6	-24	6	-12
Recovery	12	-18	0	-12	6	-12	0	0	12	-18	0	0	0	-6
Fire Regime Management	18	-6	0	0	0	0	0	0	6	0	0	6	0	0
Total	**100**	**-129**	**65**	**-47**	**141**	**-41**	**47**	**-12**	**124**	**-29**	**35**	**-12**	**112**	**-65**

Conclusions

An analysis of the data collected in this survey has provided an insight into the decision making process in the past and also provide guidance in ways to improve bushfire risk management in the future.

Further analysis is required to link the various aspects of the bushfire management business and this analysis will help advance this process.

This analysis has shown the complexity of the fire management business and how variations in the business environment affect the priorities and importance of various elements of fire management.

A better understanding of the fire management business will lead to more efficient and effective mitigation of fire damage and improve the benefits of well managed fire regimes.

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