Wildfire Risk – Integrating Community Resilience Or Vulnerability Attributes And Hazard Assessments, To Provide A Comprehensive Risk Model

K. Braun
ICS Group, Narrikup, WA, Australia

Abstract

Fire services and land management agencies have adopted a variety of models to identify wildfire "hazards", "threats" or "risks". In some cases maps are prepared which show wildfire fuel types, fuel quantity, or potential fire behaviour. This information is often used to determine the "risk" wildfires would pose to communities.

However, risk assessments rarely integrate variables which measure the capacity of a community to withstand a wildfire, or a community's vulnerability to wildfire. As a result, agencies may not be in a position to make well-informed decisions in relation to the safety of a community, both during day to day management, but also during wildfire emergencies.

This paper provides a simple wildfire risk model which integrates community resilience or vulnerability attributes into the risk assessment process. The model can be applied at strategic, as well as at local planning levels. Results from a community based risk assessment will assist agencies and their managers to make better informed decisions when financial and human resources are allocated for mitigation and community safety programs. Results from these assessments will also assist with the development of effective strategies during wildfire emergencies.

At corporate level, community based wildfire risk assessments can become a key performance indicator. This will provide for a more balanced and integrated approach to evaluate an agency's performance in achieving safer communities.

Introduction

Extensive research has been, and is being, undertaken into the causes of fatalities and building losses during wildfires. This information is used by fire services to provide advice to communities on how to minimise wildfire risk, but also to provide additional planning and building controls. This information is generally not incorporated into wildfire risk assessments.

Fire services and land management agencies apply a variety of models to assess wildfire "hazards", "threats" or "risk". Results from these assessments are used to quantify the "risk" wildfires pose to the community, and to introduce and justify strategies and programs to reduce the "risk" from wildfire. However, the assessment models used by agencies appear to focus on wildfire fuel type and structure, frequency of fire, potential fire behaviour, fire fighting resources, response time, and values exposed to a fire. These models fail to integrate variables which reflect a community's vulnerability to wildfire, or a community's capacity to withstand a wildfire.

As a result, these “hazard”, “threat” or “risk” assessments will provide misleading or wrong classifications of the level of risk which a community is exposed to. Furthermore, risk management strategies and programs which are based on such assessments will, generally, not significantly reduce the wildfire risk in a community under severe fire weather conditions, when the majority of losses occur.

This paper provides a wildfire risk model, which incorporates community vulnerability or resilience attributes. The focus of the paper is on strategic changes that are required. Detailed technical information on community vulnerability or resilience indicators is beyond the scope of this paper and is not provided here.

Wildfire Risk

The terminology used in the context of wildfire risk assessment varies and includes wildfire threat, hazard as well as risk. Each one of these terms may have a number of different interpretations. A clear definition and understanding of the concept of risk is however required before a meaningful wildfire risk assessment framework can be developed and applied.

Risk should be defined in terms of the likelihood of an event occurring – in a specified area and under specific conditions – and the impact such an event may have. The Australian Standard for Risk management (AS/NZS 4360:1999) provides the following definition for risk:

> Risk – the chance of something happening that will have an impact upon objectives. It is measured in terms of consequences and likelihood.

Events

Risk assessments must clearly define the event which is being assessed. Some risk assessments consider that every wildfire is an event, and therefore focus on the total number of fires. Risk management strategies that are derived from such an approach include programs to minimise the frequency of fires and fire suppression. In these cases it could be argued that agencies have a successful wildfire risk management program when the number of fires is reduced or when a certain fire suppression response is achieved.

Another approach would be to only consider severe wildfires as events. Typical risk management strategies would be to undertake hazard reduction burning, to introduce programs to reduce the number of fires on severe fire danger days, and to increase fire fighting capabilities – bigger appliances and aircraft, more personnel, better training, etc. Agencies may use the total area of hazard reduction burns conducted, or the size of the fire suppression fleet as an indication of whether wildfire risk has been successfully reduced.

The focus of risk assessments could also be on the number of large fires, or the losses which are sustained. In these cases it could be argued that risk management strategies are successful when the number of large fires, or losses, are low.

The above approaches do not provide an indication of wildfire risk in a community. Risk management strategies which are based on these approaches also fail on severe fire danger days and/or when multiple fires occur. On these days fire intensities, even in recently fuel

reduced areas and in pastures, often exceed those that well resourced fire crews and large water bombing aircraft can successfully contain. These are also the incidents where the majority of losses occur.

An alternative approach is to focus on the impact a wildfire can have on a community. If the impact of a wildfire on a community is seen as the event, it will be possible to determine the level of risk from wildfire in a community. It will also be possible to apply a much broader range of risk management strategies. With this approach strategies which increase community resilience to wildfire become an integral part of wildfire risk management. Traditional programs to reduce fire frequency, to manage hazards, as well as fire suppression, would remain part of wildfire risk management.

Risk Scenarios

Wildfires vary significantly in intensity and behaviour. Variables such as fuel type, structure, quantity and curing, topography, as well as weather and seasonal conditions all influence fire intensity and behaviour.

At the same time, the impact of a wildfire will depend on the severity of the fire, as well as on community attributes, such as the design and location of land developments and buildings, and on the capacity of communities and their fire services to withstand a fire, and/or to recover from a fire. The focus should be on people and their behaviour before, during and after a fire, on buildings, as well as on infrastructure (eg. power supply, roads and bridges) and the economy (eg. employment, industry, farming and plantations).

It is paramount that different risk scenarios are used when wildfire risk assessments are undertaken. It may be found that existing fire protection and response arrangements are adequate to contain 95-97% of wildfires. Generally these fires burn under conditions which are not too severe and fire services are able to contain them before they cause significant losses. It may be found that the capacity of the community to withstand such fires is not an important variable in these scenarios.

Fires may also burn under severe conditions, but without directly impacting on a community. These fires are often contained by fire services when conditions ease. Again, existing arrangements may be adequate to minimise impact. (These fires may have a significant environmental impact. Environmental issues are not addressed here. The risk model can, however, be applied to assess wildfire risk in relation to environmental, conservation and biodiversity objectives.)

It must, however, be recognised that fires which have in the past caused the majority of losses occurred on severe fire danger days (Bradstock 1995). Under these conditions existing arrangements such as fire suppression response and hazard reduction burning have generally failed to prevent significant losses, as fires often burn at intensities an order of magnitude above those that can be contained by even well resourced fire services. The capacity of communities to withstand such fires is a key factor in determining the level of risk in these scenarios. Risk scenarios must therefore include major wildfires that burn under severe fire weather conditions and impact on communities, as well as attributes which reflect a community's resilience or vulnerability to such fires.

Wildfires – Hype and Myths

Media reports provide dramatic pictures of wildfires, of houses that are on fire, of people who are evacuated or who flee a fire. Factual information is rarely provided. As a result people, including fire and emergency services personnel, tend to have a poor understanding of wildfire risk, and of wildfire risk management. The situation is exacerbated when both communities and fire services or land management agencies argue on emotional grounds that certain risk management strategies are required to prevent losses.

One such emotional debate focuses on hazard reduction burning. This can be highlighted by the submissions which were made to the Select Committee of the House of Representatives. The committee was established by the Commonwealth Government in Australia in 2003 after a severe fire season had resulted in very large fires and significant losses. A large percentage of submissions, as well as a number of committee members, argued that more hazard reduction burning was required to prevent losses in the future.

Although it is acknowledged that hazard reduction burning is one of the wildfire risk management tools, it must be recognised that hazard reduction burning alone will not significantly reduce wildfire risk and losses. Research has shown that the risk from wildfires can not be significantly reduced though hazard reduction burning, even if it is undertaken at very frequent intervals (Bradstock 1995). One such example is Dwellingup in Western Australia, which was destroyed in a wildfire in 1961. In this town 132 dwellings, a hospital, service stations, general stores, offices, saw mills and a large number of vehicles were destroyed, despite the fact that "most of the forests in the Dwellingup division had been controlled burnt in recent years, and the litter on various parts of the forest floor represented accumulations generally speaking, of 0-8 years. During this fire, buildings were commencing to catch alight long before the advancing fire reached the outskirts" of the town of Dwellingup (Roger 1961).

In the case of the Canberra fire in January 2003, over 500 buildings were lost when major fire fronts burned into build-up areas. Information available to date indicates that losses occurred as a result of ember attack on buildings and gardens, and as a result of house to house ignition (pers.com. Leonard, Gould CSIRO June 2003). Hazard reduction burning around Canberra would not have significantly reduced losses.

Another misconception is that increasing the number of fire appliances and water bombing aircraft will significantly reduce the risk of wildfires. It is correct that a well resourced and trained fire service will be in a better position to minimise losses and will limit, to some extent, the number of fires which develop into major fire runs. However, even a significant increase in fire suppression resources will not significantly reduce wildfire risk in a community under severe fire weather conditions. Generally, fire services were overwhelmed during fires where major losses have occurred in the past, and were not able to contain head fire fronts or attend to every building affected by these fires.

It must be recognised that direct attacks on fires, with fire appliances and earthmoving machinery, may only be successful when fire intensities are below 2,000kW/m. Indirect attacks would generally fail once fire intensities reach 3,000kW/m (FESA 2000). However, head fire intensities during severe fires, where the majority of losses have occurred in the past, are generally an order of magnitude higher, and often reach 50,000kW/m to 100,000kW/m. Fire intensities in recently hazard reduced areas can also be very high. It was found, for example, that in a forested area which had been hazard reduced through burning

less than 5 years earlier, head fire intensity reached 20,000kW/m during severe fire weather conditions (Braun 2002). This shows that risk management strategies based on fire suppression will fail to significantly reduce wildfire risk under severe fire weather conditions.

The above highlights that wildfire risk assessment and management must be based on research and good information, and that traditional approaches must be carefully reviewed.

Research, Learning and Well Informed Decision Making

In order to accurately reflect the level of wildfire risk in a community, it is necessary that risk assessments are based on factual, well researched information. Assessments should be undertaken by well informed personnel who have the capacity to assess potential wildfire behaviour, the level of wildfire attack, as well as community vulnerability variables.

Unfortunately, comprehensive training and professional development in wildfire risk management is either very limited, or is not available at all. As a result, current wildfire risk assessments and models do not, generally, provide good information on wildfire risk in communities. In turn, risk management strategies often fail to significantly reduce wildfire risk in communities.

It is therefore essential that agencies introduce learning programs to help fire personnel to become better informed about wildfire risk management. These learning programs should form an integral part of professional development, not only for personnel who are directly involved in planning and risk management, but also for operational personnel involved in fire suppression and incident management.

The introduction of a comprehensive learning program in wildfire risk assessment and management is an essential component of wildfire risk management.

Wildfire Attack

When a wildfire risk assessment is undertaken, it is important to determine the type and level of attack that is expected to occur within each risk scenario. The type of attack includes direct flame contact, radiant heat, embers, smoke and high winds, or a combination of any of them. The attack may come directly from a wildfire, or indirectly from gardens and buildings which are ignited by the wildfire. The level of attack provides an indication of the severity of the attack, including duration and intensity of flame contact and radiant heat flux, distance, duration and quantity of ember attack, and duration and severity of high winds.

The type and level of wildfire attack that is expected to occur provides a good indication of the attributes a community must have to withstand a wildfire within the different risk scenarios. Risk assessments must evaluate this capacity in order to determine the level of risk a community is exposed to.

It may be found, for example, that the separation distance between flammable vegetation and a building is such that flame contact is expected to occur and that radiant heat loads are very high. Where buildings are unable to withstand flame contact and radiant heat from the fire they will ignite. In this case the level of protection is not commensurate with the level of attack, and the building and its occupants would be at an extreme level of risk.

Similarly, an initial attack in suburban areas may be through embers and heavy smoke. A secondary attack may occur after spot fires develop in gardens and buildings, which in turn can result in flame contact, radiant heat, further spot fires and more smoke. Depending on the material that is ignited, smoke may also be toxic (eg. treated pine, tyres), which can exacerbate the situation. If the community and fire services have the capacity to safely extinguish the spot fires before they ignite buildings, the level of risk would be low or moderate. However, where spot fires can not be contained, the level of risk may be high or extreme.

People Behaviour

The behaviour of members of a community, but also fire and emergency services personnel and police before, during and after a fire, has a major influence on the level of wildfire risk. Examples include communities which do not maintain adequate hazard separation between flammable vegetation and buildings, or do not maintain a reliable water supply to deal with spot fires. Late evacuations directed by fire and emergency services or police, when the fire has already reached an area and/or a safe travel route and destination are not known, as well as neglecting to patrol an area for spot fires after a fire has passed, are further examples where wildfire risk will be high or extreme.

It is therefore essential that work is undertaken to determine the behaviour which members of a community and emergency personnel should display, within the different risk scenarios. The risk assessment would then evaluate whether the community and emergency personnel have the capacity, but also whether they are likely to display the appropriate behaviour. In cases where the behaviour is commensurate with the level of fire attack, wildfire risk will be moderate or low. On the other hand, where behaviour is not commensurate with the level of attack, wildfire risk would be high or extreme.

Outcomes from these assessments would show, for example, that a community which is well prepared for wildfire, but which is located in an area with a high wildfire hazard, would be at a lower level of risk than a community which is located in a low hazard area, but which is ill prepared for wildfire. The opposite outcome is generally obtained from traditional assessments which do not integrate community resilience or vulnerability attributes. These assessments generally find that communities in high hazard areas are at a higher level of risk than communities in low hazard areas.

Wildfire Risk Assessment Model

Risk assessments must be based on factual, well researched information. Personnel who undertake wildfire risk assessments must have the capacity to assess potential wildfire behaviour, the level of wildfire attack, as well as community vulnerability variables.

Ideally, detailed community wildfire risk assessments should be undertaken at local levels. Local assessments could then be collated to form district, regional and State wide assessments. However, during initial stages it may only be possible to undertake strategic wildfire risk assessments, as detailed information on community vulnerability attributes is not, generally, available. Strategic assessments would still provide valuable information, but only when they incorporate community resilience or vulnerability variables. Geographic information systems (GIS) can be used to collate information for wildfire risk assessments.

The following provides a basic framework for community based wildfire risk assessments. Detailed technical information on community vulnerability or resilience indicators, or on fire behaviour, is not provided here.

Wildfire Hazard Assessment

Maps should be generated to show wildfire hazards. This can generally be based on vegetation type and structure, but also on fuel loading. A number of different models exist for fuel assessments. At a strategic level it may be sufficient to apply default fuel loadings to different vegetation types, or to only differentiate between standing vegetation and cleared land, as outlined in a position paper developed by the Australasian Fire Authorities Council (2000).

Local assessments may include detailed information on fuel loading. However, unless this information is updated regularly, it is recommended that default fuel levels are used.

Wildfire hazard assessments should not only focus on areas adjacent to communities, but also on hazards within communities, including flammable vegetation and material in gardens, on unmanaged land and in urban reserves.

Communities – Buildings, Infrastructure, and Economy

The location of buildings, infrastructure, tourist facilities and plantations should be mapped. In many cases it may be possible to use existing data sets or aerial photos to obtain this information. Details on the susceptibility or resilience to wildfire attack should be collated. Examples include whether buildings are designed to prevent entry of embers, and whether maintenance programs are in place to remove leaf litter from roofs and gutters.

The traditional approach would focus on homes in wildfire hazard areas. However, hospitals, schools, shopping centres, factories and observatories, but also bridges and power lines, may all be susceptible to damage in a wildfire. The consequences of fire damage to them are generally severe, and it is important that they are included in wildfire risk assessments.

Communities – Behaviour

An assessment must be made of the capacity of a community to display appropriate behaviour before, during and after a fire. This includes whether adequate hazard separation is maintained between buildings and flammable vegetation, whether appropriate procedures are in place in the vent of a wildfire, not only in homes, but also in schools, hospitals, or factories. Information brochures on community wildfire safety can provide a general guide in this area.

Fire and Emergency Services – Fire Response

An assessment should be made of the response capabilities of fire and emergency services. This relates to fire appliances, as well as training and incident management capabilities. In this context, police are considered to be part of fire and emergency services.

Fire and Emergency Services – Behaviour

The capacity of emergency services to display the appropriate behaviour before, during and after a fire will have a significant impact on wildfire risk. Again, police are considered to be part of the fire and emergency services in this context.

The following areas should be assessed:

- systems for learning and continuous improvement in wildfire risk management for agency staff and volunteers;
- capacity to work with communities in wildfire risk management;
- effectiveness of community wildfire risk management strategies and programs;
- effectiveness of a regulatory framework to minimise wildfire risk;
- training for and appropriate behaviour of operational personnel in community wildfire risk management during wildfire emergencies;
- effectiveness of recovery strategies.

Risk Scenarios

Realistic wildfire risk scenarios must be developed. These should cover scenarios which are likely to occur, but also those which may only occur once every, say, 100 years. Scenarios could include single or multiple fires on days of low, high or extreme fire danger, in "normal" seasons or under drought conditions, fires which impact on communities, and fires of different size and magnitude. It must be remembered that fires which caused the majority of losses only occur at very infrequent intervals, but their consequences were generally catastrophic.

Wildfire Attack

For each risk scenario, the type and level of attack must be determined. Different areas will be exposed to flame contact, radiant heat, ember attack, smoke and possibly high winds. This information can be displayed as zones in the GIS or on maps. The extent of the zones should be based on the hazard assessment and respective risk scenario for an area. Where research is not available to provide distances for these zones, estimates may have to be made until relevant research becomes available.

Wildfire Risk

The level of wildfire risk in a community can be obtained for each risk scenario by determining the losses which are expected, based on the level of attack from a fire and on the evaluation of the capacity of a community and its fire and emergency services to withstand such an attack. Where the capacity of the community is commensurate with the level of attack, wildfire risk will be lower. However, where a gap exists between the level of attack and the capacity of a community to withstand such an attack, wildfire risk would be higher.

The information from the risk assessment also provides valuable information on management strategies which would have to be introduced to minimise wildfire risk.

Qualitative versus Quantitative Risk Assessment

Traditional models tend to assign numerical values to variables, in order to provide a composite risk value. Attempts are sometimes made to assign different weights to individual

variables to better reflect their importance. However, results from these assessments can become very misleading. It may, for example, be found that a section of a community complies with most risk management requirements, but fails to meet one requirement. The result of a quantitative assessment would show that the level of compliance was high, and that the level of risk would be relatively low. However, it is possible that the variable which was not complied with had a substantial risk associated with it, with potentially fatal consequences (eg. late evacuation). It is therefore not recommended to apply quantitative models to calculate a composite level of risk.

A qualitative risk assessment model, similar to the one developed by Emergency Management Australia (2000), is more suitable. Results from such an assessment would still show that the level of risk in the above example is extreme, as the focus is on the consequence, rather than on the level of compliance.

Qualitative risk analysis matrix

Likelihood	Consequences				
	Insignificant	Minor	Moderate	Major	Catastrophic
almost certain	high	high	extreme	extreme	extreme
likely	moderate	high	high	extreme	extreme
possible	low	moderate	high	extreme	extreme
unlikely	low	low	moderate	high	extreme
rare	low	low	moderate	high	high

Where the level of risk is high or extreme, Emergency Management Australia recommends that action is taken to reduce the level of risk. (This table has been reproduced from Emergency Risk Management – Applications Guide EMA 2000).

Performance Indicators

One of the key objectives of an agency involved in wildfire fire protection should be a safer community. It is possible to use the outcomes from wildfire risk assessments as key performance indicators to provide a measure of the level of wildfire risk in a community.

Where well informed risk assessments are undertaken, which integrate community vulnerability or resilience attributes, key performance indicators can become a powerful tool for assessing an agency's performance in achieving or maintaining a safer community. Performance indicators can also be used to support budgeting decisions. It could be demonstrated, for example, that a significant increase in fire appliances and fire fighting aircraft would not significantly reduce wildfire risk in the community when major fires burn under severe fire weather conditions. On the other hand, allocating human and financial resources to programs which will help communities to become more resilient to wildfires would result in a significant decrease in wildfire risk.

However, agency performance is often measured by indicators such as response time, the number of call outs, or the number of hectares of native vegetation that were burned in a hazard reduction program. These indicators fail to incorporate community vulnerability or resilience. In these cases an agency may have met all its key performance indicators, but the community may still be at an extreme level of risk in a severe wildfire emergency, or even worse, significant losses may have occurred even though an agency had met all its

performance criteria. Fundamental change is therefore required in the way agency performance in wildfire risk management is reported.

Conclusion

The above paper provides a basic wildfire risk assessment model which incorporates community vulnerability or resilience attributes. It does not provide all the solutions, and more work is required to further develop the model and assessment criteria. However, the model offers a new approach that better reflects wildfire risk in communities.

In an audit on prevention and preparedness, the Auditor General of Victoria has identified that "the relationship between hazard reduction burning and the overall wildfire risk is currently limited". At the same time, agency reporting was based on hazard reduction burning targets which had to be achieved to reduce wildfire risk. To overcome this deficiency, the Auditor General recommended that reporting should incorporate "measures that more accurately reflect the level of risk reduction being sought and achieved" (2003).

Fundamental change is required in the way wildfire risk, and in turn an agency's performance are assessed. In addition, training in wildfire risk management and a framework for learning and continuous improvement must be introduced. Without this change, it is unlikely that significant reductions in community wildfire risk can be achieved.

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