TWELFTH INTERNATIONAL

WILDLAND FIRE SAFETY SUMMIT

PROCEEDINGS

SYDNEY, AUSTRALIA
OCTOBER 25 – 26, 2012

International Association of Wildland Fire

INTRODUCTION

12th International Wildland Fire Safety Summit

In October, the 12th International Wildland Fire Safety Summit in Sydney, Australia brought together students of fire from all over the world to explore new approaches in wildland fire safety. Participants attended from the USA, Switzerland, Hong Kong, France, New Zealand and Australia to take part in the summit.

The summit was preceded by two well attended and interesting workshops: *Being Wrong, Being Human: Using Failure as a Recipe for Success* and *Wildland Fitness Assessment Battery – FireFit Program.* On Thursday, IAWF President Dan Bailey welcomed all to the conference followed by a keynote presentation on *Teaching High Reliability Organizing (HRO) Principles Using Staff Rides* by Mike DeGrosky. The remainder of the day was filled with presentations about lessons learned, getting the „deep smarts" from our elders, the impact of human factors in decision making and genuine learning, and the possible prevention of some of the negative psychological impacts of our „business".

Barrister Michael Eburn ably and engagingly closed the day with a presentation on *Enforcing Safety with Law - Implications for Incident Controllers and Fire Agencies*.

Alan Goodwin, IAWF Board member and Conference Chair, opened Friday with a succinct and insightful review of Thursday's presentations and discussions, and introduced keynote speaker Christine Owen who spoke about *Bulldogs and Boundary Spanners: Contested Visions of Leadership, Communication and Teamwork in Emergency Incident Management***.** This was capably followed by presentations around decision making, especially under duress; Alaska, response priorities in the rural-urban interface, how we measure „fit" for fire work, and some insightful analysis of radio messages made at life-critical moments.

Thursday evening the poster presenters shared their work with others during the social hour. Later in the evening the Hot Stove Session was an opportunity to share Stories of Close Calls, Personal Disasters and Lessoned Learned. This session was well attended and a highlight of the conference.

Encouragingly there was a warm and engaging atmosphere ensuring lively discussion on many of the topics, and notable cross-referencing between sessions. The theme of the conference – innovative approaches to addressing long-term safety problems and "passing on the torch" were clearly evident.

We received an overwhelming positive response from the participants.

- One of the best conferences I've attended. the order of the proceedings was almost spot on, with each successive presentation, almost without exception, building on the previous one.
- It is a 'meeting' of a likeminded people that strive to improve organizational safety and behavior; and therefore performance.
- The sharing of information with the passion and willingness of the presenters to transfer their knowledge and experience.
- "The most important thing about going to a fire, is going home".
- Was worried it may be too fire centric, as I am from a non-fire agency. But many of the issues are generic to all Emergency services. Good crew of people that were friendly and generous with their knowledge!

If you missed the conference, all of the Power Point Presentations have been posted online.
http://www.iawfonline.org/Sydney2012/Program.php

The generous conference sponsors were Travers Bushfire & Ecology and Bushfire Cooperative Research Centre (CRC). Also, a special thank you to the steering committee who worked hard to pull together a very successful event; Alan Goodwin, Tony Blanks, Neil Cooper, Max Coulter, Tim McGuffog, Ron Steffens and Roger Strickland. Also special thanks to Mikel Robinson Executive Director of the IAWF for her insight and direction.

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CONTENTS

ORAL PRESENTATIONS

POSTER PRESENTATIONS

ADDITIONAL PRESENTATION ABSTRACTS

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Teaching the Principles of High Reliability Organizing (HRO) Using Staff Rides

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Abstract. Empirical evidence suggests that problems associated with the practice of leadership contribute to accidents and fatalities in the work environment of wildland firefighters in the United States (U.S.). Findings, of both investigations and academic studies, identified leadership as a performance gap requiring attention by wildland fire agencies (DeGrosky, 2005; National Wildfire Coordinating Group [NWCG], 2007: NWCG, 2009; Useem, Cook & Sutton, 2005). In response, U.S. wildland fire organizations sought to improve their leadership performance via human factors and leadership development training. As part of a concerted leadership development training curriculum led by the National Wildland Fire Cooordinating Group (NWCG) Leadership Development Subcommittee, the firefighting community adopted staff rides; an organizational learning method. A staff ride consists of a case study of historical events, conducted on the ground where those events occurred (Robertson, 1987). In the military, a staff ride typically occurs at the site of a noteworthy battle or other engagement, to contribute to the leadership development of junior officers. The intent of a staff ride is to put participants in the shoes of the decision makers involved in an historical event, facilitate learning from the actions of historical decision-makers, and enable participants to apply their learning to their own decision-making and leadership behavior in the future. The author explores lessons learned from six staff rides designed and conducted with the intent of imparting knowledge of high reliability organizing (HRO) principles to wildland fire personnel. The selected staff rides include four escaped prescribed burns, one human-caused suppression fire, as well as a Wildland Fire Use incident. All resulted in unintended consequences including, entrapment and burnover of fire personnel, dramatic loss of homes and other structures in the wildland-urban interface, and/or significant socio-political consequences.

Additional Keywords: Suppression costs, preparedness levels, simultaneous equation models

Introduction

Empirical evidence suggests that problems associated with the practice of leadership contribute to accidents and fatalities in the work environment of wildland firefighters in the United States (U.S.). Findings, of both investigations and academic studies, identified leadership as a performance gap requiring attention by wildland fire agencies (DeGrosky, 2005; National Wildfire Coordinating Group [NWCG], 2007: NWCG, 2009; Useem, Cook & Sutton, 2005). In response, U.S. wildland fire organizations sought to improve their leadership performance via human factors and leadership development training. As part of a concerted leadership development training curriculum led by the NWCG Leadership Development Subcommittee, the firefighting community adopted staff rides. The author explores lessons learned from six staff rides designed and conducted with the intent of imparting knowledge of high reliability

organizing (HRO) principles to wildland fire personnel. The selected staff rides include four escaped prescribed burns, one human-caused suppression fire, as well as a Wildland Fire Use incident. All resulted in unintended consequences including, entrapment and burnover of fire personnel, dramatic loss of homes and other structures in the wildland-urban interface, and/or significant socio-political consequences.

High Reliability Organizing (HRO)

High Reliability organizing (HRO) is an area of organizational behavior theory predicated on three broad assumptions.

1. High risk and high effectiveness can co-exist
2. Some organizations must perform well in high risk operating environments
3. Performing effectively in high risk operating environments takes conscious, intensive effort

Value of HRO Theory

This area of theory presents organizations with a set of principles enabling exceptional performance and resilience under conditions of uncertainty and threat.

What HRO Looks Like in Real Life

When organizations operate according to the principles of HRO, one tends to see organizational behavior that manifests itself as interactions between people who are responsive to their operating environment in an organization that allows and facilitates their interaction and responsiveness.

Staff Rides

Staff rides represent an organizational learning method originally conceived by the Prussian Army in the early 19th Century. A staff ride consists of a case study of historical events, conducted on the ground where those events occurred. In the military, a staff ride typically occurs at the site of a noteworthy battle or other engagement, often to contribute to the leadership development of junior officers. The intent of a staff ride is to put participants in the shoes of the decision makers involved in an historical event, facilitate learning from the actions of historical decision-makers, and enable participants to apply their learning to their own decision-making and leadership behavior in the future. Staff rides are conducted in three integrated phases, as follows:

1. Preliminary Study Phase
2. Field Study Phase
3. Integration Phase

NWCG Leadership Development Program Staff Ride Library

The National Wildfire Coordinating Group (NWCG) staff ride library provides a useful resource in which one can find staff ride examples, a staff ride planning template, facilitator tips, and

other valuable resources. The staff ride library is at:
http://www.fireleadership.gov/toolbox/staffride/index.html

Lessons Learned

The author explores lessons learned from six staff rides designed and conducted with the intent of imparting knowledge of HRO principles to wildland fire personnel. These staff rides include four escaped prescribed burns, one human-caused suppression fire, as well as a Wildland Fire Use incident. All resulted in unintended consequences including, entrapment and burnover of fire personnel, dramatic loss of homes and other structures in the wildland-urban interface, and/or significant socio-political consequences.

General

Lesson Learned: A staff ride anchors, in reality, HRO principles that can prove a bit abstract and academic for audiences made up of fire personnel who tend to be kinesthetic learners. Staff rides drive home HRO principles by providing an intense experience that effectively ties HRO principles back to the ground level

Lesson Learned: Don't fall in love with staff rides as the only valuable learning method; there are others. However, a field trip, a site visit or a field case study cannot replace the experience of a staff ride.

Lesson Learned: There is no single, right way to conduct a staff ride. However, there *are* several principles that must guide your design, planning and conduct.

Lesson Learned: The author views staff rides as adult learning opportunities, and think about them through that lens. Our role is not to spoon feed people the "right" answers, but to provide people with the opportunity to acquire information, think about that information critically, come to their own conclusions, do their own learning, take home what they find relevant, and apply their newfound knowledge to their lives.

Design

Lesson Learned: When incorporating a staff ride as an element of a larger training session or workshop the staff ride must be planned and designed so that it is fully integrated into the overall workshop. Links between the staff ride and classroom sessions or other elements must be well planned and mutually supporting. It is very important to draw a very clear connection between HRO principles and the staff-ride content.

In addition, it is essential to make sure that the entire experience then relates back to taking HRO home and transferring it to application. Begin by assuring that staff ride objectives are well integrated with the overall staff ride objectives. Next, make sure that the staff ride facilitators and stand presenters adequately, consistently, and clearly link the content of the staff ride stands with HRO principles.

Think hard about how you sequence the elements of your overall effort and how the sequence best achieves your overall objectives. For example, in one of our efforts, we put the staff ride in the middle of the training session and it worked well. Some participants have suggested that organizing the staff ride relatively early in a course or workshop provides a valuable bonding experience for the participants.

Lesson Learned: From time-to-time, participants call for examples of individuals and/or organizations successfully managing or meeting objectives. Some specifically wish to avoid near misses, failures and tragedies as examples; preferring examples of people "getting the job done."
However, this perspective misses the mark in the context of HRO. HRO is, after all, fundamentally a theory helping us understand how organizations can avoid failure by anticipating and containing unexpected events including human error. At the bottom line, if there's no risk, no tempo, and no potential for failure; there's no HRO. We are interested in HRO because we recognize that wildland fire operations occur in a high-risk environment with potential for unacceptable organizational failure, and we want to give our constituents a tool to help them avoid that failure. We *could* provide an effective example of an organization that met their burn acreage target, met all their ecological objectives, and are generally good stewards of our natural resources. However, unless we can demonstrate how they did so by anticipating, containing, and recovering from unexpected, undesirable events that could cause them to fail, in my opinion, we will be have missed our intent. In short, avoiding the subject of organizational failure takes us off the HRO map. When employing a staff ride to convey learning about HRO, the cadre must explicitly explain the rationale for the chosen historical event and emphasize the importance of revisiting organizational failures, not to locate blame, but to learn from the misfortunes of others so that they, and the people for whom they are responsible, do not replicate those failures or the actions leading to them.

Lesson Learned: There are pros and cons to using a fire scenario for your staff-ride. Some participants provide feedback suggesting that they would have been better served by a non-fire context that prevented participants from over-focusing on tactics, thereby preserving the broader intent of the staff ride. Conversely, participants occasionally suggest that a non-fire staff ride context would have taken firefighters too far out of their "comfort zone." Staff ride organizers must know their audience, and their learning preferences well. Participants must know the nature of the staff ride before they engage.

Audience

Lesson Learned: Staff rides are an unfamiliar learning method for many participants. Reinforce/reiterate staff ride principles, protocols and procedures multiple times by multiple means. For example, many staff ride participants are tacticians and many staff rides focus on tactics. However, if your focus is not tactical, you will have to work hard to keep the focus where you want it and to manage expectations to meet your intended objectives and avoid disappointment. To succeed, staff ride organizers must clearly communicate their intent as well

as the purpose and design of the staff ride starting with their first contact with the participants. The cadres should deliberately reinforce their intent, purpose and design throughout the staff ride. Facilitators working directly with participant groups can maintain group focus on the intended objectives.

Preliminary Study Phase

Lesson Learned: The Preliminary Study Phase is not simply "pre-work" for the Field Study Phase. A staff ride involves three learning phases, (1) the preliminary study phase, (2) the field study phase and, (3) an integration phase. Each represents one-third of a cohesive learning experience. Participants conditioned by traditional learning approaches common to the wildland fire service can fall into a familiar pattern in which they regard the preliminary phase as pre-work which, anecdotally, training practitioners know frequently goes uncompleted. Participants neglecting to complete the preliminary study phase materials will find themselves at a distinct disadvantage and may even detract from the experience of others. Consequently, staff ride organizers should treat the preliminary study phase as 1/3 of an integrated learning experience, and encourage the participants to do the same.

Field Study Phase

Lesson Learned: Allow adequate time, particularly enough time at each staff ride stand during the field phase. Allow enough time at each stand to specifically discuss the content presented as it relates to HRO. Also allow enough time to provide additional instruction during the field phase of the staff ride. When the overall time frame was too short, so was the time allotted for each stand during the field study phase. Stands that are rushed tend to produce discussion that is not as rich as envisioned.

Lesson Learned: There are pros and cons to using actual participants as staff ride stand participants. Many participants have found staff rides utilizing actual participants as staff ride stand presenters very powerful. In other cases, doing so has stirred controversy.
When using actual participants as staff ride presenters, recognize that you must:

- Encourage staff ride presenters to tell their story (rather than relay isolated facts) and share their thought processes

- Assure that the staff ride presenters have at least a rudimentary understanding of HRO principles, so that they can relate their story to HRO. Orient the stand presenters to what the participants are learning using video, etc.

- Accept that involving actual participants may require working around sensitivities and that may require making some compromises in the interest of personal privacy, confidentiality of people contributing to the content, interagency relations, public relations, or courtesy

Lesson Learned: Orient participants to the area to provide context. Consider using narration on

the transportation and careful route selection (that purposefully introduces participants to surroundings)

Lesson Learned: To link HRO principles to the staff ride context/case strongly and consistently you need a facilitator role/presence in the staff ride groups. Fully prepare the group facilitators to meet the staff ride objectives. Be very clear about the facilitator role. Provide training and advance materials (and even homework assignments) to group facilitators to prepare them for the staff ride. Get them out on the staff ride site in advance for planning and familiarization.

Lesson Learned: A staff ride can be an intense and taxing experience. Allow some recovery time following the staff ride. Consider providing a time during which people can "download" in an unstructured environment, a period of quiet reflection, opportunities to journal, or other low-intensity activities appropriate for the given audience.

Integration Phase

Lesson Learned: The Integration Phase of a staff ride is critical, and it is hard to do well. Consider that:

- Everyone participating must understand the purpose, the importance, and the conduct of the Integration Phase before it begins. The facilitator may need to reinforce these points periodically.

- Some participants will get bored and impatient if the Integration Phase lasts too long, particularly if the information sharing seems redundant to them. Do not short this critical element, but make it a highly interactive and participatory activity with active and skilled facilitation.

- Active and skilled facilitation is essential during the Integration Phase. However, assure an appropriate balance between student input and comments by the facilitator.

- The Integration Phase is intended to be a highly interactive and participatory activity. However, in larger groups, participants tend to get irritated when all participants are asked to speak individually during the Integration Phase. Consider working first as groups, then with larger audiences.

Lesson Learned: The cadre should participate in the staff ride and that it is helpful for the training cadre to take notes during the staff ride to assure continuity from the Field Study Phase to the Integration Phase. Cadre members should note points that they feel would be important to share during integration, including discussions occurring at the stands that participants might not remember or that linked the case study to the HRO principles. On the other hand, assure that cadre members do not dominate the Integration Phase, either individually or collectively.

Lesson Learned: Everyone can benefit from hearing questions and answers brought up in

discussion during the staff ride. Assure that the products of key discussions are illuminated for all during the Integration Phase.

Logistics

Lesson Learned: Support materials including maps, photos and PA/audio capacity in the field can make or break your staff ride

Lesson Learned: Find a training venue close to the staff ride location (<60 minutes)

Lesson Learned: Reduce the number of vehicles required for the staff ride (favor busses or similar)

Lesson Learned: Make sure transportation and other logistical details are in place well in advance. Be very strategic about all major components; staff ride, training venue, airport, transportation, food, etc. available in right combination. Conduct organizational conference calls at key points. Have a couple of people dedicated to working the staff ride only; there is too much work to treat the staff ride as a collateral duty. Problems with logistical arrangements that crop-up at the last minute can distract from content preparations.

Conclusion

Empirical evidence suggests that problems associated with the practice of leadership contribute to accidents and fatalities in the work environment of wildland firefighters in the United States (U.S.). Findings, of both investigations and academic studies, identified leadership as a performance gap requiring attention by wildland fire agencies (DeGrosky, 2005; National Wildfire Coordinating Group [NWCG], 2007: NWCG, 2009; Useem, Cook & Sutton, 2005). In response, U.S. wildland fire organizations seeking to improve their leadership performance via human factors and leadership development training have adopted staff rides; an organizational learning method originally conceived by the Prussian Army in the early 19th Century and used extensively by the modern U.S. military. The intent of a staff ride is to put participants in the shoes of the decision makers involved in an historical event, facilitate learning from the actions of historical decision-makers, and enable participants to apply their learning to their own decision-making and leadership behavior in the future. Staff rides have proven effective at achieving the intent of imparting knowledge of HRO principles to wildland fire personnel. However, staff ride planners would be well-advised to take heed to the lessons learned by the personnel who planned and conducted six staff rides conducted for this purpose.

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Utilising planned burning as a learning mechanism – Creating a whole of government approach to skill acquisition.

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Abstract.
Post the Victorian Black Saturday bushfires in February 2009 there has been significant community interest, angst, and expectations about planned burning. Despite a vigorous public debate about the limitations and value of planned burning, community understanding of the issues remains limited.

In response to the Victorian Bushfires Royal Commission investigation of Black Saturday, the state government of Victoria has given the Department of Sustainability and Environment (DSE) a mandate to increase burning to 5% of the total public land estate per annum. The Country Fire Authority (CFA) has oversight for fire prevention and suppression; however 78% of the state is managed by other land managers.

CFA volunteer fire brigades have a long history of planned burning. However a decline in the availability of volunteers and a risk-averse community, combined with complexities such as legislative and environmental considerations, have led to reduced volunteer involvement in planned burning in parts of the state.

There is a need for rapid up-skilling of both volunteer and professional fire fighters. That is 'passing on the baton' from retiring fire fighters to next generation. A 'whole of government' approach is required to ensure that knowledge is transferred between the agencies to achieve this.

This paper looks at the history of planned burning in Victoria, its socio-political and legislative context, and the lessons learned.

Additional Keywords: Prescribed burning, multi-agency, Country Fire Authority, Victoria

Background

Fire Operations in Victoria, Australia

Fire operations, tactics and strategies vary greatly between countries, even definitions of commonly used terminology. This section looks at providing a picture of those aspects fire operations or more so fire management in Victoria.

In the Australian context the term 'wildfire' has been interchangeable with 'bushfire'. Bushfire means unplanned fire as distinct from planned fire. In this sense bushfire can occur in grassland, forest or scrublands and in a variety of landscapes ranging from naturel areas (including reserves on public land) to agricultural or urban land use.

Bushfire suppression in the state of Victoria is provided by two fire authorities. Public land (which includes national and state parks, and other crown land) is the responsibility of the Department of Sustainability and Environment (DSE). THE Country Fire Authority is responsible for the remaining non-public land, which expanses approximately 78% of Victoria's 227,600 square Kilometers.

Bushfire risk management activities that relate to non-emergency activities are known collectively in Victoria as fire management. Fuel reduction treatments (which include planned burning) are considered a fire management activity.

The CFA Act 1958 is the key legislation that describes fire prevention responsibilities for the non-public land areas of Victoria. Under the Act landowners are responsible for the management of fuel hazards on their land. The CFA is not a land manager, but under the CFA Act may undertake fuel reduction work at the request of the land manager or owner.

On public land DSE has legislative responsibilities for bushfire risk management both as the land manger and fire suppression agency. DSE employs full time fire fighters and a part time workforce in the bushfire season. Other land managers who maintain fire-fighting resources include private timber plantation companies and Water Authorities such as Melbourne Water Cooperation who look after vast tracks of forested land that protects the water supply for the Victorian capital city, Melbourne.

CFA fire prevention and suppression is undertaken largely by volunteer fire-fighters as members of volunteer fire brigades. During major bushfire events, CFA and DSE resources routinely work together.

Planning for suppression and prevention occurs at a strategic level using a variety of mechanisms, which allow for a multi-agency, land-tenure, blind approach. In contrast fire prevention and planned burning activities tend to closely follow legislative and administrative boundaries. There is a history of jointly planned and conducted fuel reduction burns across these administrative boundaries and tenure, however this not systematic or consistent across the state.

Planned Burning by CFA volunteer fire brigades

Planned burning by volunteer fire brigades on road reserves, railway reserves and to a lesser extent, private land is a long established practice in Victoria, particularly in the rural areas. Much of the burning is a continuation of historical treatments for township protection or to assist with suppression of bushfire by providing a strategic fuel modified break from which suppression can be managed.

Anecdotal evidence suggests that these types of brigades regard fuel reduction burns as a pertinent training exercise to acquire and maintain bushfire suppression skills.

Brigade capability to undertake fuel reduction burning varies significantly across the state. Those brigades with unbroken practice of burning are able to maintain skills and confidence. Whereas in peri-urban areas or rural areas with significant population decline and an aging volunteer workforce, capacity is decreasing or being lost completely.

The retention time for a typical volunteer is only five years and this is a critical factor in the loss of expertise amongst volunteers. At the point at which we have trained the volunteers to be confident skilled planned burners we are losing them. We need to be able to rapidly build our skills and capacity in this area.

In order to meet public and government expectation surrounding planned burning, opportunities for volunteers to train, be mentored, and gain experience will need to be increased.

Black Saturday

On February 7, 2009 bushfires ravaged the state of Victoria killing 173 people, injuring a further 414 others and destroying 2,030 houses. In response to the disaster the Victorian government established a Royal Commission to enquire into the circumstance and factors that contributed to the devastating losses. The Victorian Bushfire Royal Commission (VBRC) in its final report made 60 recommendations; the government of the day committed to implement every one of these. One recommendation in particular would see a huge shift in business practices by the Department of Sustainability and Environment, and the management of Victoria's reserves and forests under their responsibility.

RECOMMENDATION 56

The State fund and commit to implementing a long-term program of prescribed burning based on an annual rolling target of 5 per cent minimum of public land. (Victoria, 2010)

The emphasis on conducting of fuel reduction has led to enhanced pressure from the community and various specialty groups such as environmentalists. Fuelled by media debate, pictures of koalas, an iconic Australian animal in bandages suffering burns with articles stating local residents are demanding investigations to determine why a burn off has injured wildlife (K. Shorten, Courier Mail. Oct 20011). Further exacerbated by articles condemning agencies for undertaken and leaving Central Business Districts of capital cities inundated with smoke, causing grief to community members trying to dry their clothes outside and leaving a putrid tainted smell for community members to suffer within (Anon, Herald Sun. March 2010. C.Frost & R.Lentini, 2012). Not one Burn OIC sets out to allow a planned burn to escape, however if this does occur and the outcome attracts media attention, one can expect the finger to be pointed and for reporters to explain how the works are not worth the risk and details the emotions and impact of those concerned (D.Guest, 2011).

The debate of benefit versus consequence of planned burning and the communities and community group's belief itself is a sordid and complex discussion. Numerous community members and groups, whether they be individual community members, environmental groups forest recreation groups have taken the opportunity to develop papers, make submission to the numerous government enquiries surrounding fire and planned burning. Altangerel & Kull (2013) used a textual analysis to look into the prescribed burning debate in Australia; *Conflicts and Compatibilities* and found:

> The individuals concerned enough about prescribed burning policies to write a submission to a government Inquiry have much in common. All three narrative groups present detailed discussions of the effects of prescribed burning, marshal various kinds of evidence and experiences, implicate a number of shared moral principles, and seem to genuinely care about its impacts on the environment, human lives, and assets. Yet they radically differ in their interpretations of their experiences and examples, and the positions to which they come.

The debate on how much to burn and where, has brought a greater focus on the strategic fuel reduction to protect assets, particularly in the peri-urban areas surrounding rural townships and the City of Melbourne. The focus on the importance of planned burning on public land has also highlighted the need to treat fuel hazards on private property.

Building agency capacity for planned burning and the benefits of inter-agency planned burning in the fire services

Planned burning is a high risk operation and broadening the skill base we have to draw from brings with it a higher level of confidence that the outcomes will be achieved and the risk will be lessened. The benefits flow on to increasing the skill level of all of the participants who in turn can pass this skill on to others. The narrow window of opportunity we have to carry out planned burning due to weather constraints, personnel constraints and equipment limitations can be broadened by utilising personnel and equipment from across agencies and thus take every weather opportunity available.

The inclusion of planned burning has become the core business of CFA since Black Saturday. Many documented learning tools can be used in planned burning and some of these have been expanded on below.

James Reasons Swiss Cheese model of accident causation (2000)
Reason made reference to two approaches to the problem of human fallibility; the Person Approach and the System Approach. The Person Approach has contributed to some of the short-comings experienced in the past, examples being when a planned burn escapes and formal investigations or even internal politics/culture results in the finger being pointed and the blame game begins. Reason (2000) argues, "If something goes wrong, it seems obvious that an individual (or group of individuals) must have been responsible. Seeking as far as possible to uncouple a person's unsafe acts from any institutional responsibility is clearly in the interests of managers. Reason also argues that it is legally more convenient to place the blame on individuals. (p. 768)

Imagine a trainee burn OIC is subjected to internal and potentially external pressures such as this, the resultant stress could result in that individual never wanting to participate in these types of activities again and has the potential to deter others from stepping into this specialist area. Reason continues

> Effective risk management depends crucially on establishing a reporting culture. Without a detailed analysis of mishaps, incidents, near misses, and "free lessons," we have no way of uncovering recurrent error traps or of knowing where the "edge" is until we fall over it. The complete absence of such a reporting culture within the Soviet Union contributed crucially to the Chernobyl disaster. Trust is a key element of a reporting culture and this, in turn, requires the existence of a just culture—one possessing a collective understanding of where the line should be drawn between blameless and blameworthy actions. Engineering a just culture is an essential early step on creating a safe culture. (p. 768-769)

A Just Culture is an end state that is difficult to achieve when dealing with high risk operations within an organisation that is in its infancy with planned burning. A key aspect of this model is

in relation to high reliability organisations expecting to make failures, Reason (2000) summarizes treatment of failures in his statement

> Perhaps the most important distinguishing feature of high reliability organisations is their collective preoccupation with the possibility of failure. They expect to make errors and train their workforce to recognise and recover them. They continually rehearse familiar scenarios of failure and strive hard to imagine novel ones. Instead of isolating failures, they generalise them. Instead of making local repairs, they look for system reforms. (p.770)

After Action Reviews

CFA has long displayed their skill and expertise in relation to fire fighting, and has been recognised as an established professional volunteer emergency service. Even after incidents that appeared to progress smoothly those whom worked within the incident are required to undertake after action reviews (AAR). Looking at:

- What went well?
- What did not go so well? and
- What can be improved upon?

It is expected that nothing is ever perfect, accidents occur and there is always room for improvement. This is considered standard for all incidents and being able to approach these AAR's without a blame mentality, rather a lessons-learned approach is key to the success of this process in order to improve in the future. This process also needs to be adopted for the likes of prescribed burning.

An After Action Review (AAR) is a structured discussion of an event, focused on performance standards, that enables firefighters to discover for themselves what happened, why it happened, and how to sustain strengths and improve on weaknesses. It is a tool leaders and units can use to get maximum benefit from every incident or project.

The AAR was developed by the military in order to create an avenue for feedback, promote evaluation and improve unit cohesion. The AAR is now used worldwide by military organizations, governments, and private industry. It is considered a valuable tool in high-risk professions where the smallest mistakes can lead to disastrous results.

It is essential for bushfire firefighters to learn from past mistakes and to capitalize on past successes. The price we pay for failure can be exceptionally high and the amount of effort put into our successes is often left unrecognized. The objective of the After Action Review is to immediately identify these success and failures. Once they have been recognized, further exploration allows the team to perfect its skills and be better prepared for future endeavours. **(http://www.fireleadership.gov/toolbox/after_action_review/)**

AAR's particularly within this multi-agency environment not only allow the trainee Burn OIC to display and further develop their leadership qualities but also highlights key lessons to be learned, drawing on all the expertise as provided by the differing agencies. The skills and lessons learned encourage and empower the participants, particularly volunteers to start building expertise and developing their "slide show of experiences" to be called upon in the circumstances of worst case scenario decision making. This can greatly enhance firefighter safety.

Worst Case Scenario Thinking

PhD Research carried out by Claire Johnson from CFA explored Worst Case Scenario Thinking and found that barriers to worst case scenario (WCS) thinking were:

- Inexperience
- "Tunnel vision"
- Underestimation of risk
- Suboptimal attitudes
- Situation characteristics
- Interpersonal issues
- Standard procedures

Some of these barriers can be overcome by taking an active part in planned burning. Planned burning can be one of the strategies used to develop WCS thinking as a decision tool. Strategies used in planned burning that can improve WCS thinking include:

- Forecasting: The use of forecasting the impact of the fire ahead in time and space encourages developing WCS thinking.
- Multiple Scenarios; planned burning requires planning for the most likely scenario as well as WCS which provides training to planners and OIC's that they can take on to emergency situations.
- Long Term Planning: Planned burning teaches the benefits of looking beyond the short term.
- "What if" thinking; understanding the current situation and addressing what can go wrong
- Back up plans; having a range of plans that deal with the range of 'what ifs' and triggers to know when to implement the backup plan.
- Critiquing Plans and After Action Reviews; respectful discussion and review of plans and post burn analysis with all members of the team leads to a greater understanding of fire behaviour, processes, and scenarios giving the participant "mental slides" to recall when needed.
- Adaptive Decision Making; Planned Burning can provide opportunities to gain practise in adaptive decision making as changing conditions can often call for changes within the plan while the operation is underway.
- Focus on Fundamentals; internal and external pressures can lead to poor and inappropriate decisions. Planned Burning with a focus on the fundamental rules of safety ensure internal and external pressures do not undermine the plans.
- Motivation to Learn; balanced post burn reviewing and AAR increases the motivation to participate and encourages team members to review their own performance and decision making process and to look for ways to make improvements.

Cardinia Case Study

Background.

In 2011, CFA was approached by the Melbourne Water Corporation (MWC) due to the MWC's concern about the conflicting legislative issues. MWC is nominally a partner agency of DSE as a Networked Emergency Organisation (NEO). MWC is also a land manager in its own right. Within emergency response MWC has legislated immunity provisions against adverse occurrences by being captured within the Forestry Act 1958 for all land gazetted as being within the Fire Protected Area (FPA). As per the Forests Act 1958 the Fire Protected Area is defined as being 'Any land which is –

(a) Within any state park;
(b) Within any forest;
(c) (Unless excised pursuant to an Order under subsection (3) of this section or affected by declaration made under subsection (4) of this section) within 1.5 Kilometres of –
    (i) Any reserved forest or any area of unoccupied Crown Land proclaimed as protected forest pursuant to the Act or any corresponding previous enactment;
    (ii) Any national park; or
    (iii) Any protected public land;
(d)Within any protected public land.'

For day-to-day activities, MWC is governed by the Water Act of 1989. The Water Act does not take into consideration fire prevention or bushfire response. MWC is mandated by Section 43 of the Country Fire Authority Act of 1958 'In the country area of Victoria it is the duty of every municipal council and public authority to take all practicable steps (including burning) to prevent the occurrence of fires on, and minimise the danger of fires on and from any land vested in it or under its control and management.'

MWC has the legislative immunity provision via Section 94 of the Country Fire Authority Act 1958, however within the current risk adverse environment is hesitant to rely on the protection offered as it has been determined that this piece of legislation has thus far not been utilised.

This has the potential to lead to vast areas of bushland reserve adjacent to water supply catchments; a valuable resource for the community and often located within the urban interface, being managed to a minimalist effect, and having CFA fire-fighters responsible for the suppression of bushfires in the area.

The Issues:

- The need to introduce fire into a complex landscape being managed by Melbourne water to prevent the impact of bushfire on the surrounding community and potential adverse effects on the water reservoir by an emergency response. This factor and the negative outcomes have been reviewed in depth by Morris et al 2009.
- Concern from Melbourne Water in relation to legislative protection and indemnity under the Waters Act 1989. The bushfire CRC is currently looking into the findings of post-event inquiries, judicial decisions and insurance claims to identify how law is applied to the fire ground and to determine if legal principals are an impediment to effective fire ground management, in fact the Bushfire CRC Fire Note Issue # 8 (Eburn, 2011) looks at claims for compensation against the NSW rural fire services and outlines that for the

period 1989 to 2010 the NSW RFS received 263 claims for compensation between 25 and 30% of these claims being related to hazard reduction burns.

- Lack of experience in CFA crews due to inexperience in conducting large complex burns.
- Volunteer aspect of CFA and difficulty of having unpaid personnel at planned burns for extended periods of time or for adverse shifts. Research as conducted by McLennon 2008 into the issue facing Australian Volunteer based emergency services organisations discusses the primary barriers to volunteering as being:
    - Time/Priorities. When asked, the most common reason given by individuals as to why they do not volunteer is 'lack of time'. However, this is obviously only partly true—a more complete answer is that volunteering is not seen to be sufficiently important, compared with other activities which need to be undertaken in the time available. Work and family are the two major 'competitors' with emergency services volunteering, particularly for individuals aged 35-44 years. Individuals in this age range are less likely to be interested in becoming volunteer firefighters compared with those from older or younger age groups. There is some evidence that they are also more likely to resign from a volunteer emergency service agency because of work/family demands.
    - Reluctance to commit to the strictures of formal volunteering. Emergency services volunteering imposes stricter demands than many other types of volunteering in terms of (a) obligation to respond when called upon, and (b) adherence to procedures to ensure that tasks are performed safely and effectively. Emergency services volunteers are laden with copious amounts of training required and the formality of this training, skills maintenance and the expectation of community to respond when required. Self-perceived unsuitability for the demands of formal volunteering: Age, infirmity, ill-health, emotional vulnerability.
    - Fear of adverse consequences of volunteering: Death, injury, loss of income, legal action.
    - Opposition from employer.
- CFA being unable to complete works such as establishing breaks or conducting hazard tree removal works due to lack of heavy machinery.

The Tactics

- Multi agency planned burn, throughout all stages of burn planning to post burn review.
- CFA member as Burn OIC. Being mentored by an experienced member from an external CFA district.
- CFA was present during original ignition, when most of the risk and resources are required.
- Additional shifts i.e. night shift and all shifts after the initial 24 hours were resourced by paid MWC staff.
- Experienced MWC staff mentored CFA personnel in key positions such as lighting crew leader.
- CFA brigades who had planned burns identified for later in the season were invited to attend and gain experience.

The Benefits

- *Leadership skills*
  CFA Burn OIC was able to gain experience in a high stress multi agency environment allowing individuals to develop their skills as leaders in multi-agency briefings, and in the directing and tasking of personnel from all agencies on an actual fire ground. This enables the burn OIC and all crews involved to start building on their 'Slide show' of experiences. This type of task would normally be undertaken by more experienced IMT personnel. This is enabling safer and more effective fire fighting operations in the future.
- *Exposure to a more challenging environment*
  CFA has conducted burning works in the past however these have been limited to smaller scale less complex works, or sites that can be burnt and secured within a day, therefore only exposing our people to the less challenging aspects of fire behaviour. By being able to actively participate in and be a key player within a burn of this size and to enable paid work force of Melbourne Water to undertake tasks of blacking out and follow up patrol works. The utilisation of the Melbourne Water staff means the expectations on the volunteers to undertake the follow up works are alleviated ensuring that CFA can have personnel attend and actively participate in these events, being able to experience this fire behaviour and participate within these more complex burns.
- *Practical Exposure to Fire Behaviour*
  CFA crews that attended for support and resourcing of the burn were all able to gain experience in lighting patterns and fire behaviour in complex environments, normally in environments such as this, the only experience would be bushfire incidents when personnel are focusing on extinguishing the fire rather than taking the opportunity to observe and learn from the fire behaviour.
- *Familiarisation with local environment*
  The conducting of works in an area not normally accessible to public and brigade members except when responding to emergency incidents also enabled the local members to gain a familiarity of the site in question.
- *Passing on skills and knowledge*
  MWC personnel were able to pass the knowledge of years of land management expertise onto CFA personnel who are currently embarking on a huge culture change to use planned burning to provide greater fire protection whilst continuing to maintain their own skills in this area of expertise during this time of legislative uncertainty. MWC was also able to complete their land and catchment management objectives as mandated by relevant legislation, whilst maintaining their responsibility to protect the Victorian community and community assets.
- *Increasing confidence*
  As CFA is only a newcomer to the field a burn of this size attracted substantial attention of broader stakeholders and land managers. After seeing the effectiveness of this model these land managers were more obliging to the concept of having these works conducted upon their land.

Cardinia burn 2012, (Budziarski)

Mentoring

The Report of the investigation and inquests into a wildfire and the deaths of Five Fire-fighters at Linton on 2 December 1998 as produced by the state coroner's office, Victoria (State coroner Victoria, 2002) made the following reference. Recommendation 19 promoted:

> The CFA consider introducing a system of 'mentors' to ensure that new fire-fighters and fire-fighters going into a new fire fighting environment for the first few times receive appropriate guidance and directed experience. DNRE should also consider extending its mentoring system to its fire-fighters who fall into this category.
> In order to ensure the 'Mentoring' system is workable, practical, delivering appropriate levels of guidance and experience to all new fire-fighters (or fire-fighters going into a new fire fighting environment for the first few times).

Although in this context it is making reference to enhancing safety provision on the fire ground a planned burn would be just as valuable in achieving this experience prior to being subjected to these pressures in a more dynamic situation of bushfire. This is proposed and has also been recently undertaken between organisations.

Human Behaviour, Situational Awareness and Planned Burning

The Victorian Volunteer Fire Brigades Victoria Association the peak organisations that represents CFA volunteers state-wide, made the following statements in their submission to the Victorian Royal Commission; (VFBV, 2010)

HUMAN BEHAVIOUR AND SITUATIONAL AWARENESS
An analysis of the 'Near Miss Incident Reports' compiled by the CFA based on the evidence of volunteers suggests that a number of the incidents that occurred over the 2008/09 fire season may have been avoided by a greater recognition of the overall existing and forecast changes to the environment in which crews were operating, commonly termed 'situational awareness'.

Situational awareness is achieved through a combination of knowledge of the local environment, the key factors that influence fire behaviour and personal behaviour. Safe outcomes require each firefighter, regardless of their role, to focus on situational awareness while on the fire ground and to respond accordingly. A lack of situational awareness or lack of response to signals on the part of firefighters, can lead firefighters into dangerous situations. The gravity of this cannot be overstated.

Accordingly the next quantum step in enhancing firefighter safety requires enhancement in training in situational awareness. Such training should be incorporated into the existing curriculum, but also as stand-alone courses. These Courses should be designed to highlight the various environmental and human factors that expose firefighters to potential danger, incorporate risk analysis and illustrate appropriate, safe responses.

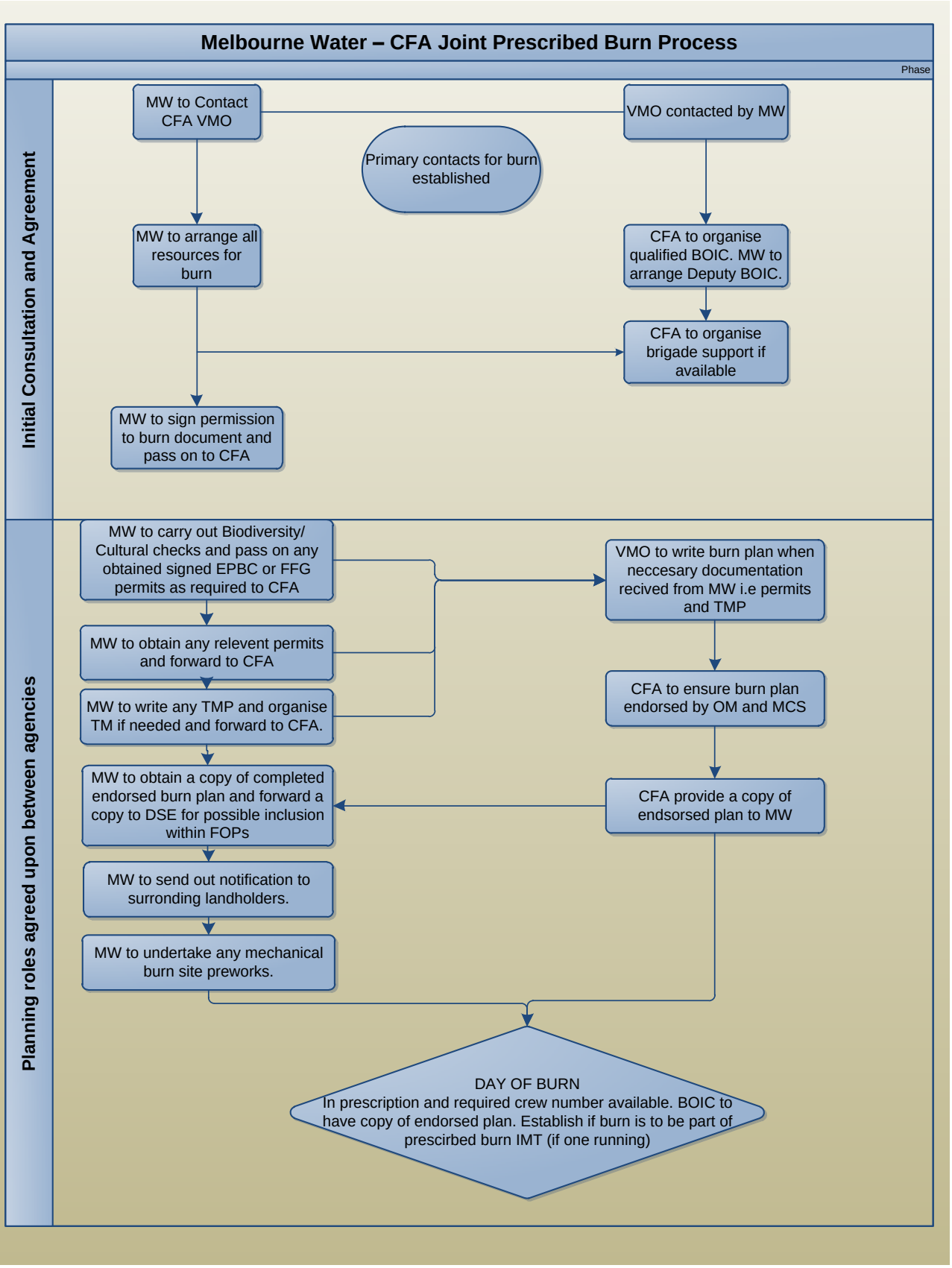
PRESCRIBED BURNING
Participation in prescribed burning can be a useful training tool for developing an understanding of some aspects of fire behaviour. There are particular benefits for volunteers who participate in these activities, including greater local ownership of risk reduction, an improved understanding within the community of the need for prescribed burning and in particular an increased level of understanding of fire behaviour and fireground safety. As a result VFBV encourages the participation of volunteers in prescribed burning activities.

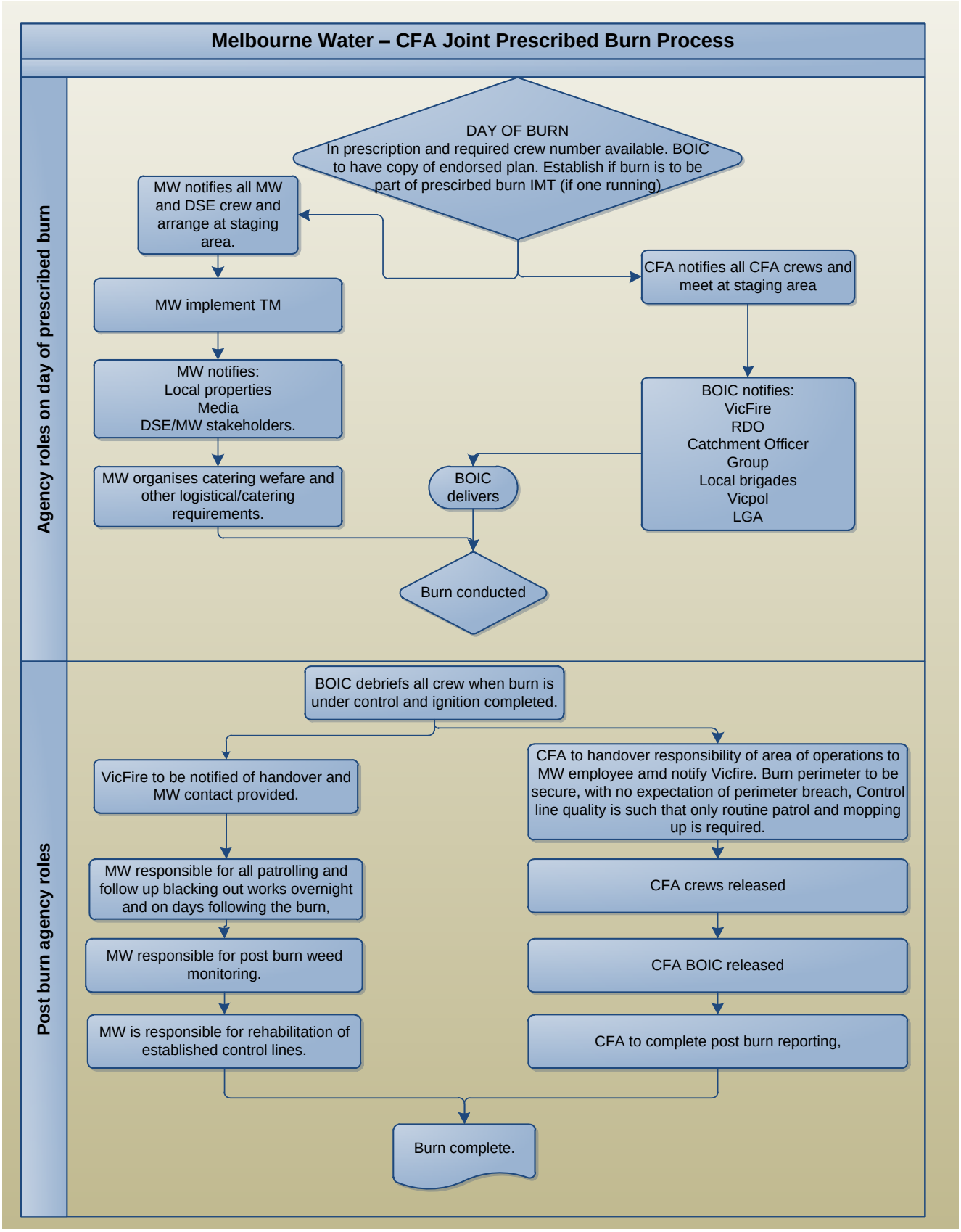
Unfortunately the reduced level of prescribed burning conducted by brigades in recent years has reduced the opportunities to participate in this practical training. Notwithstanding this, there are some good examples of co-operative prescribed burning being undertaken with CFA volunteer brigades and DSE. Where local fire brigades are prepared to participate in the conducting of prescribed burning and flexibility exists with both timing and prescription, the involvement of volunteers should be facilitated.

In cases where prescribed burning is occurring on public land, additional financial incentives should be available to DSE to conduct these programs where supervision may be necessary out of normal work periods. This will enable improved opportunities for volunteers to participate at times when they are more readily available.
VFBV Submission: Fire fighter Safety.

Solutions
A Melbourne Water/CFA Bushfire Partnership agreement has been developed, which will include a process for joint agency planned burns. This gives the agencies an agreed upon process to follow, which will allow them to assist each other and reap the benefits. This forms part of their *Bushfire Partnership Agreement*.

A flow chart highlighting some of the agreed steps and consultation points for each agency is outlined below.


Melbourne Water – CFA Joint Prescribed Burn Process
Phase
Initial Consultation and Agreement
MW to Contact CFA VMO
VMO contacted by MW
Primary contacts for burn established
MW to arrange all resources for burn
CFA to organise qualified BOIC. MW to arrange Deputy BOIC.
CFA to organise brigade support if available
MW to sign permission to burn document and pass on to CFA
Planning roles agreed upon between agencies
MW to carry out Biodiversity/ Cultural checks and pass on any obtained signed EPBC or FFG permits as required to CFA
VMO to write burn plan when neccesary documentation recived from MW i.e permits and TMP
MW to obtain any relevent permits and forward to CFA
CFA to ensure burn plan endorsed by OM and MCS
MW to write any TMP and organise TM if needed and forward to CFA.
MW to obtain a copy of completed endorsed burn plan and forward a copy to DSE for possible inclusion within FOPs
CFA provide a copy of endsorsed plan to MW
MW to send out notification to surronding landholders.
MW to undertake any mechanical burn site preworks.
DAY OF BURN
In prescription and required crew number available. BOIC to have copy of endorsed plan. Establish if burn is to be part of prescirbed burn IMT (if one running)


Melbourne Water – CFA Joint Prescribed Burn Process
Agency roles on day of prescribed burn
DAY OF BURN
In prescription and required crew number available. BOIC to have copy of endorsed plan. Establish if burn is to be part of prescirbed burn IMT (if one running)
MW notifies all MW and DSE crew and arrange at staging area.
MW implement TM
MW notifies:
Local properties
Media
DSE/MW stakeholders.
MW organises catering wefare and other logistical/catering requirements.
CFA notifies all CFA crews and meet at staging area
BOIC notifies:
VicFire
RDO
Catchment Officer
Group
Local brigades
Vicpol
LGA
BOIC delivers
Burn conducted
Post burn agency roles
BOIC debriefs all crew when burn is under control and ignition completed.
VicFire to be notified of handover and MW contact provided.
MW responsible for all patrolling and follow up blacking out works overnight and on days following the burn,
MW responsible for post burn weed monitoring.
MW is responsible for rehabilitation of established control lines.
CFA to handover responsibility of area of operations to MW employee amd notify Vicfire. Burn perimeter to be secure, with no expectation of perimeter breach, Control line quality is such that only routine patrol and mopping up is required.
CFA crews released
CFA BOIC released
CFA to complete post burn reporting,
Burn complete.

A collaborative systems approach is needed and this includes many facets such as:

- *Consultation*

To actively engage in open discussion between all agencies and relevant stakeholders to form an effective working relationship.

- *Negotiation*

To develop a Multi-agency Community Engagement (MACE) group to deliver a common agency message and to bring all stakeholders on board.

- *Collaboration*

To develop cross tenure landscape plans that deal with fire risk across the landscape to provide large scale protection to life and assets.

- *Multi agency burning consistent with whole government approach*

To share resources and experience to enable fuel reduction to be a more achievable, safer viable option.

- *Constraints put upon staff and overtime*

To ensure Funding is available to allow staff to attend burns by paying overtime or rostering on with other agencies to maintain skills and to allow mentoring

- *CFA has no earthmoving equipment*

To form a working relationship with other fire and land agencies that enables the sharing of resources. Both Melbourne Water and DSE have access to the machinery needed. This will then Expose CFA personnel to complexities of working with this equipment in an environment less complex then a fire ground.

- *Reporting Culture*

To promote a blame free reporting culture that uses the various tools such as AAR's, and Worst Case Scenario Thinking to build a Just Culture and promote rapid learning.

- *Volunteers often time constrained*

To develop a system that works with the time poor volunteer. Volunteers are under increasing pressure from workplaces and their home life to balance their time commitment to both and then to fit in volunteer work. Often these same people will volunteer for many organisations; commonly fire brigades, football clubs, schools and other community groups.
The expectations placed on a volunteer at a fire brigade is to attend training, often twice a week and then to attend emergency calls. Whilst many of them see prescribed burning as a great benefit to their community and a great training opportunity, the expectation for them to 'drop everything' and attend a burn with little notice, represents a huge impost on their time. Additionally, the possibility that this interruption will be to no avail because the burn is called off at the last minute imposes a massive burden on their time and may be seen as a waste of that time.

There is also limited numbers of volunteers available at short notice or on weekdays. Planning crew management can alleviate many issues. Shorter shifts not only mean volunteers spend less time away from home or work but also means more volunteers can be utilized in the burn process and thus exposed to prescribed burning to increase their skills.

Having several burns planned, prepped, and ready to go but only burning one at a time reduces the chance of the volunteers being sent home at the last minute. A burn may be called off at the last minute due to local weather conditions or high fuel moisture content but the crew can

be redeployed to another more suitable site. A good relationship with neighbouring districts and fire organisations ensures this system will work across district and organisational boundaries.

By using multi agency crewing there is a reduced reliance on volunteers although the opportunity still exists for them to attend. This potential leads to a greater number of planned burns being completed and an increased opportunity for volunteers to attend.
By having several burn plans ready and prep work done, crews can be deployed to whichever site is ready and within prescription, when crews are available.

Kilsyth South case study
Several volunteer brigades assisted by Melbourne Water carried out a successful planned burn in Kilsyth South. The site had an extreme fuel hazard and a fuel load of 38t/ha presenting a fire risk to the neighbours and was located at the base of the Dandenongs Ranges in Victoria. The burn had been planned for two years and although only two and a half hectares in size was of high ecological significance. Planning involved extensive consultation with Maroondah Council, Department of Sustainability and Environment (DSE), Trust for Nature, and Melbourne Water. Melbourne Water land abutted the site.

Limitations

- CFA unable to put in extensive control line work due to lack of machinery.
- Local CFA crews inexperienced in planned burning.
- Availability of CFA crews on weekdays was limited.
- Melbourne Water crews available but not able to take on the role of burn OIC.
- Task beyond the scope of the local council, Trust for Nature and Local Friends Group.
- Time and weather constraints.
- Significant biodiversity issues present that may be both threatened and benefit from burning.
- Uncooperative neighbour relationship.

Strategies employed

- Regular multi agency meetings from the early planning stage until the day of the burn to address all issues and concerns.
- Regular contact with the neighbour to address his concerns, both real and perceived.
- Final plan accepted and endorsed by all participating agencies.
- Agency roles and expectations clearly defined.
- Tasks allocated with specific time frames and reporting.
- Constraints of the prescription made clear to all involved.
- Fuel moisture content readings and weather reports fed back to all agencies.

On the day of burn

- Council notified all neighbours, schools and Trust for Nature.
- CFA notified Melbourne Water, Vicfire and all internal notifications.
- CFA organised CFA volunteer firefighters for support and Burn OIC.
- CFA crews were mixed with experienced Melbourne Water crews for specific tasks such as lighting crews and Sector Commanders.

- Council supplied lunch.
- Trust for Nature sent observers and a Biodiversity Consultant.
- After Action Review implemented as a learning tool.

Post burn analysis and monitoring

- Results of After Action Review discussed to improve process
- Trust for Nature, local Friends Group and Biodiversity Consultant reported on their observation during the burn and in the weeks following.
- Discussions held with participating CFA volunteers as to the benefits or otherwise on the process.

The burn could not have gone ahead without all agencies working together. Melbourne Water could not take on the role of Burn Officer in Charge (BOIC) and needed CFA BOIC's. CFA did not have the crew numbers to carry out the burn in a safe manner and also lacked experienced crew members.
The council needed to meet their legislative obligations for fire prevention in an ecologically sensitive situation.

Spear-grass regrowth Kilsyth South (S. Merritt 2012)

This was a great opportunity for building confidence, learning, and increasing safety for all organisations involved.

Current socio-political and legislative blockers

External stakeholder confidence building is also a challenging process in relation to the conduction of planned burns.

> *As is often observed, managers are likely to assume that fire (both natural and ignited) is an ecologically sound and cost-effective tool, and therefore, it should be used for forest management. However, the use of prescribed burning inevitably confronts political*

> *and/or emotional hurdles. Managers may "understand" prescribed burning within a highly technical and/or intellectual domain. Affected residents, however, may "feel" prescribed burning in a different realm; they may think prescribed burning is dangerous and potentially uncontrollable. In addition, prescribed burning may degrade— at least from an aesthetic point of view—the scenic quality of forested land. Prescribed burning may also degrade air quality, raising health concerns among residents.*' (Kumagai & Daniels, 2002)

The above quote relates to resident concerns however this can easily be related to external stakeholders such as land managers public and private and conservation groups. With all the successful multi-agency burns conducted as per the above case studies stakeholder relations are enhanced by showing the capability of CFA in working in this area. We are providing opportunities for external stakeholders to review the works being undertaken and highlight the pros of these works in relation to fuel reduction as well as the risk of conducting the works verses risk of not conducting the works and the ecological benefits. We are also enhancing our capabilities in the area of conducting these works. The Cardinia case study was a 62 ha burn and comments were made from professional stakeholders such as the local shire in relation to not being able to effectively and safely conduct the works. After successful completion this same organisation is now seeking CFA assistance in conducting planned burning works within their own tenure.

In the Kilsyth South case study, Trust for Nature and the local Friends Group had initial concerns that many threatened species were at risk of a significant decline as a result of the proposed burn. Control line work was avoided in sensitive areas and existing tracks were used. Trust for Nature and a Biodiversity consultant attended the burn as observers and documented the vegetation and wildlife prior to the burn, wildlife response during the burn, and monitored regrowth after the burn. Their involvement gave the firefighters a very valuable insight into the complexities of biodiversity, and also provided Trust for Nature and Friends Group education about the benefits of planned burning for both safety and biodiversity. Trust of Nature and the Friends Group saw this as an opportunity to eradicate some particularly persistent weeds (particularly Gorse, *Ulex europaeus*) in the ensuing year. They gathered data for an assessment of the flammability of vegetation in two plots, one of them inside the planned burn and a matching one outside. Monitoring changes in the data over coming years will give them an indication on how effectively the fire reduces fire hazard and over what period. The data also included details of the abundance of each plant species, to allow determination of the effects of the fire on individual plant species.

Only 80% of the area burnt and some of the unburnt patches were large enough to serve as refuges for small fauna such as lizards and antechinus sps. No animal remains were seen in the burnt areas.

The site was monitored post fire by the Friends Group and this was instructive for many participants. It highlighted that much of the safety benefit added by the fire was due to removal of the shallow layer of leaf litter next to the mineral earth - a feature that not many of the Friends Group had looked at yet.

The Friends group reassessed selected plots at intervals to determine the rate of return of plants and bushfire fuel, and hence the effectiveness and longevity of the planned burn for hazard

reduction and the consequences for the vegetation. This was a great opportunity for building confidence, learning, and increasing safety for all organisations involved.

Results of After Action Reviews and the current climate in which we still work poses a number of issues in relation to the continuation of work in the planned burning arena. These include:

- Mind Set Barriers; the "*Why should CFA conduct these works*?" attitude. – This attitude reflects an internal culture, which has developed over the years within the echelons of the CFA hierarchy. This attitude leads people to ask "*This is not our land, we are not a land manager, why should we be conducting these works?"* The need to highlight the benefits of conducting these works against the drawbacks has to occur. The benefits of planned burning are well highlighted in research and the capability of vastly improving the safety of our fire fighters and people has to combat this attitude, although it is still a work in progress to ensure this culture change.
- Stream lining legislative procedures to ensure the intent of the legislation is met whilst not creating inappropriate time and resource demands. Such as:
    - Traffic Management Act and the requirements of this legislation to ensure the safety of individuals working on roadsides. In an emergency situation, legislation enables CFA to close the road using emergency vehicles, planned events such as planned burning requires additional traffic management procedures to ensure safety of road users and those working on the roadsides. This change requirement and the justification for this different approach needs to be adopted by all personnel and the procedures streamlined to ensure the requirements are capable of being met with minimal impact on the planning and conducting of these works in a safe and efficient manner.
    - Environmental legislative processes also need to be adopted to streamline the process to obtain information relating to potential adverse environmental impacts the methods to mitigate the impact.

Future direction

Trial on Hoddles Creek

There are currently plans for planned burning in the Hoddles Creek Area, which includes a combination of private and public land. These plans have come together as a result of land holders lobbying both DSE and the CFA for works to be conducted. There are significant works required to prepare these properties for burning and engaging not enraging the surrounding communities. The local brigade has already completed much of the ground-work in this space. If these plans are to proceed continued multiagency support and involvement is needed to achieve them.

This is an excellent opportunity for all agencies to work together to achieve some real fire management and safety for the local community as opposed to burning small isolated blocks that have no strategic benefits to stop the impact of a large bushfire. This will also provide a great opportunity for local CFA and DSE firefighters to establish a good working relationship and an opportunity to examine the intricacies of fire behaviour in practical terms in their own landscape. This will also create opportunities for Incident Controllers, Sector Commanders, Strike Team

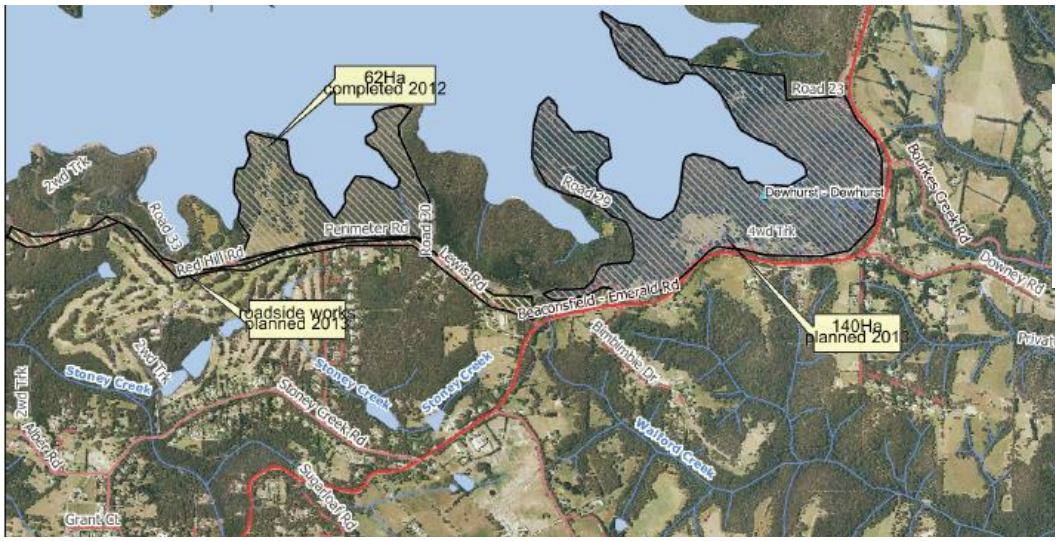
Leaders and Crew Leaders to gain some practical training in a positive learning environment with some experienced mentors.

Cardinia Reservoir: The next phase.

Plans are underway to consolidate the works completed in 2012 into a mosaic of fuel hazard levels, and age/class distribution across the water reservoir.

This area is fundamental due to the peri-urban interface and the risk upon the community and water assets, there is also dire bushfire history with 21 deaths experienced in Upper Beaconsfield during the Ash Wednesday fires, located south of this reservoir, 12 of these deaths being fire-fighters actively engaged in fire fighting.

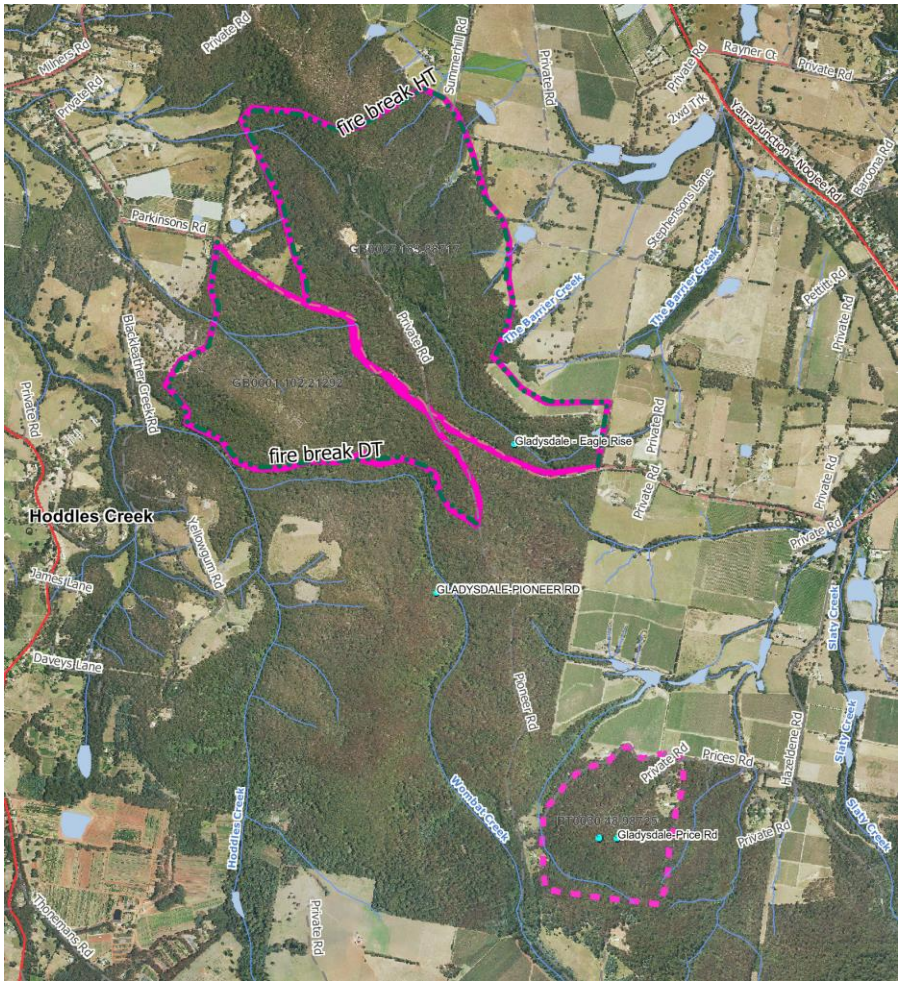
This planned burn again will be undertaken on land under MWC management, which will ensure a number of agencies being involved drawing on and learning from the skills across all agencies. The proposed burn is larger and crosses CFA administrative boundaries allowing for more brigades to be involved and gaining the experience in managing fire, leadership, predicting fire and fire behaviour.



Map of completed and planned burns for Cardinia Reservoir Budziarski, 2012.

Significant works are required in relation to planning, and control line implementation. The burn is approx. 140 ha in size greatly out of the capability of volunteers in relation to follow up and patrol works due to requiring a 24hr operation for a number of day's at least. Crews will further be able to establish relationships with external agencies and to build on internal cross boundary relationships. Varied topography and fuel types will add to the varied fire behaviours of which will be observed by fire crews giving them the opportunity to build on their slides in a controlled/ planned environment.

Belgrave South



Map of Multi Agency Burn Planned for Hoddles Creek (DSE 2012)

There are approximately 3543 residents in Belgrave, Belgrave South and Belgrave Heights. The 1983 Ash Wednesday fires swept through Belgrave South and Belgrave Heights destroying many houses. Many lives were lost including firefighters as a result of these fires. More recently in 2009, fire once again threatened this area and firefighter's lives were risked and one tanker was lost.

Plans are currently being drawn up to provide a strategic break along the south west of the Belgrave South Township. This will provide protection to the towns of Belgrave, Belgrave heights and Belgrave South and increase the chance of first attack success by the fire services. The land to be assessed and fuel reduced is managed by a combination of DSE, Local Government and private land holders. Joint agency meetings have produced a plan with a joint objective to reduce fuel and provide greater protection to life and property. This plan will require co-operation between the agencies and a co-ordinated approach to planned burning.

The burns have been carefully mapped and planned to reduce biodiversity impact and will be carried out jointly by the fire agencies. The Shire Yarra Ranges will assist with pre burn works on council land and the issuing of Fire Prevention notices on private land where necessary. This again will be an excellent opportunity for local CFA and DSE firefighters to establish a good working relationship and an opportunity to examine the intricacies of fire behaviour in practical terms in their own landscape. This will also create opportunities for Incident Controllers, Sector Commanders, Strike Team Leaders and Crew Leaders to gain some practical training in a positive learning environment with some experienced mentors.

Conclusion

There are many constraints to planned burning such as:

- Declining volunteer capacity
- Increasing environmental concerns
- Increasing safety regulations
- Increasing complexity with urban areas
- Increasing fines for non-compliance in regards to permits
- Increasing risk aversion
- Increasing awareness of the role of human factors, which lead to poor operational outcomes and the need to manage and mitigate these factors.

Given the high-risk involved in the operation the problem lies across all agencies and there is a great need for a collaborative systems approach using currently available tools. In the future all these planned burning opportunities will lead to greater safety on the fire ground at an incident due to a greater understanding of fire behaviour through practical application and mentoring from those with a vast wealth of experience. There are many opportunities to provide leadership skills in a practical fire environment under experienced mentoring. This will benefit Incident Controllers, Sector Commanders, Strike Team Leaders and Crew Leaders as well as firefighters.

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The 1958 Wandilo Forest fire tragedy revisited

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Abstract. The 1957-58 fire season in South Australia is remembered for the tragic loss of life that occurred in the south-east region of the state on 5 April 1958. Eleven fire fighters found themselves entrapped on a narrow firebreak when a fire burning in a radiata pine plantation suddenly developed extreme fire behaviour characteristics involving mass spotting and active crowning.

Eight of the men attempted to run back along the narrow break, but perished as a result of being exposed to intense radiation and direct flame contact. The three remaining men survived with moderate burns. Two sheltered in the cab of one of the three fire trucks that become stuck in the soft sand of the firebreak or had broken down; they emerged safely after the intensity of the bushfire had subsided even though their vehicle was well alight. The other man survived by sheltering in a deep sandy wheel rut and covering his face with his coat.

The main part of the fire season had been relatively mild though autumn was dry, and one would not have predicted such an extremely serious fire situation to occur at that time of year. This incident occurred at a time when bushfire behaviour research in Australia was still in its infancy and years before methods were available to fire managers to quantitatively assess fire potential.

The purpose of this presentation is three-fold: (i) to review the description of the fateful events and environmental conditions associated with the fire as found in the case study report prepared Alan McArthur and others that was published in 1966; (ii) re-examine the incident in light of new knowledge on fire behaviour in native forests and exotic pine plantations; and (iii) to increase fire fighter safety awareness in general as a result of both remembering and learning from the past.

Additional keywords: crown fire, fire behaviour, fire fighter fatalities, fire safety, crown fire, South Australia

The powerpoint associated with this presentation is available for viewing and downloading at:
http://www.fs.fed.us/wwetac/projects/PDFs/12th%20WFSS%20Talk%20Gould%20Alexander%20Cruz.pdf

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Wildfire safety-related decisions and actions: lessons from stress and performance research

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Abstract: We review scientific research concerning the effects of high levels of psychological stress on human performance of complex tasks, and relate these to wildland firefighter safety. Findings across studies involving different stressors, participants, and tasks suggest that high levels of stress may compromise individuals' wildfire safety-related decisions and actions on the fireground in at least four ways: (a) attention is likely to become narrowly focussed on only a few aspects of the developing situation so emerging threats may not be acted upon; (b) important tasks may take longer than anticipated and mistakes may be more likely; (c) working memory is likely to be impaired and important information may not be remembered; and (d) forming sound judgements and making good decisions may become progressively more difficult as thinking becomes more rigid. These have important implications. For training: wildland firefighter 'survival mode' procedures need to be simple, and practiced frequently under realistically simulated life-threat conditions. For operations: 'worst case scenario' thinking needs to be cultivated in order to foster anticipation of rapid escalations of threat situations. For after-action debriefs and reviews, and post-incident investigations: possible effects of threat-related stress on cognition need to be investigated and taken into account in any analysis.

Additional Keywords: anxiety, bushfire, fireground, human factors

Both official reports (e.g., United States Department of Agriculture Forest Service 2001) and informal accounts (such as those by Maclean 2003) indicate that stress is often associated with wildfire safety-compromising incidents. However, the *processes* by which stress may compromise firefighter safety in threatening situations on the fireground are seldom discussed. In this paper we examine findings from the stress and human performance research literature concerning fear/anxiety and cognitive[1] abilities, and discuss their relevance for understanding the behaviour of firefighters under imminent threat from wildfire.

We use the term 'stress' to refer to the totality of an individual's negative psychological experiences associated with a wildfire threat as the stressor[2]: fear and anxiety in particular; but also worry, frustration, anger, pain and physical discomfort. We follow Lazarus and Folkman (1984) in conceptualising such psychological stress as resulting from interactions among three elements of an individual's appraisal of a wildfire threat situation under conditions of uncertainty: (i) the likely actions demanded of the individual; (ii) the individual's self-perceived ability to cope with these demands; and (iii) the perceived severity of threat posed by the stressor. We distinguish *stress*, as a negative mood state, from *arousal* as activation or energisation (Cox and Mackay 1985). We acknowledge that individuals differ, both in tendencies to experience negative mood states such as anxiety and fear in the face of threats, and in the

kinds of impacts their fear and anxiety might have on safety-related decision-making; however, space constraints do not allow us to explore this.

Method

The research literature concerned with stress and human performance is extensive. We first examined general reviews, including those by Driskell and Salas (1996), Hammond (2000), Kavanagh (2005), and Staal (2004). We then made electronic searches of data bases (such as PSYCHINFO, Web of Science, and Google Scholar) for experimental or quasi-experimental quantitative studies of performance in the face of potentially life threatening stressors, in field or naturalistic settings. Numerous studies have examined effects of different stressors on cognition and performance, including: fatigue, heat and cold, hunger and thirst, noise, sleep-deprivation, time-pressure, mental workload, and physical and psychological threats. These studies were conducted in a range of settings including laboratory studies, simulation exercises, naturalistic environments such as combat training, and field settings such as parachuting and underwater diving.

The criteria for inclusion in our review were: (a) the research used an experimental or quasi-experimental design; (b) the stressors were likely to be perceived as having the potential to cause pain, injury, or death; (c) cognitive performance was assessed in a field or other naturalistic setting; and (d) the cognitive performance assessment tasks had to be related directly to the stressful aspects of the task environment rather than being incidental to the task environment—the methodological importance of this was discussed by Berkun (1964). Only 10 reports of experimental research conducted in field or naturalistic settings (such as parachuting, diving, rock climbing, and military training) were located which examined effects of stressors generating fear or anxiety associated with threat of possible pain, injury or death, on performance of cognitive tasks[3]. In the absence of systematic research involving wildfire safety-related decision making specifically, we used these plus an additional laboratory study[4] to infer likely effects of imminent wildfire threat on firefighter cognitive performance.

Results and Discussion.

General reviews of the stress and performance literature indicate that, overall, stress of all kinds tends to degrade cognitive processes and impair performance. Table 1 summarises the studies we identified as potentially relevant to firefighters making safety-related decisions and taking actions under imminent wildfire threat: the 11 reports described a total of 17 separate studies. Most reported evidence that the task situation was stressful, as measured by increase in heart rate, self-reported increase in anxiety following exposure to the stressor, or biological assay (Ice and James 2006). More details of the studies are in McLennan *et al.* (2011a). We followed the suggestions of Staal (2004) to examine findings in relation to four aspects of cognition: attentional control; perceptual-motor skills; memory; and judgment and decision-making.

Attentional control

Findings from four studies indicate that maintaining concentration on a primary task becomes more difficult (Kivimaki and Lusa 1994), and attentional control is degraded by anxiety so that perception becomes more narrowly fixated, or tunnelled (Pijpers *et al.* 2006, Weltman and Egstrom 1966, Weltman *et al.* 1971). The implications are that firefighters experiencing high levels of anxiety due to imminent wildfire threat may: (a) find it difficult to concentrate on tasks

central to safety, and (b) fail to attend to cues of newly emerging dangers—such as radio information, wind changes, or approaching vehicles.

Table 1: Fear/anxiety-related performance decrements: participants; stressor; potential implications for wildfire safety

% Mean Decrement (Study)	Participants	Stressor	Potential Implications for firefighters under imminent wildfire threat
Attentional Control:			
28% reduction in maintaining mental focus on the primary task (Kivimaki & Lusa 1994)	Young adult male firefighters	Dark, potentially hazardous environment to be navigated wearing breathing apparatus	Difficulty in maintaining concentration on an essential task
48% narrowing of attentional focus (Pijpers *et al*. 2006)	Novice rock climbers	Height	Attention is focussed narrowly on the main potential threat, so other emerging hazards may not be attended to
31% narrowing of attentional focus (Weltman & Egstrom 1966)	Novice divers	Open ocean dive	Attention is focussed narrowly on the main potential threat, so other emerging hazards may not be attended to
50% narrowing of attentional focus (Weltman *et al.* 1971)	Students in a pressure chamber	Simulated air pressure equivalent to 60 feet (18.3m)	Attention is focussed narrowly on the main potential threat, so other emerging hazards may not be attended to
Perceptual Motor Skills:			
6% reduction in manual dexterity (Baddeley & Idzikowski 1985)	Novice divers	Imminent open-water dive	Difficulty in assembling, handling, or operating equipment, clumsiness
23% lower visual letter-search time; 40% slower symbol-search time (Idzikowski & Baddeley 1987)	Novice parachutists	Imminent parachute jump	Slow to notice changes in the environment
5% slower choice-reaction times (Jones & Hardy, 1988)	Female university students	Imminent 4.6 m jump down to padded mats	Slow to respond to sudden changes in a threat situation
72% slower climbing time, associated with more, tentative, limb movements (Pijpers *et al.* 2006	Novice rock climbers	Height	Complex action sequences slower to complete successfully
Memory			
38% reduction in retrieval of	Army recruits in	Anticipated	Difficulty in remembering

survival information from long-term memory (Berkun 1964)	basic training	emergency aircraft 'ditching'	important safety-related information
19% reduction in working memory capacity (Idzikowski & Baddeley 1987)	Novice parachutists	Imminent parachute jump	Difficulty in remembering a correct sequence of actions needed to successfully undertake complex tasks
41% reduction in working memory capacity; 11% reduction in processing efficiency (Leach & Griffith 2008)	Novice and experienced parachutists	Imminent parachute jump	Reduced ability to retain new information, to interpret the significance of changes in the environment and to remember a correct sequence of actions needed to complete complex tasks
33% reduction in working memory efficiency (Robinson *et al*. 2008)	Nautical college students	Helicopter underwater emergency evacuation training	Reduced ability to interpret the significance of changes in the environment
***Reasoning, Judgement & Decision Making*:**			
10% reduction in reasoning and judgement accuracy (Berkun 1964)	Army recruits in basic training	Anticipated emergency aircraft 'ditching'	Errors in interpreting information; making safety-compromising decisions
33% reduction in reasoning and judgement accuracy (Berkun 1964)	Army recruits in basic training	Fear of being accidentally shelled by artillery	Errors in interpreting information; making safety-compromising decisions
18% reduction in reasoning and judgement accuracy (Berkun 1964)	Army recruits in basic training	Fear of having accidentally injured a fellow-soldier in a demolition exercise	Errors in interpreting information; making safety-compromising decisions
7% reduction in reasoning performance (Idzikowski & Baddeley 1987)	Novice parachutists	Imminent parachute jump	Difficulty in interpreting warnings and processing information in the environment so as to form an accurate assessment of the threat and matching this to safety options
39% reduction in reasoning performance, associated with incomplete and inefficient scanning of decision alternatives (Keinan 1987	University students	Threat of electric shock if incorrect alternative selected	Hasty, incomplete and inefficient consideration of safety options

Perceptual Motor Skills
In six studies, which employed a variety of perceptual-motor tasks there was a decrement in performance associated with increased anxiety: changes in the task environment took longer to detect (Idzikowski and Badderley 1987, Jones and Hardy 1986); and movements were slower and less skillful (Badderley and Idzkowski 1985, Pijpers *et al.* 2006). Implications are that firefighters experiencing high levels of anxiety due to the stress of imminent wildfire threat may: (a) be slow to detect some threatening developments in their environment; (b) take somewhat longer than normal to complete complex tasks; and (c) be less skillful, or clumsier, than usual in some of their actions—such as deploying personal fire shelters.

Memory
Findings from four studies suggest that high levels of anxiety are likely to reduce both working memory capacity (Idzikowski and Badderley 1987) and processing efficiency (Leach and Griffith 2008, Robinson *et al.* 2008), and to interfere with retrieval of knowledge from long term memory (Berkun 1964). The implications are that individuals under imminent wildfire threat may have difficulty in: (a) keeping safety-relevant issues in mind; (b) correctly interpreting the significance of emerging threats; and (c) being able to remember safety-enhancing information—such as escape routes.

Reasoning, Judgment, and Decision-Making
Findings from five studies indicated that high-level cognitive processes involved in reasoning, judgment and decision making are degraded by stress: there were decrements in the ability to apply logic in reasoning (Berkun 1964, Idzikowski and Badderley 1987) and in the ability to fully and efficiently consider decision options (Keinan 1987). The implications are that individuals experiencing high levels of anxiety due to imminent wildfire threat may engage in safety-compromising behaviour by: (a) misunderstanding information provided to them; or (b) failing to evaluate relevant options available before committing to an action.

Summary
The unweighted mean cognitive performance decrements associated with stress in the studies reviewed (Table 1) were:

- perceptual motor skills: 29%
- attentional control: 39%
- memory functioning: 33%
- reasoning, judgment, and decision-making: 21%
- across all 17 studies: 30%.

These findings from the stress and performance research literature suggest the potential for significant negative effects of fear/anxiety on cognitive performance. Firefighters experiencing high levels of fear/anxiety due to imminent wildfire threat as a stressor may make decisions and take actions, which jeopardize their safety. On the fireground, some stressed firefighters might: (a) become distracted from essential tasks and fail to notice cues of emerging threats; (b) be slow to respond to indications of threat and be clumsy in their actions; (c) have difficulty keeping safety issues in mind and remembering important information; and (d) find it hard to think issues through so as to select and implement a safe option.

Evidence from the fireground

Two objections can reasonably be raised against a too-ready application of the above findings from the research setting to the fireground. First, with the possible exceptions of the research by Berkun (1964) and by Kivimaki and Lusa (1994) the cognitive tasks were artificial and unrelated to the kinds of tasks that firefighters undertake on the fireground. Second, with the possible exception of the study by Kivimaki and Lusa, the participants in the research had no prior training or experience on the tasks—unlike wildland firefighters. If the discussion of research summarised in Table 1 is to have merit beyond an academic exercise then there should be evidence of firefighter stress-related cognitive performance decrements from the fireground.

In an attempt to respond to the objections, we looked for evidence of stress-related cognitive performance decrements associated with safety-compromising wildland fire incidents. We asked several colleagues involved with serious incident investigations working for the Victorian Country Fire Authority (CFA) and the Department of Sustainability and Environment (DSE) to describe safety-compromising incidents where stress may have played a role. We then examined reports on the Wildland Fire Lessons Learned Centre web site (http://www.wildfirelessons.net/Home.aspx) and Centres for Disease Control National Institute of Occupational Safety and Health Firefighter Fatality Reports (http://www.cdc.gov/niosh/fire/), and noted a potential problem: namely, while there were several fireground incident investigation reports where it seemed very likely that firefighter stress played a role, few contained independent evidence that those involved were, in fact, experiencing high levels of stress at the time.

A sample of potentially relevant incidents is summarised in Table 2. These should be regarded as suggestive of ways in which stress *may* degrade cognitive performance and compromise safety on the fireground. The incidents illustrate how stress-related impairments of attentional control processes, perceptual-motor skills, memory—both working memory and knowledge retrieval, and judgment and decision-making can play a role in compromising wildland firefighter safety.

Countering the adverse effects of stress on cognitive performance

Incidents involving high levels of imminent threat during a wildfire need not necessarily cause stress-related cognitive performance deficits sufficient to result in serious injury or death. The following is an account of wildland fire crew survival during a tanker entrapment and burnover:

> The fire was now crowning in the trees on the windward side of the tanker. The crew rolled down the cab inner reflective safety curtains and velcroed the curtain edges together. Conditions in the cab were now extremely hot and pitch black. The front passenger window glass broke, probably due to direct flame impact. The velcro strips fastening the safety curtain flaps melted, forcing the crew leader to hold them together with his gloved hands. Unable to drive forward for fear of hitting the tanker in front, the crew attempted to reverse back along the track. The view to the rear was almost completely obscured by smoke and the roll-down reflective safety curtain. The tanker veered off the track, collided with a large tree and was immobilised. The crew attempted to retrieve woollen blankets from cab lockers to cover themselves but had great difficulty opening the sealed plastic stowage bags wearing their wet gloves. Embers entered the cab through the broken window and ignited the plastic dashboard. The crew leader extinguished this fire temporarily with his feet. One of the crew began to express fear,

and was silenced authoritatively by the crew leader. As parts of the tanker began to burn and conditions in the cab became marginal, the crew leader who was sitting on the windward side of the truck, asked the rear seat crew member to check the state of fire on the lee side. This was judged to be now survivable. The crew exited the cab of the burning tanker successfully after one of the crew assisted the crew leader out over the cab centre console by hauling on his coat, then cushioning the crew leader's fall to the ground with his body. All three then walked out of the burning forest together, shielding themselves from radiant heat using a single woollen blanket. Injuries were limited to minor burns and bruising. (CFA Upper Ferntree Gully tanker entrapment, based on the crew's account)

Table 2: Examples of possible firefighter stress-related cognitive failings associated with safety-compromising decisions and actions

Cognitive function	Example (source)
Attentional control	When multiple spot fires broke out and smoke impeded visibility two lookouts became apprehensive. They decided to leave the lookout site and move to the safety zone. They began a rapid retreat down a rocky gully. Lookout #1 did not take time to put on his gloves, believing their lives were in danger. Subsequently, while attempting to break-in to a building to shelter from the oncoming fire he sustained injuries to his hand requiring medical treatment (Lessons Learned Review, Horseshoe 2 Fire) A firefighter died as a result of being struck or run over by a fire vehicle. The victim was trying to escape from a fire that was about to overrun his fire vehicle. The victim left the vehicle and attempted to escape on foot. Ten other fire vehicles were attempting to leave the area. Due to the volume of vehicles attempting to escape the fire, the poor visibility due to the smoke, as well as a variety of tanker mechanical issues resulting from the intense heat, fire fighters were driving their tankers off the road, frequently colliding with each other, blocking each other in, and, as a result, many had to escape the fire by backing out (NIOSH Firefighter Fatality Report F2011-09)
Perceptual-motor skills	As the tanker began to be burned-over, the driver (so he believed) deployed the vehicle protection water spray system. The tanker was destroyed, the crew narrowly escaped death. The spray system operating switch was later found to be in the "off" position (CFA Upper Ferntree Gully tanker entrapment, based on the crew's account)

Memory	When the wind changed there was a blow-up. In their haste to escape an imminent burnover, the crew forgot to depressurise the hose and they could not disconnect it. This meant that as they tried to reverse the fire truck to safety there was a risk that the hose would foul the wheels. Fortunately the hose burnt through. (CFA Upper Ferntree Gully tanker entrapment, based on the crew's account)
Judgment and decision-making	Two firefighters (DIVS1 & DIVS2) were on foot when their escape was cut-off by the fire. DIVS1 said, "We need to deploy! We need to deploy!" They discarded their packs and started to deploy their fire shelters. DIVS1&2 raked the ground to prepare the site for deployment. DIVS2 looked at the surrounding fuels and decided that a shelter deployment would not be survivable. He said "We need to go down the hill!...We won't survive with deployment". Finally he said, "Follow me! I am going down the hill!" DIVS1 did not respond. DIVS2 balled up his shelter under his arm and ran down the hill. DIVS1 had deployed his shelter and did not follow. Subsequently, DIVS2 reached a road safely. DIVS1 did not survive. (USDA FS Accident Investigation Report Panther Fire Entrapment)

In-depth interviews with the crew suggested that the key to their survival was their ability to: (a) control their level of stress sufficiently to be able to maintain attentional focus on survival-relevant aspects of the threat environment; (b) identify and make sound judgments about options; and (c) take effective and timely survival-enhancing actions. This analysis is consistent with other accounts of survival under extreme threat (e.g., McLennan *et al.* 2011b, Wise 2009) which emphasize the importance of down-regulating stress levels to permit sound judgments and effective actions. There has been considerable research about psychological processes involved in emotion regulation generally (for a review, see Koole 2009) and a critical factor in down-regulating fear/anxiety appears to be prior training or experience relevant to survival in the particular threat situation (Wise 2009).

While we are not aware of research which shows specifically that training enhances firefighter safety under imminent wildfire threat, there is abundant research evidence from the training literature, especially military training, of the benefits of training for subsequent effective actions under stress (e.g., Aguinis and Kreiger 2009, Freidland and Keinan 1992, Keinan *et al.* 1990; McClernon *et al*. 2011, Zach *et al.* 2007). Taber (2010) cited research reporting overall survival rates from helicopter crashes in the ocean of 92% for those with helicopter under-water escape training, and only 66% for those without such training.

Concluding Discussion

In his classic 1832 treatise *On War*, Clausewitz asserted, "Everything is very simple in War, but the simplest thing is difficult" (1982 p. 164). Our review suggests that in wildland firefighting, threat-induced stress can make the simplest decisions and actions difficult, because stress can

degrade any or all of four cognitive functions: attention, perceptual-motor skills, memory, and judgment and decision-making. This has important implications for several aspects of wildland fire safety. We suggest three in particular: training, operations, and after-action reviews and investigations.

For wildland firefighter safety training, 'survival mode' procedures need to be simple, and be practiced frequently under realistically simulated life-threat conditions. The purpose of such training is to generate protective behaviours which are relatively automatic and do not require high levels of mental workload and complex thinking which can be disrupted easily by high levels of anxiety due to threat. Training unit personnel must keep in mind a fundamental distinction (Anderson 1983) between recognitional knowledge ('knowing about') and procedural knowledge ('knowing *how to*'). They must resist cost pressures to substitute classroom recognitional knowledge acquisition about safety in place of hands-on learning and practicing safety exercises and drills, which are as realistic as possible. In about AD 75, the historian Flavius Josephus wrote of the Roman approach to waging war: "...it would not be far from the truth to call their drills bloodless battles, and their battles bloody drills" (1999 p. 781). Perhaps agencies should approach survival training for their wildland firefighters in the same spirit! By way of illustration, a senior wildland fire instructor commented to the first author about the importance of requiring fire appliance crews to practice their burnover survival drills in a range of different circumstances (and without advance warning) until they become automatic. It is also crucial that they engage in hot-fire activities such as planned burning in order to improve their understanding of fire behaviour, and not limit their training to cold drills at the fire station.

For operations, 'worst case scenario' thinking (Johnson 2011) needs to be cultivated in order to foster anticipation of rapid escalations of threat situations. Kahneman (2012) argues, "Plans are best-case scenarios. Let's avoid anchoring on plans when we forecast actual outcomes. Thinking about how the plan could go wrong is one way to do it" (p. 128). Safety-related scenarios should be a central component of training activities, using all available methods, including table-top map exercises, staff rides, and simulations. The importance of self-monitoring generally, and especially under threat, should be emphasised so that firefighters become skilled at recognising indications that they are experiencing increased stress levels and may need to take effective emotional self-regulation actions. Such actions can include: positive self-talk, mental re-evaluation of the situation and assumptions, information- or advice-seeking, physical movement, calming breathing, and effortful-ignoring of issues which are not immediately relevant to the most serious emerging threats (Australian Psychological Society 2012, Seaward 2009, US Marine Corps 2012).

For after-action debriefs and reviews, and post-incident investigations possible stress-related decrements in judgment and decision-making quality need to be taken into account. This means first that potential stressors, stress experiences, and effects on judgments, decisions and actions should be acknowledged, discussed and explored. For investigators, the possibility of stress-related degradation of cognitive performance should be a key human factors issue to be considered and analysed carefully rather than, say, being viewed simply as evidence of human failure.

We noted in the course of our literature searches that researchers have given relatively little systematic attention to effects of stress associated with threat of death or injury on wildland firefighter performance. It seems highly desirable that researchers increase our knowledge and understanding of the effects of threat-related stress on wildfire safety through studies focused on

firefighters' experiences and actions on the fireground. As two pioneers of disaster research observed:

> In the laboratory one can produce very frightening (and even traumatic) experiences but must stop short of those, which constitute a real threat to the continued existence and health of the subjects involved--and actual disasters do not "stop short." An experiment cannot introduce the disaster stresses of overwhelming threat to life and limb... (Fritz and Marks 1954 p. 26)

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Notes [1] We follow generally accepted practice within psychology by using the term 'cognitive' to refer to human perception, learning, remembering, thinking, and acting (e. g., Sternberg, 2009, p. 578)

[2] Discussions of stress and wildland fire safety from a High Reliability Organizing (HRO) perspective have emphasized the role of social/organizational/relational/communications issues as stressors (Wildland Fire Lessons Learned Center 2011). In this paper we restrict our discussion to the material presence of wildfire as the stressor. See also Note 4 below.

[3] We excluded studies, like that by Lieberman *et al.* (2005), which employed stressors such as sleep deprivation, fatigue, and hunger in addition to physical safety threat.

[4] We included a study by Keinan (1987). While it was conducted in a laboratory, it fulfilled the other criteria, used a self-report measure to confirm that participants in the 'stress' conditions reported higher levels of stress than controls, and the findings have been cited previously as evidence for the negative effects of stress on decision-making.

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Enforcing safety with law - implications for incident controllers and fire agencies

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Abstract.
The obligation to protect fire fighters is enshrined in common law, criminal law, and work health and safety legislation. This paper, and the associated presentation at the *International Association of Wildland Fire* 'Safety Summit', hosted in Sydney in October 2012, considers recent developments in Australian case law and legislation from both Australia and the United Kingdom and how these developments may impact upon, and reinforce, the overriding obligation to put fire fighter safety first.

Additional keywords. Liability, work health and safety, legislation, law

Introduction.

Fire fighter safety is a primary concern for all involved in fire fighting. The obligation to protect fire fighters is enshrined in common law, criminal law, and work health and safety legislation. Notwithstanding this, fire fighters are still asked to put their own lives at risk to save others. Balancing the need to protect fire fighter safety with the inherent risks involved in the work they do is a challenge for the law, but a greater challenge for incident controllers and chief officers.

This paper, and the associated presentation at the *International Association of Wildland Fire* 'Safety Summit', hosted in Sydney in October 2012, identify recent developments in Australian case law and legislation from both Australia and the United Kingdom and how these developments may impact upon, and reinforce, the overriding obligation to put fire fighter safety first. These legal obligations need to be understood by fire officers if they are to meet their duties both to fire fighters and to those in need of fire and rescue services. The lessons identified are relevant to fire agencies in Australia and the UK as well as agencies from countries with similar legal traditions such as the United States, New Zealand, and Canada.

What's the measure of success for fire-fighters?

Communities expect many things from their fire agencies. In particular, they want a rapid response and an effective resolution of their emergency. Fire fighters are portrayed as selfless, self-sacrificing heroes who are expected to, or at least rewarded for, putting themselves in danger to save others. Sometimes however, fire-fighters are not able to bring an ideal resolution to an issue: loss of property or even loss of life cannot reasonably be the measure of success for a fire service, yet fire services are judged, after an event, by what was lost rather than what was saved.

To understand what the emergency services see as a success, or failure, researchers conducted interviews with a number of chief officers of the Australian fire and emergency services. The research participants were drawn from those chief officers that attended an Australasian Fire and Emergency Services Authorities Council (AFAC) Commander's Forum and who agreed to take part. Semi-structured interviews were conducted, recorded, and

transcribed. The interviews were given with a commitment to anonymity, accordingly the identity of the relevant speakers, when quoted below, is undisclosed. The research protocol was approved by the ANU Human Research Ethics Committee (ANU 2011).

Chief officers' nominated a number of possible measures of success, such as being judged by what is saved rather than what is lost; by whether they were able to execute their pre-event plan or, by whether everyone did the best that they could in the circumstances. All of those measures, as measures of success, have difficulties, and it is beyond the scope of this paper to discuss those limitations. What was clear however was that there was one, unanimous view of success – a mission was a success if, and only if, no fire-fighter died. Some comments from the chief officer interviews are below:

> "The aspirational goal is no loss of life, but not at the cost of more lives … we've stopped killing fire fighters at least for now… Our success rates in fire fighter safety are very high. So that has to be an indicator" (Research Participant #8).
>
> "The first life that you're concerned about is the life of your own staff" (Research Participant #9).

The 'flip side' of that view is that the death of a fire fighter is always a failure:

> "[A fire fighter death] will always scar that operation. It's no longer successful because there's been a fire fighter death…when they die something has clearly gone wrong" (Research Participant #8).

Fire fighter safety is the primary concern of fire brigade chief officers. That obligation, that priority, is also enshrined in the common law of negligence, criminal law and work health and safety law.

Common law of negligence

At common law, an employer owes a duty of care to an employee; but there is generally no duty to a stranger and no duty to rescue. The mere fact that someone, such a fire brigade, is aware that someone is in danger, needs their assistance and could in fact be assisted does not, of itself, give rise to a legal obligation to assist. As Justices Gummow, Hayne and Heydon, of the Australian High Court said, "The co-existence of knowledge of a risk of harm and power to avert or minimise that harm does not, without more, give rise to a duty of care at common law."[1]
The duty of an employer to devise and implement a safe system of work and to take reasonable care of their employee's safety is beyond question.[2] If there is a duty to those in need of rescue, whether imposed by statute or common law, it will only call for an agency to take reasonable steps to meet that obligation. In deciding what is reasonable, an agency must have regard to "… the magnitude of the risk and the degree of the probability of its occurrence, along with the expense, difficulty and inconvenience of taking alleviating action a**nd any other conflicting responsibilities which the defendant may have**."[3]

A fire agency would have to consider not only the risk to the person in need, but also the risk to fire-fighters. Putting fire-fighters in harm's way to save a victim may conflict with their obligation to take reasonable care for the safety of their employees.

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1 *Stuart v Kirland-Veenstra* (2009) 237 CLR 215, [88].

2 *Czatyrko v Edith Cowan University* [2005] HCA 14, [12] (Gleeson CJ, McHugh, Hayne, Callinan and Heydon JJ).

3 *Wyong Shire Council v Shirt* (1980) 146 CLR 40, 48 (Mason J) (emphasis added).

Criminal law

The common law offence of negligent manslaughter requires proof of 'gross negligence' or recklessness that causes or substantially contributes to a death.[4] One can be found guilty for an act that causes death if that action is a substantial contributor, but one can only be liable for failing to act and thereby causing death were there was a positive legal duty to act.[5] In the context of fire fighter safety directing a fire fighter into danger may be seen as an act. The incident controller that makes that order may be guilty of manslaughter if the decision making is so poor as to be considered so far below the standard expected of the reasonable incident controller as to warrant punishment or if he or she realised that death was likely but proceeded anyway. If, on the other hand, the incident controller stops, takes time to think of the safety issues and takes steps to minimise the risk to fire fighters, then they cannot be guilty of manslaughter, even if the person awaiting rescue dies. In that case they did not act to cause the death; they omitted to act and they can only be liable for that omission if there was a legal duty not to make that omission. As noted above, the mere fact that you know someone needs help is not sufficient to give rise to a duty to act, and even if it did, it would not be an obligation to put your own staff at needless or excessive risk.

Further developments in the criminal law, particularly in the United Kingdom and the Australian Capital Territory reinforce that the paramount obligation of a fire agency must be to fire-fighter safety. The legislatures in these jurisdictions have created an offence of 'corporate' or 'industrial' manslaughter. In the United Kingdom the offence of corporate manslaughter is committed if the corporation's activities represents a breach of a legal duty and causes death. The police and emergency services are largely exempt from these provisions except where the legal duty is owed to their own staff.[6] In the Australian Capital Territory, the offence of industrial manslaughter is committed if a corporation or a senior officer recklessly or negligently causes the death of a 'worker'.[7]

From a fire brigade perspective it follows that the mangers of the brigade could be guilty of corporate manslaughter for negligence that causes the death of an employee or worker, but not for the death of a third person, even if that person is the person they have been called to rescue. This will be discussed in more detail in relation to the case of Alison Hume, below.

Work health and safety

In the UK, it is an employer's duty to ensure the health, safety and welfare of employees. The business must be conducted to ensure that other people, affected by the business, are not exposed to risks to health or safety.[8] Similar rules apply in Australia[9] where the 'primary duty of care' is

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4 *Andrews v DPP* [1937] 2 All ER 552.

5 *Airedale NHS Trust v Bland* [1992] UKHL 5.

6 *Corporate Homicide and Corporate Manslaughter Act 2007* (UK) ss 1, 5 & 6.

7 *Crimes Act 1900* (ACT) ss 49C and 49D.

8 *Health and Safety at Work Act 1974* (UK) ss 2 and 3.

9 In 2012 the Australian States and Territories were meant to introduce uniform work health and safety laws (see http://www.safeworkaustralia.gov.au/sites/swa/legislation/modelwhsact/pages/modelwhsact.aspx). Whilst not all states have passed that legislation, for the sake of simplicity this

owed to workers (including volunteers) and people put at risk from the work, but not people put at risk from other sources, such as a fire.[10]

Actual prosecutions

Criminal prosecutions of the emergency services for dangerous work practices are not common, but they are not unheard of. In *Workcover v NSW Fire Brigades*[11] the Fire Brigades were prosecuted over the deaths of four factory workers and for exposing fire fighters to unnecessary danger. The fault was not decisions made on the ground by the incident controllers rather it was the failure of the Brigades to adequately train and equip the fire-fighters to deal with the situation. As a result the defendant was the NSW Fire Brigades rather than an individual fire-fighter, but the threat and reality of prosecution, remains.

In the United States, Curt Varone, US fire lawyer, reports that he is tracking 12 cases "since 2001 where fire and EMS personnel have been charged criminally with murder or manslaughter for on-duty actions" (Varone 2010) In the United Kingdom, the investigation of a factory fire in 2007 lead to three incident controllers being charged with manslaughter over the deaths of four fire-fighters (Ellicot 2011; Hayes 2011) although all were ultimately acquitted (BBC 2012, Eburn 2012).

It appears that authorities are looking to use the law to enforce fire fighter safety but that raises an obvious dilemma. Fire-fighting is intrinsically dangerous and fire-fighters (as indeed are all emergency responders) are asked, if not expected, to put their lives at risk to help others, while the agency for which they work is required to ensure the fire fighters safety and to put that safety ahead of the safety of others. Expecting fire services, and their incident controllers, to guarantee fire-fighter safety would, at its logical extreme, mean not dispatching fire-fighters to an emergency!

That extreme position is not reasonable, nor is it required by law. What is required is a balancing act between the risk to fire-fighters, which is minimised through training and equipment, and the value of the outcome, whether that's extinguishing the fire or rescuing the person in need. Striking that balance is a challenge for fire services and for incident controllers, a challenge that is compounded by the threat of legal action.

The problem in practice

The dilemma of how to balance these competing interests was demonstrated in the case of a mine rescue in Scotland in 2008. The victim in that case fell down a disused mine shaft. The fire and rescue service were called and fire-fighters were willing to make their way down the shaft in order to rescue the victim, but they were stopped by the incident controller who was aware that the fire service had issued an order that their equipment, provided to ensure safe working at heights, was not to be used in a rescue. Their standard operating procedures required that the Police Mountain Rescue Squad be called for this type of rescue, and this was done. The decision not to allow the fire-fighters to make the rescue was confirmed by subsequent incident controllers. Unfortunately the delay caused by waiting for the arrival of the Police Rescue Squad

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paper will refer to the *Work Health and Safety Act 2011* (NSW) which is based on the model Act and so is consistent across most, if not all jurisdictions.

10 *Work Health and Safety Act 2011* (NSW) s 19.

11 [2006] NSWIRComm 356.

meant that the victim died of injuries that were otherwise survivable.

Before a Fatal Accidents Inquiry, the Sherriff (the equivalent of a coroner) said that one of the incident controllers "… in particular, considered that the rescue operation was a success. In his view he had adhered to the policies and procedures set out by [the] … Fire and Rescue Service… There had been no casualties other than the one to whom the Service was called upon to rescue." The Sherriff did not agree. He said, "Unfortunately this was not a successful operation: a woman died who had not only sustained survivable though life threatening injuries, but who had also ultimately suffered and died from acute hypothermia …" (Leslie 2011).

Given what has been identified above as the current law, what was the incident controller to do? The fire service was not the cause of Ms. Hume's injuries; they did not cause her to fall down the well. The mere fact that she was in danger, that they knew of that danger and could, possibly do something about it, is not enough to give rise to a common law duty to act.[12] The primary obligation was to the fire-fighters[13] and the incident controller could have been charged with manslaughter if a fire-fighter had died, but not for her death.[14] The law was clear despite the Sherriff's criticism of the fire service's conduct and despite criticism that informed, trained and experienced fire fighters should have been allowed to perform the rescue that they believed they were competent to perform.

The problem was that the incident controller, despite all of the above, did not conduct a proper risk assessment. In the words of the Sherriff, "The core consideration of a risk assessment is a question of whether or not the risks to be taken are proportionate to the benefits gained… It is difficult not to form the view that [the] … approach to risk assessment was to effectively eliminate risk. I did not think that a process of risk assessment was adopted whereby risks were identified and those risks accommodated to achieve the central purpose of the attendance of Strathclyde Fire and Rescue Service" (Leslie 2011).

The failure to actually think about the risk to fire-fighters and balance that against the benefit to Ms. Hume was compounded by the fact that the Fire Service directive on the use of 'safe work at heights' equipment, tied the hands of the Incident Controller. A subsequent review into the Fire Service and its practices recognised that fire service policies "… exist for a reason… incident commanders had a duty to take into account the Service's operational guidance and, in other circumstances, would have been held to account had they not done so" (Torrie 2012).

What's to be done?

The picture painted, so far, is gloomy. It suggests that in all cases the lives of people who depend upon the fire or rescue service as their best hope for survival, have to be sacrificed for fire fighter safety. That appears to be inconsistent with the job of fire fighting that is, by its very nature, dangerous, and which means that safety can never be guaranteed. It is also probably inconsistent with the motivation of people who join a fire and rescue service which probably includes a desire to save people who need saving.

That may be the perception and it may even be the reality if incident controllers, fire services and others think that the law requires strict procedures, and strict adherence to them. If that is

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12 *Stuart v Kirland-Veenstra* [2009] HCA 15, [88].

13 *Health and Safety at Work Act 1974* (UK) ss 2 and 3; *Work Health and Safety Act 2011* (NSW) s 19.

14 *Corporate Homicide and Corporate Manslaughter Act 2007* (UK) ss 1, 5 & 6.

the belief, then agencies that try to comply will impose the type of strict rule that applied in the Scottish rescue. There was no option to use the safe work at heights equipment even if it was assessed as an acceptable risk; its use was prohibited. The Sherriff put it this way, "For a rescue to be achieved, some *imagination, flexibility, and adaptability* [is] necessary. There [is] clearly a balance to be struck between the interests and safety of the rescuers, and those of the casualty they [are] there to rescue … " (Leslie 2011, emphasis added and changed to the present tense).

'Imagination, flexibility, and adaptability' are not only necessary, but haveto be expressly allowed. Many people may believe that the law will not allow this, but that is not the case. For example, health and safety legislation does not require that safety is guaranteed, rather it requires agency do what is reasonably practicable. Deciding what is reasonably practicable takes into account

- The probability of harm;
- The degree of harm;
- What's available to mitigate the risk;
- Is the cost of mitigation disproportionate to the risk.[15]

If the cost of waiting for other equipment and specialists, whether that cost is in dollars, time or the risk to the victim's life, is disproportionate, compared to a low risk of injury to staff, then it may not be 'reasonably practicable' to wait. In that case it may be appropriate to find other ways to resolve the problem, in this example to make the rescue.

The common law of negligence, when deciding whether a person's actions were reasonable, considers similar factors. As noted above Justice Mason said that in order to determine what the reasonable response to a recognised risk is, a court must consider, "… the magnitude of the risk and the degree of the probability of its occurrence, along with the expense, difficulty and inconvenience of taking alleviating action and any other conflicting responsibilities which the defendant may have."[16] If fire agencies want to allow 'imagination, flexibility, and adaptability' they should avoid rules that are too restrictive. As one chief officer said:

> "… lawyers are writing the plans, or helping us write the plans. They are so prescriptive as to be almost irrelevant. Every operation has its own unique dynamic. Plans should be, you know, principle based and fairly broad and give a large landscape in which to operate with some principles in which to comply with.
>
> But we're getting so much prescription … Well, that's great, but then you've got the documents and then you've got the environment which you've got to operate it within. I'm yet to be convinced that the two will ever align…" (Research Participant #8).

The plans, whether for the rescue of an individual or the response to a catastrophic fire have to allow incident controllers flexibility to adjust strategies to suit the environment, rather than expecting the environment to comply with the plan.

As the rescue (or failure) to rescue Ms. Hume shows, having strict policies, and sticking to them does not guarantee success nor does it guarantee that there won't be criticism for trying to comply with the plan. As a South Australian coroner, investigating the death of 9 people during wildfires in 2005 said "… it has to be borne steadily in mind that one can always find fault in a

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15 *Work Health and Safety Act 2011* (NSW) s 18.

16 *Wyong Shire Council v Shirt* (1980) 146 CLR 40, 48.

setting of such complexity. The temptation to criticise the minutiae of every decision that was taken by a group of individuals or by the individuals themselves is sometimes difficult to resist" (Schapel 2007). The UK Fire Services Inspectorate recommended that "… given the broad and ultimately un-definable range of incidents which the Service might be called on to respond to, the best operational policies are ones which set out what can and cannot reasonably be done but which allow for intelligent and informed decision making on the incident ground" (Torrie 2012).

If we want rescuers to exercise 'imagination, flexibility, and adaptability' then the training and doctrine of the organisation has to empower and authorise them to assess outcomes and if necessary, depart from policy. Policy, training, and law have to be flexible, and identify factors to be considered and how to balance different risks, and then empower controllers to make the final judgement. The modern law, with its focus on what is reasonably practicable and its express direction on the factors to be considered could incorporate such flexibility. A fire service could move away from edicts and stringent standard operating procedures but that would require a significant amount of trust in their staff and a willingness, still, to accept that there will be consequences that the community does not like –people will still be allowed to die when the assessed risk to rescuers exceeds the likely benefit, and fire fighters will die when a rescue is considered 'worth the risk' but an unlikely, worst case residual risk occurs. In either case, when reviewing these events, incident controllers deserve to be judged on the basis of the information available at the time the decision was made (including standing orders and service doctrine) and not with the distorting effects of 'hindsight bias'. Regardless of the decision making process, if someone dies, incident controllers are going to be required to answer questions and justify their decision.

Courts are quite capable of recognising when a person is given discretion and understand that it's not negligence even if, with the benefit of hindsight, it appears another decision may have led to a more favourable outcome.[17] They are conscious of the need to avoid 'hindsight bias' and not see actual outcomes as if they were inevitable at the time critical decisions were made.[18] It follows that if an incident controller is directed 'you must not do *x*' then doing *x* is, on the face of it, negligent and culpable. If, on the other hand, the incident controller is directed to the effect that he or she should consider various actions and in deciding what to do consider that the primary but not sole obligation is to employees and others not already exposed to danger, look to the risks to fire-fighters, the cost in terms of lives lost of the alternatives, what steps can be taken to mitigate the risk, and whether, ultimately the risk is 'worth' it, then, if that is done and if the decision process and the issues that have been considered are recorded, then even if there is an poor outcome, the chances are that a court would be unwilling to 'second guess' the judgment of an experienced, trained incident controller.

Conclusion

These real situations demonstrate the very real dilemmas facing incident controllers and the problems of applying work health and safety laws in the context of the emergency services. The law requires everyone, including fire fighters, to do what is 'reasonable' but that gives little guidance. Many people are in positions where they have to balance competing objectives and considerations but, unlike emergency service incident controllers, they don't have to do it in a

17 *Leishman v Thomas* (1958) 75 WN(NSW) 173, 175.

18 *Vairy v Wyong Shire* [2005] HCA 62 [124]-[130](Hayne J).

dynamic environment in which, whatever they decide, lives are in the balance.

On the current law, and faced with the direction not to use safe working at heights equipment in a rescue but to call the Police Rescue Squad, the Scottish incident controller was correct in ordering the fire-fighters to withdraw from the edge of the mine shaft and to deny them permission to attempt the rescue. The outcome was of course tragic, but the incident controller had little option.

The result does not necessarily, however, require a change in the law but a change in practice. Despite belief to the contrary, the law can accommodate flexibility (though, but it does make employee, and in this case fire fighter safety the paramount consideration). Incident controllers, even if given flexibility, have to be told that it includes the right to make the decision that was made at the place of Ms. Hume's rescue, which was that at. At times the risk to fire fighter safety will be too great and people will have to be allowed to die. that rescue or internal fire fighting will not be done. This will, inevitably, lead to criticism if people die in circumstances that, later, the community, or the press or the Sherriff decided was not so risky after all. Allowing incident controllers to make decisions necessarily requires being prepared to stand by them and their decision even if the outcome is poor.

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Field studies of fire-atmosphere interactions in complex terrain: Implications for fire fighter safety

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Abstract.
Meteorological data are crucial to predict fire behavior. Current meteorological tools for wildland fires consist of both portable and fixed networks of Remote Automated Weather Stations (RAWS) and belt weather kits. Soundings from the fixed network and Fire Spot Weather Report from the nearest National Weather Service (NWS) office may also be used. However, most wildfires do not occur near the fixed RAWS network, near the cities with the daily soundings, nor near a NWS office. These factors combine to make it difficult to make accurate meteorological predictions at a wildfire. With current advances in meteorological technology, new observations can be made using the latest state-of-the-science instrumentation including mobile, remote sensing platforms at wildfire incidents.

San Jose State University and San Francisco State University through a National Science Foundation (NSF) grant have developed the California State University-Mobile Atmospheric Profiling System (CSU-MAPS). This rapidly deployable 4x4 ¾ ton Ford F250 pickup truck and portable trailer system consists of the following instruments:

- 32-m extendable meteorological tower
- HALO Photonics Scanning Doppler Wind Lidar
- Radiometrics Microwave Temperature / RH Profiler
- Vaisala Radiosonde Balloon System.

The CSU-MAPS can be deployed as a single unit or as a more mobile facility where the lidar, microwave profiler and radiosonde system are mounted in the truck without the trailer. In either configuration, the CSU-MAPS system can provide micrometeorological data from a location near the wildland fire.

The motivation for the CSU-MAPS came from the need to study fire behavior in the wildland rather than in the laboratory. The ability to study wildland fires on location as they occur is paired with the field studies performed during experimental prescribed fires to advance the understanding of wildland fire behavior.

A current series of experiments examine the slope effect of fire behavior and aim to create a data set for testing the new generation of fire behavior models. The pilot study was performed on June 24th, 2010 during a prescribed burn at Camp Parks, CA. A single 12 m micrometeorological tower was placed midslope on a 20° slope. 3 m RAWS were placed at the bottom and top of the slope, a SODAR wind profiler at the bottom, and time lapse cameras at the bottom and mid-slope on the left flank. The experimental design called for the ignition line to be at the base of the slope and a head fire to run through the instrumented tower. However, on the day of the experiment, the winds changed and a cross slope flow occurred. The fire was ignited

at the base and then continuously up the left flank so that head fire would run thorough the tower. A blackline was also created on the right flank to prevent escape. Because multiple drip torches were used to create the fireline, the dataset, although interesting is not conducive for use in modeling. While the pilot experiment was not ideal, new observations were made during cross-slope flow: pressure decrease of ~0.5 mb ahead of fire front; fire intensity ~100 kW m^{-2}; wind profile modification caused by plume. Near-surface advection of plume air occurred ahead of fire front passage. In addition, the experiment verified that the Radiosonde, camera system and SODAR wind profiler could be deployed at a fire and provide useful data.

A second pilot study was performed at Grant Park, CA to test the LIDAR and radiometer. The main goal was to determine if the instruments could measure wildland fire plumes. The lidar and radiometer were placed upwind of the 600 acre burn unit. The sodar was placed downwind. Radiosondes were simultaneously launched upwind and into the plume several times during the burn. A 6 m micrometeorological tower was placed in the burn unit. RAWS were placed at the base and the top of the burn unit. The results from the second pilot were as follows: moisture in the morning combined with low wind speeds throughout the day kept the fire intensity low for the prescribed burn, the lidar performed well and was able to penetrate the main convection core of the plume, the lidar detected strong radial velocities beneath and within the plume and reduced velocities were observed downwind of the plume indicating ambient wind modification.

On June 19-21, 2012, two experimental grass fires were conducted at Fort Hunter Liggett in central California. These burn plots were on slopes with angles between 20-26° with uniform grass fuels. A suite of instruments including CSU-MAPS, in situ micrometeorological towers, ground and aerial based video, and time-lapse and infrared cameras, recorded environmental information before, during, and after the fires. Both fires had slight cross slope winds, which altered the direction of spread of the fires from directly upslope. The first burn experienced a nearly 180° wind shift which occurred first above the ridge crest and later at the slope bottom which further influenced the direction and rate of spread of the fire. The radiosonde sounding detected the strong directional wind shear at 500 m above the base of the slope. The lidar was able to capture the wind shift on the slope as the upper-level winds surfaced. It also captured fire whirl formation during the burn. This wind shift caused the fire progression to change from an upslope head fire to an upslope backing fire.

These experiments show great promise in increasing the ability to obtain in situ meteorological data at a wildfire thus contributing to more accurate fire behavior predictions.

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Radio communication and misunderstandings in wildland firefighting

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Abstract:
Unclear, ambiguous radio communication during a wildland fire can have serious consequences for firefighters' safety. This paper grounds its observations in Media Richness Theory (Daft and Langel, 1984), where media richness refers to the number of channels of contact afforded by a communication medium. Each channel identified in the model roughly corresponds to one of our senses; consequently, face-to-face communication is classified as the richest medium because it simultaneously allows for verbal and non-verbal communication as well as oculesics (eye contact), olfactory communication (smell), and haptic communication (touch). According to Daft and Lengel's theory, media richness is a function of (1) the medium's capacity for immediate feedback, (2) the number of cues and channels available, (3) language variety, and (4) the degree to which intent is focused on the recipient. Mediated communication, like that which takes place via radio is considered a less rich medium than face-to-face communication because of the lack of simultaneous non-verbal cues that reinforce or contradict verbal communication. However, because of logistical issues, radio remains one of the most widely used media of communication during wildland fires. The more complex the fire, the more opportunities for miscommunication due to multiple communication channels being used, large distances being covered, multiple crews being involved, multiple messages competing for attention, and increased stress.

This paper analyzes investigation reports and radio transcripts of the Dutch Creek Incident (Idaho, 2008) – 1 fatality, the Cramer fire (Idaho, 2003) – 2 fatalities, and the Panther fire (California, 2008) – 1 fatality. In these incidents ambiguous, information-poor messages affected understanding, decision-making, and the safety of firefighters. While radio miscommunication was not the only contributing factor to the complex outcomes of these incidents, it was an important contributor deserving further research.

In the Dutch Creek Incident, an 8-foot stump broke off a large tree and crushed the leg of a faller, cutting his femoral artery. The message communicated to the Sheriff's office suffered from serial distortion as it passed from one communicator to another. The initial message was: *'Man Down Man Down. We need help. Medical emergency. Dozer pad. Broken leg. Bleeding. Drop point 72. Call 911 we need help*.' The message that the dispatch operator passed to the Sheriff's office was "Sounds like a broken leg" (National Park Service Investigation Report, 2008, p. 77), which led the paramedics to carry equipment that would treat a fracture but not severe bleeding. By the time he arrived at the hospital, the injured firefighter had lost too much blood and perished.

In the Cramer fire, two rappellers asked for helicopter pick up when they noticed smoke coming towards them from the west; the response was an ambiguous message that failed to accurately describe that both helicopters were down (one for inspection and the other for refueling). The two rappellers adjusted their expectations and waited for the helicopter until it was too late to save themselves on foot.

In the 2008 Panther fire in California, two Division Group Supervisors (DIVS 1&2) representing the incoming Type 1 organization failed to clearly communicate their position and their next move while conducting a reconnaissance of the fire line and found their escape routes cut off by the expanding fire. DIVS 1 elected to deploy his shelter and was overcome by fire, while DIVS 2 survived by running through heavy unburned fuels.

This paper advances three recommendations:

1. When uncertainty is high, firefighters need to compensate for the less rich medium of radio with messages that provide spatial (where I am, what I see and hear) and temporal details (what I've done, what I'm currently doing, what I'll do next, how long it might take me).
2. Firefighters should use feedback loops, standard phraseology, and alarm cues for critical situations to prevent misunderstandings.
3. More training in message design is needed along with increased awareness about the potential consequences of firefighters' talk at work.
4. A database containing examples of miscommunication during fires should be researched and built as a teaching tool.

Additional Keywords: Radio, communication, Cramer, Dutch Creek, Panther, media richness

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Using extreme value analysis to enhance defendable space for fire fighters and residents.

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Abstract. While wildland fires (bushfires) are an anticipated event with each fire season, it is important that the extent of likely annual fire weather conditions and those of more extreme conditions are identified as part of community preparations for fire season. Historically extreme value analysis has been used for floods, storms, temperature, and wind, however, little work has been produced for extreme fire weather. This may be because historically a fire weather index is a composite of differing weather conditions, which, at their extreme, individually may not be related to wildland fire alone. Fire danger index systems generate non-dimensional parameters and in Australia, this has generally focussed on the forest fire danger index or grassland fire danger index.

While it is difficult to ascertain individual extremes related to individual parameters for wildland fire, the use of the Generalised Extreme Values distribution is a suitable process for fire danger indices. This can be applied to deterministic fire behaviour assessments whether through the identification of rate of spread, flame length, intensity or suppression effort.
This paper offers new insights in the use of extreme value assessments for both MacArthur Forest Fire Danger Index (FFDI) equations so as to determine suitable defendable space for buildings under both existing and planned urban developments in NSW, Australia. Treatment options for existing homes can be more effectively determined and quantified under such an approach so as to better balance resident and fire fighter safety as well as recognising environmental assets.

The approach may therefore have broader application for other countries' danger indices when preparing communities and fire fighters for extreme fire weather conditions.

Additional Keywords: land-use planning, construction practice, fire weather, extreme value analysis, wildland fire.

Introduction

Bushfires are regular but variable phenomena in the landscape. Bushfires can occur with some regularity, however, extreme bushfire events are less likely and hard to predict. These events are dependent on the antecedent weather conditions, which give rise to severe conditions, resultant low fuel moisture and strong hot gusty winds (Sullivan 2004). This gives rise to complex spatial and temporal variations in the landscape and the resultant fire behaviour.

Determining the severity of a potential bushfire for land-use planning purposes is crucial in any assessment process (Douglas and Ellis 2001; Douglas, et al 2006). Property protection measures are therefore related to the concept of a 'design bushfire' (Douglas 2012). Obtaining the correct inputs for developing the design fire is therefore critical in considering the protection

of life and property of assets, including resident and fire fighter safety, protection of homes and other infrastructure and balance with environmental objectives. It is also necessary to develop models of fire cover and recognition of likely fire scenarios, which may occur in any given year for minimum fire fighter safety and existing property protection. Work by Butler and Cohen (1998) and Cohen (2004) in the USA and Douglas and Tan (2005) in Australia applied existing deterministic approaches combined with fire engineering principles to determine defendable space for fire fighters and building protection.

In fire safety engineering practice, the design fire is principally based on the combustible materials within a confined area (ABCB 2005). In bushfire engineering, the design fire is dependent on topographical conditions over which the fire burns as well as the predominant vegetation class (fuel loads or fuel structure) over which the fire burns (Ramsay et al 2006). In some cases designers may seek to develop alternate design fires as weather conditions are less severe than those required by the deemed to satisfy design conditions provisions of the building code. An excessively high design fire may add significantly to costs of construction and or land clearance for property protection purposes.

The quantification of extreme weather events assists in determining suitable design bushfires based on a risk profile and some attempts at using logistic regression and percentile analysis have been considered previously (Andrews et al 2003). The use of extreme value techniques are regularly used in areas of storm, flood and high wind events (Coles 2004), however, little work has been produced for extreme fire weather. One study has been noted of fire size (Alverado et al1998) in relation to extreme value assessment but few studies have been found by the author for bushfire indices.

The current study aims to develop interim risk criteria for classes of development and use extreme value analysis for determining fire weather conditions so as to ascertain appropriate defendable space conditions.

Historical fire events.

The extent of historical house losses arising from bushfire has been considered as relating to fire weather conditions (Blanchii and Leonard 2005). Two major fires are worth noting; the ACT fires of 17 January 2003 (McLeod 2005), and the 7 February fires in Victoria (VBRC 2010).

The fires of the Australian Capital Territory on 17 January 2003 resulted in over 500 homes lost and four fatalities. The insurance bill is recorded as exceeding $350 million (McLeod 2005). The fires also resulted in losses of major infrastructure and culturally significant buildings such as the Mt. Stromlo Observatory facilities.

On 7 February 2009, the Black Saturday fires had a devastating effect on the community in Victoria. A Royal Commission was established to enquire into the events of the fires and measures to prevent their reoccurrence. During the fires 173 people lost their lives 123 of whom died in, or immediately near their homes. The fires left 7,000 people homeless with excess of 2,000 homes being destroyed (VBRC 2010). In addition, two schools and two child-care facilities were also burnt down with many businesses and important community infrastructure.

Of the 67 recommendations of the Victorian Bushfire Royal Commission, 17 related to planning (land-use) and building controls. In particular, the recommendations identified the need to determine appropriate defendable space requirements as part of the review of guidance materials and planning provisions for the bushfire management overlay (VBRC 2010). However, the question remains as to the most accurate process of determining suitable risk criteria for the

development of defendable space, not only for property protection of new and existing developments, but also fire fighter safety.

Developing defendable space criteria for property protection and life safety

To better assess the question of enhanced safety, it is important to develop suitable criteria (risk criteria) for the different land-use and building options used for new and existing developments.

To do so, it is necessary to ascertain inputs relating to:

- The bushfire hazard (fuel or vegetation class);
- The bushfire weather (derived from station data); and
- Land-use patterns and topography within the landscape.

This allows a process of deterministic modeling based on empirical models of fire behaviour and life and property loss criteria. For simplicity, the Macarthur equations developed by Noble et al (1980) have been used to determine fire behaviour characteristics including rates of spread, fire line intensity and flame length.

The intent of this paper is to focus on forest fires of south-east Australia and New South Wales (NSW) in particular, however, the approach should be suitable for many fire prone areas of differing fuel classes and geographical conditions. In particular, the approach uses extreme value analysis (GEV) to ascertain whether the forest fire danger index (FFDI) can be used for developing defendable space (APZs).

NSW is divided into 21 fire weather districts (including the ACT) which are shown on a generalised map in Figure 1 below (NSWRFS 2006). Major weather stations are also located on the map although there are substantially larger numbers of stations than illustrated.

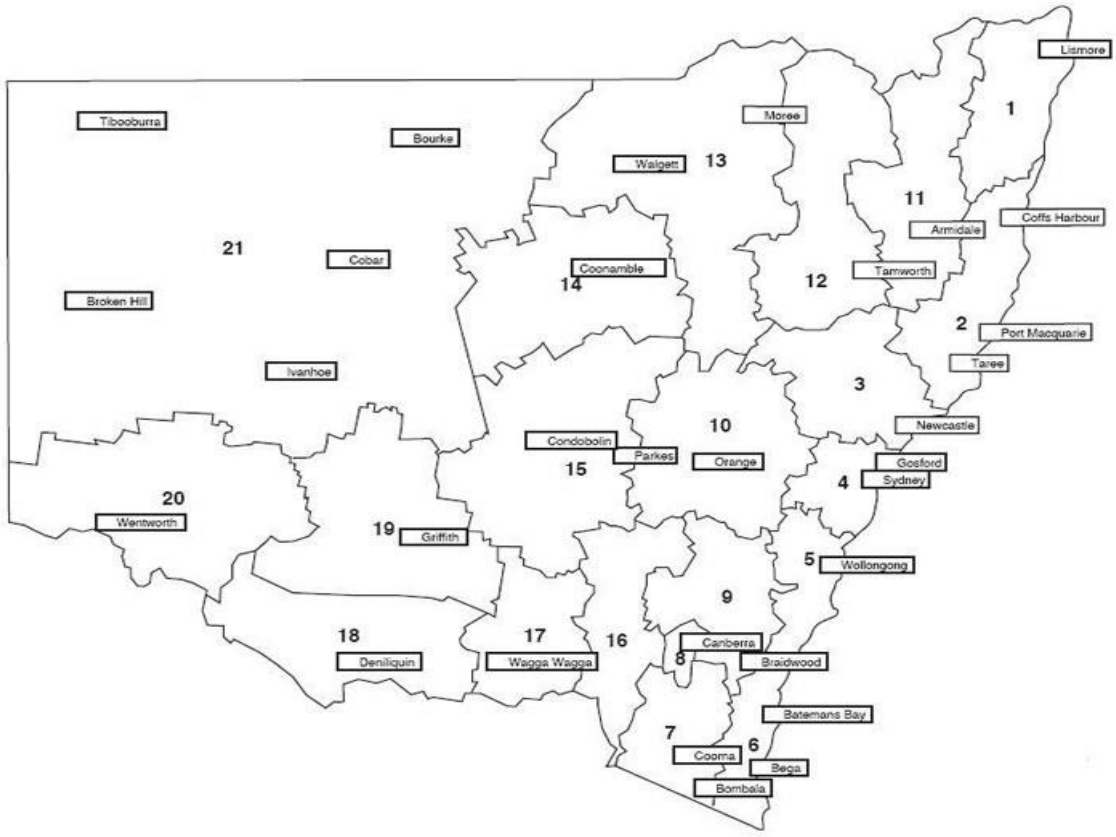

Figure1: NSW Fire Weather Districts & AWS locations used in the study (source: NSWRFS).

Previous fire weather assessment work has focused on historical weather records and frequency distribution models (Andrews et al 2003) but not Pareto distributions or extreme value assessments. The focus of this study is to illustrate the usefulness of extreme value analysis as a preferred statistical tool due to its ease of use and strong correlation of return values.

The nature of the range of existing and proposed land-uses in bushfire prone environments is an important consideration as it can be difficult to retrospectively address landscape fuel management post-development in a way that might be applied for proposed new developments. As such, the criteria applied to existing housing stock may be of a lower standard than that planned for future developments. In addition, the subdivision of land should provide for lower cost construction outcomes rather than simply the transfer of development onto a future homeowner at the benefit of the land developer. The concept of vulnerability of land-use must also be considered such that schools, nursing homes, child care facilities, hospitals, tourist developments and the like get a higher level of protection than industrial sites which have a more mobile workforce in character and may aid the dependability of the facility.

This is partly reflected in the underlying philosophy of the National Construction Code (NCC) which has developed criteria for different types of buildings with differing resilience characteristics based on loadings to buildings from wind, earthquake and snow (ABCB 2011). These characteristics are described as importance levels (for buildings) and design events for classes of hazards. The NCC does not consider bushfire, which is not a loading issue but rather an issue of fire resilience level.

Table 1 below is taken from the National Construction Code and illustrates the current importance levels for buildings subject to various hazardous events (ABCB 2011).

Importance Level	Building Types
1	Buildings or structures presenting a low degree of hazard to life and other property in the case of failure.
2	Buildings or structures not included in Importance Levels 1, 3 and 4.
3	Buildings or structures that are designed to contain a large number of people.
4	Buildings or structures that are essential to post-disaster recovery or associated with hazardous facilities.

Table 1: Importance levels of Buildings and Structures (adapted from ABCB 2011)

Table 2 provides the current design events for safety of these buildings to wind, snow and earthquake events.

Importance Level	Annual probability of exceedance			
	Wind		Snow	Earthquake
	Non-cyclonic	Cyclonic		
1	1:100	1:200	1:100	1:250
2	1:500	1:500	1:150	1:500
3	1:1000	1:1000	1:200	1:1000
4	1:2000	1:2000	1:250	1:1500

Table 2: Design events for load safety (adapted from ABCB 2011).

For bushfire events, the land-use planning criteria in Table 3 (below) have been developed to illustrate the application of this principle to various proposed and existing works. The basis of the safety criteria is identified as being either or a composite of meeting construction practice outcomes, land-use planning outcomes or operational fire fighting outcomes.

Land-Use Category	Exceedance	Nature of exposure	Design Flame temperature	Basis of safety criteria
Infill dwelling	1:50	29kW/m2	1090K	Construction
Subdivision (residential)	1:50	19 kW/m2	1090K	Planning and Construction.
Industry, shops, office, etc	1:20	40kW/m2	1090K	Operational
Vulnerable developments.	1:100	10kW/m2 (10 seconds)	1200K	Planning and Operational
Existing development	1:1	Flame contact	N/A	Operational

Table 3: Proposed land-use safety criteria for bushfire prone areas.

Although the above exceedance and exposure criteria are illustrative, the infill dwelling is based on the current stated criteria in AS 3959-2009, the subdivision is based on stated criteria by Victorian and Tasmanian planning provisions (Douglas 2011) and vulnerable developments are based on NSW criteria for Special Fire Protection Purpose developments (NSWRFS 2006).

As can be seen, developing criteria is not simply a matter of an exposure but is determined on the basis of likely exceedance (risk), design fire considerations (flame temperature), and the exposure to be calculated. The basis of safety is also important as it establishes whether the outcome to be achieved is solely based on construction practice (e.g. a residential infill), an operational consideration (e.g. fire fighting in a typical year) or capacity of user to support its own fire fighting effort (e.g. industry). In the case of vulnerable developments, the exposure and duration is related to peak flame temperatures for supporting personnel rather than exposure of those inhabiting these structures and could include a community shelter or refuge.

Fire Weather Data.

Three (3) weather datasets were acquired from the Bureau of Meteorology (BoM) and include:

1. 1976/86-2009 data on FFDI/GFDI and associated data (Lucas 2010) (16 stations);
2. All 1950-2009 daily data available at 3:00pm for wind, RH, Temp, gusts and rainfall;
3. 1994-2009 drought indices (DF, KBDI & SDI) with 3pm RH, T max and 24 hr rainfall (88 stations).

The datasets have been consolidated and 30 locational datasets have been produced covering all 21 fire weather districts (see Figure 1). These include FFDI (& in western NSW GFDI), daily maximum temperature, 3:00pm wind speed/directions, RH and 3pm Temperature. This covers the period from 1976 to 2009 for the 16 available datasets (Lucas 2007) and another 14 derived datasets covering the period of 1994-2009.

The forest fire danger index or FFDI is determined (Noble et al 1980) by the formula:

FFDI = 2 exp (-0.45 + 0.987ln(D) – 0.0345 H + 0.0338T + 0.0234V) where:

D = drought factor (derived from Keetch-Byram Drought Index)
H = relative humidity (in percent)
V = wind speed (at 10m) in kph; and
T = temperature in degrees Celsius.

The above data is provided to derive a surrogate for daily maximum FFDI using 3pm data for wind speed and relative humidity, daily drought factor and maximum temperature. For a discussion of the limits and suitability of this data set, see Lucas (2010). The weather data used in this study does not represent a 'worst case' of daily FFDIs, which could be exceeded at times other than 3pm.

Notwithstanding these limitations, the data does provide a consistent as well as will be seen, a somewhat robust dataset in terms of outcomes.

Methodology.

In the past, the common practice of fire authorities has been to consider the limited weather data available for a site and determine whether the policy decision for construction practice should be based on either the:

a) FFDI being exceeded on more than one occasion assumed as 1:50 year event (NSWRFS 2006);
b) FFDI which is a frequency percentile value of the dataset (e.g. 99% value); or
c) derived FFDI from maximum values of wind speed, minimum relative humidity, maximum temperature and drought factor for summer data (Adrian 2009).

Each of these methods has significant shortfalls and do not represent a valid approach to the assessment of fire weather, but have been used in the absence of a clear methodological and statistically appropriate approach.

An examination of a typical data set illustrates the problem. The graph (Figure 2) below shows the distribution of data for a given site (Sydney Airport) by season. The highest 3pm FFDI in the dataset is 95, which occurs in Summer, however the FFDI value corresponding to the 99 percentile value of the dataset is FFDI for both Spring and Summer and is only approximately FFDI 40. The 99.9 percentile for Spring is higher than Summer, although both are close to FFDI 70. Seasons are defined by calendar dates.

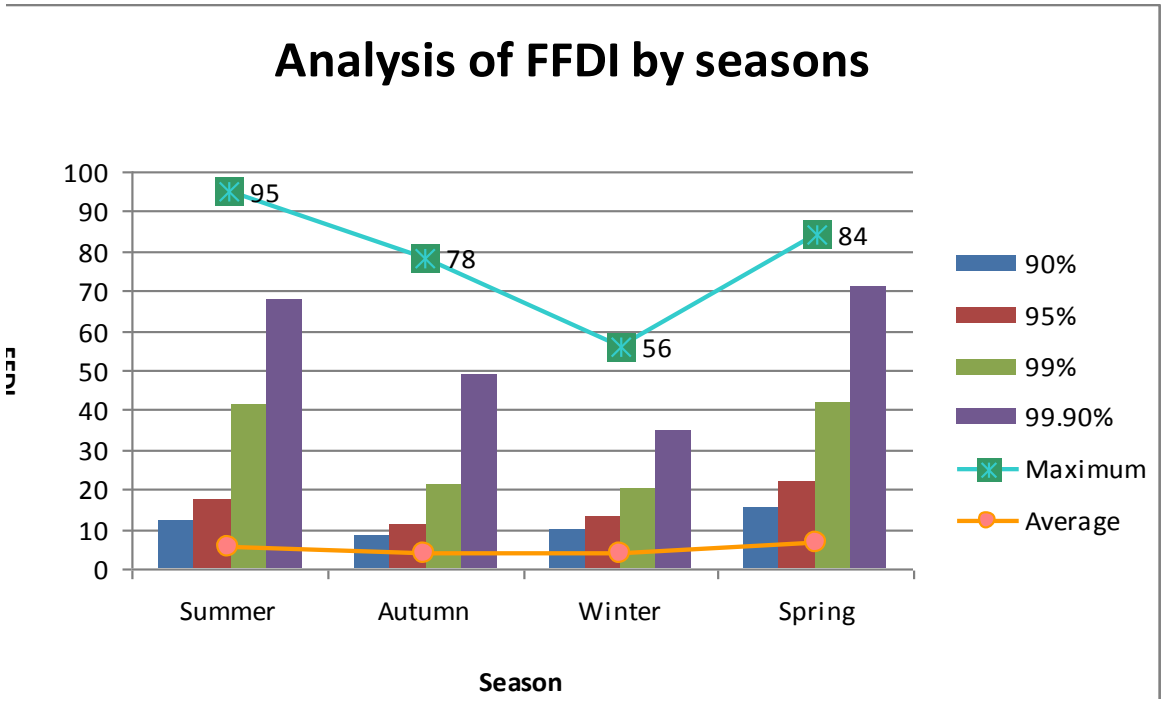

Figure 2: Frequency distribution of 38 years of FFDI data for Sydney Airport (Douglas, 2012).

A question now arises: Does the 1:50 year return period for annual exceedance values fall within this range or outside the range of data which is 38 years long?

Note that seasonal averages are also low. The data, even at the 90% value may be simply noise and may not reflect any extreme (not to be confused with Extreme forest fire danger rating) events. It is also not possible to simply estimate a threshold if using a Pareto approach.

An examination of the highest FFDI days at the same station, also illustrates the problem of attempting to use maximum values.

Table 3 provides the highest 7 FFDI days and the breakdown of individual weather parameters from the Sydney Airport dataset. The highest FFDI of 95 (23/12/1990) does not have the highest associated temperature, minimum relative humidity or maximum wind speed. In this case the highest FFDI is associated with a high drought factor (and KBDI). These data points also need to be considered within the context of 38 years of data.

The theoretical basis of Generalised Extreme Value (GEV) is covered elsewhere (Gumbel 1958; Coles 2004; Reiss and Thomas, 2007), but is seen by some (Makkonen, 2006) as being the preferred technique over other approaches. GEV Analysis provides a feasible tool for the determination of risk associated with the occurrence of these extreme weather conditions. A drawback of the approach is that on its own it only provides a static assessment in the absence of the effects of climate change.

In general, it has been assumed that the use of a GEV analysis must utilize annual maximum values and that a Pareto analysis is best where a peak over thresholds approach is used. The annual maximum approach can be substituted for a broader maximum values approach and applied where these values approach annual maximum.

Date	FFDI	T_{max}	RH_{3pm}	DF	KBDI	Direction (degrees)	Direction (bearing)	Wind Speed kph
16/12/1979	75	40	6	9.2	116.8	315	NW	31.7
25/11/1982	77	43.4	4	8.3	81.2	270	W	29.5
2/03/1985	78	39.2	13	9.3	121.7	292.5	WNW	44.6
23/12/1990	95	41.7	15	9.8	131.4	270	W	50
24/09/2006	82	34.6	13	7.1	33.7	320	NW	64.8
22/11/2006	75	40	8	9.5	111.2	326	NW	33.5
3/10/2007	84	36.2	7	8.6	49.8	308	NW	46.4
Mean	80.86	39.3	9.43	8.83	92.26	300.21	NW	42.93

Table 3: Seven (7) highest FFDI days for Sydney Airport weather station and weather parameters.

This study uses a maximum values approach (Makkonen 2006), which is assessed based on the inclusion of a minimum of n +1 years of data points.

The GEV distribution uses the equation T= (N + 1)/M where:

T = return period (recurrence)
N= no of years of data
M = rank value.

An Excel spreadsheet was used to determine rank values for the FFDI values to and in some cases below the 1:1 year outcomes. The resultant plot was then subject to a log linear graph and the resultant line of best fit and correlation (using R^2) determined. This line is considered as accurate as other more sophisticated programs such as SPSS, SAS and Minilab (Spiegel and Stephens 2011).

Results.

GEV values for 1:1, 1:20, 1:50 and 1:100 mean return periods (recurrence intervals) have been determined for all sites within the 21 fire weather districts. An example of the resultant graph of one site is set out in Figure 3 below for the Sydney Airport weather station.

An example of the application of return periods for the safety criteria discussed above is set out in Table 4 below for part of the dataset provided by the Bureau of Meteorology (Lucas 2010). This includes nine sites for NSW and the Australian Capital Territory. The table includes the R^2 correlation co-efficient for each line of fit. These show good correlation and fall within the theoretical line for the GEV assessment method discussed above.

As can be seen in Table 4, in some cases the 1:50 year event can be either higher than or lower than the maximum recorded for the site.

Discussion.

The method of using GEV analysis provides a better understanding of risk and can be applied to various design fire conditions. In addition, it is possible to quantify regional FFDI conditions for various SE-Australian fire weather districts based on individual weather stations.

A limitation is that the results may not be representative of the geographical and climatic characteristics of the whole of the region, but it will still be a better indicator than existing techniques. It is also possible to use the data to verify weather models, which seek to map such fire weather conditions over the region. For example, Sydney Airport and Richmond Airport are both located within the Greater Sydney Fire Weather District. AS 3959-2009 (Standards Australia 2009) and the NSW *Planning for Bush Fire Protection 2006* document (NSWRFS 2006) allocate a predictive 1:50 year fire weather event of FFDI 100, based on method "a" as discussed in Section 5 above (i.e. value has been exceeded on at least 2 occasions).

The value for Sydney 1:50 year event is calculated using the GEV approach as 98 (near to the regional value of 100) whereas Richmond is 112, suggesting that Western Sydney should have a higher FFDI for determining design fire conditions. However, based on the given dataset, both weather stations had maximum FFDI values of 95.

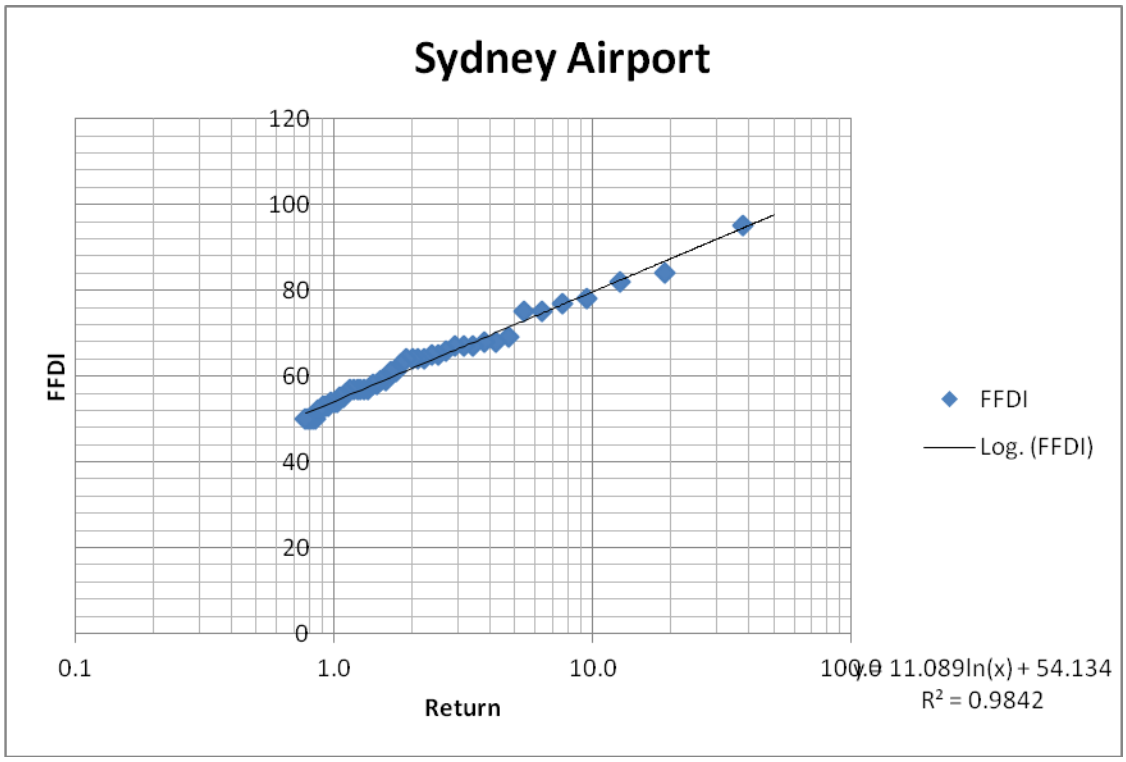

Figure 3: Return Period (recurrence/annual exceedance) for FFDI at Sydney Airport, NSW.

Summary	FFDI	Correlation	HR	Dwellings	Vulnerable
Station	**Max Recorded**	**R^2**	**1:1**	**1:50**	**1:100**
Williamtown	99	0.98	55	106	116
Wagga Wagga	138	0.98	69	122	131
Sydney	95	0.98	54	98	105
Richmond	96	0.97	60	112	121
Nowra	120	0.95	50	112	123
Coffs Hbr	95	0.97	24	96	108
Casino	101	0.94	66	120	129
Canberra	99	0.96	52	100	108
Dubbo	99	0.99	56	107	116
Moree	125	0.92	49	115	127

Table 4: Calculated maximum FFDI, correlation co-efficient(R^2) and return periods for safety criteria.

As can be seen from Figure 3 and Table 4, high correlations have been achieved in all cases for all weather stations. The correlation of all sites was found to be greater than R^2 of 0.92 and follow the curve $y=a \ln(x) + b$, where b is the intersect with the one year return period (or recurrence). This curve is consistent with the use of GEV distributions (Makkonen 2006, Reiss and Thomas 2007).

On the basis of the safety criteria used in Table 2 above, the calculated distances for enhanced defendable space is provided in the Table 5 below. Table 5 shows that distances for planning, construction and operational purposes can be determined using GEV for the determination of appropriate fire weather conditions. Table 5 is derived using Method B of AS3959-2009 for forest vegetation on flat ground (i.e. zero slope).

A limitation of the current study is that the identified data points are not likely to be the actual maximum FFDI's on the days identified and that some higher values may be missed. However, the strong correlation of the curve suggests that this is a good starting point for extreme fire weather conditions and can be used as a basis for planning, construction and operational purposes.

Development Class	Sydney		Richmond	
and return period	FFDI	Defendable space (m)	FFDI	Defendable space (m)
Infill home (1:50)	98	25	112	28
Subdivision (1:50)	98	35	112	38
Industry (1:20)	87	18	99	20
Vulnerable (1:100)	105	70	121	78
Hazard Reduction (1:1)	54	15	60	16

Table 5. Defendable space (m) and FFDI values for different classes of development (uses Method B of AS3959-2009 for forest vegetation and zero slope).

The use of GEV is normally applied in relation to specific weather parameters such as temperature, wind speeds, rainfall, hail events, etc. It can be difficult to use the GEV distribution for individual parameters for fire weather as the extreme conditions may not apply when conditions are otherwise suitable for bushfire events. For example, wind speeds at the extreme are not associated with bushfire weather, but rather for cyclonic or other high wind conditions.

Conclusion.

The current study has found that the use of GEV assessment techniques provides a more robust statistical assessment of fire weather as expressed through FFDI than current approaches used for land use planning, construction practice and operational preparedness.

Current approaches have been limited by shortage of reliable data, and while the current study does not use actual daily maximum (which may not be available for the period covered), the derived maximum FFDI provides an acceptable approach to establishing the design bushfire for the purposes proposed.

The development of an appropriate suite of safety criteria is also important in the prevention and preparedness of communities to future bushfire events. The identified land-use, construction and operational preparedness criteria recognize both the existing pattern of land use, and the capacity of strategic planning decisions to be incorporated in policy deliberations for new areas of development.

The application of GEV is a suitable method for determining return periods for FFDI, which are a function of one fire weather index system. It may be possible to apply this method to other indices such as those used in Canada and United States of America.

It is also clear that the technique is simple using a common Excel spreadsheet format, and does not require the determination of thresholds for use in establishing design bushfire conditions. Within the limitations of the datasets available, the use of a GEV assessment process

is a suitable approach for land-use planning, construction, and operational purposes when assessing new developments in bushfire prone areas.

Acknowledgements.
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I would also like to thank the Bureau of Meteorology, Sydney Regional Office, for making the various datasets available upon which this study is based.

The results of this paper represent only preliminary findings of a broader study currently being completed as part of a PhD into fire weather for NSW by the author. The results are due for completion in 2013.

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Students of fire

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Abstract: As the international wildland fire community looks to meet challenges faced by bush and wildland firefighters around the globe, a group of wildland firefighters, trainers, educators and fire researchers in Victoria Australia have taken up a challenge left by the late Paul Gleason, USFS Hotshot Superintendant and Wildland Firefighter (1946-2003), through an innovative approach to learning called "Students of Fire".

Paul who in 1991 coined the acronym LCES (Lookouts, Communications, Escape Routes and Safety Zones) now LACES (Lookouts, Awareness, Communications, Escape Routes, and Safety Zones) spent his working life promoting fireline safety and the need to study fire science, to better understand fire behavior. Paul exhorted anyone who would listen, the need for firefighters to become lifelong learners or Students of Fire.

The culture of blame prevalent in many workplaces inhibits our ability to share knowledge learnt on the job and stops us from becoming true learning organisations. It is hoped that by formalising Paul Gleason's vision for "Students of Fire," an opportunity to explore new ways of sharing learning through real-life case studies, story-telling, and lessons learned is fully realised.

Additional Keywords: Community of Practice, Lifelong Learning, Learning Organisations, Paul Gleason

Welcome and Introduction

Hello and welcome. My name is Rod Stebbing and I would like to thank IAWF for the opportunity to attend and present at this the 12th International Wildland Fire Safety Summit conference here in Sydney.

I have been a Volunteer Firefighter with the Country Fire Authority (CFA) in Victoria for 38 years, serving as Captain of the Monbulk Fire Brigade from 1992-2002. Monbulk is a Wildfire and Structure risk profile brigade that also specialises in Road Accident Rescue. I am currently Group Officer for the Dandenong Ranges Fire Brigades Group, which is a close knit team of 15 volunteer fire brigades working together to provide both fire prevention and fire suppression to our communities in the difficult wildland urban interface of the Dandenong Ranges in Melbourne Victoria's outer east.

My day job is vocational education and training, during which I lead emergency services training at a local multi-sectoral University and community college. As an Educator I am privileged to work with agency, industry and community firefighters alike, to provide competency based learning and assessment in both firefighting operations and community safety.

The topic I would like to present to you here today is titled "Students of Fire."

Students of Fire – The Background

"Students of Fire" is a personal project that I have been working on with two of my close friends and colleagues Roger Strickland and Alan Richardson. I say personal in the fact that the project we are developing does not belong to an agency or an organisation. This will be a key point I will elaborate on further in my presentation.

The title "Students of Fire" was coined by US Forest Service Hotshot Superintendent and wildland firefighter, the late Paul Gleason. Paul implored all who would listen, the need for "firefighters to begin to realize the importance of being a student of fire". Paul who in 1991 also developed the acronym LCES (now LACES), spent his working life promoting fireline safety and the need to study fire science, to better understand fire behavior.

Paul Gleason articulated the phrase "Students of Fire" again to Jim Cook and Angela Tom in an interview given by Paul for the website "Leaders We Would Like to Meet" as part of the US National Wildfire Coordinating Group (NWCG) Wildland Fire Leadership Development Program. The interview given by Paul in February 2003 was done the day before he passed away after a short battle with cancer. One of the key questions in that interview was "Do you think a legacy is important and if so, what do you want your legacy to be?" Paul's response was,

> If you choose to lead others you will have a legacy. But that legacy will be determined by those that follow you. I suppose I would want my legacy to be that firefighters begin to realize the importance of being a student of fire and that I was able to help make that happen.

On the "Leaders We Would Like to Meet" website Cook and Toms noted, *"*In the final tally, as always, Paul was a role model 'student of fire.' To the very end of his life he was engaged in teaching and learning about fire.*"*

Reading this a long way away here in Australia was a pivotal moment for me personally. I knew back then, at that time, that I would explore Paul's legacy further and look for ways to extend the vision for such an attribute as "Students of Fire" to exist here among Australian firefighters.

As a firefighter I had just learnt of a near miss incident in our local fire district where a colleague Captain Pete Smith and two of his crew members were burnt over in a fire tanker at a fast moving grass and scrub under extreme and difficult fire conditions, at the Nixon's Road Fire in 2009. The tanker was destroyed but miraculously no lives lost, without any detail at that time, I wondered how this could happen.

As a wildfire trainer I am very aware of the levels of knowledge and skills training available to firefighters in the areas of wildfire science, wildfire behavior and suppression and also fireline safety and survival.

As an educator I am profoundly aware of the strengths and the weaknesses of various learning methods or strategies used in course design and delivery. I am also aware of the many barriers to learning for individual firefighters and their co-workers. The pressure on individuals to perform for initial assessment, and then to go on to achieve subsequent endorsement for fireline roles, has the effect that some of their key learnings remain behind in the training room at the end of a course, or at least dissipate over a period of time.

Reading about Paul Gleason, hearing his words and pondering the near loss of fire colleagues all too close to home, I felt deeply moved to consider the effectiveness of our current wildfire training regimes and question how we go about delivering what is required of wildland firefighters for their own safety, as well as equipping them to effectively and efficiently prevent and suppress wildland fires or "bushfires" (my emphasis) as we are apt to call them here in Australia.

Wrestling with a number of thoughts and ideas, I went to visit my friend and very much a mentor, Roger Strickland. We talked for a long time about our current systems of learning, endorsement processes for fireline roles and the use of case studies, lessons learned and role models to better train firefighters for the future.

We talked for some days and weeks afterwards about the conversion of new-found knowledge and skills into changed behaviors and performance on the fireground, called the Transfer of Learning. It is this transfer of learning and the retention of knowledge and skills for firefighters that is, I believe, one of the most important challenges facing wildland firefighters and their agencies around the world.

I spoke to Roger about my thoughts on what I had read about Paul Gleason and his legacy, "Students of Fire." Bringing in our mutual close friend and work colleague Alan Richardson, Roger and I began to plan out a bit of a framework for how a "Students of Fire" cohort might look or operate. Together the three of us agreed to form a small steering committee to plan and develop a project around a Students of Fire community of practice in Victoria, with view to expanding it to a wider geographical audience in the future. With the idea of implementing such a project under the banner of IAWF the concept for a "Students of Fire" was born.

Students of Fire – The Project

Our first step was to meet with IAWF and float the idea, seeking their in-kind support as a global leader in the wildland fire community. The opportunity for this presented itself back in September 2011 when IAWF Executive Director Mikel Robinson and then President Chuck Bushey attended the Australasian Fire Authorities Council (AFAC) Conference here in Sydney. A short link up after the conference, prior to their departure back to the States, allowed a face-to-face opportunity to meet and discuss firsthand the "Students of Fire" concept with Roger, Alan and myself.

The project so far!

Strongly encouraged by Mikel and Chuck, who agreed to support the development of the initial concept and assist in introducing the idea formally to IAWF for consideration, our Victorian steering group proceeded to invite a group of wildland firefighters, trainers, educators and fire researchers in Victoria to come together as a focus group to help develop the idea of "Students of Fire" as a unique and innovative approach to firefighter learning. The steering group, which included internationally known researchers Drs. Jim McLennan and Mary Omodei, proceeded to conduct two initial focus groups of invited firefighters, researchers and local fire trainers at,

- Monbulk Victoria on 18 February 2012 and
- Warragul Victoria on 2 June 2012

The idea of the focus groups was to gauge the level of interest from local fire personnel from a range of fire domains, to set up and support a 'community of practice' under the banner of a "Students of Fire" project. Both forums were unanimous in their support for the concept and much discussion has ensued on how a "Students of Fire" project might look, how it would be administered and how it could operate into the future. The focus groups have validated draft versions of vision, mission, and values statements, which once endorsed will set the scene for how we proceed.

How will it work?

The idea is for an initial Victorian chapter of "Students of Fire" to invite like-minded colleagues, from multi agency and community groups, to join as full financial members of IAWF, to extend the learning framework we are building to a wider geographical audience.

As stated earlier in this presentation, a key principle was established that a "Students of Fire" community of practice would be open to the individual firefighter or community member only, and not be seen as agency or organisationally based. This is because the purpose of "Students of Fire" will be to use the collective knowledge and skills of its membership to build desired attributes and aid in the professional development of the individual at a personal level and not necessarily be linked to organisational profiles or agendas.

This does not mean to say that agency and organisational support for "Students of Fire" will not be appreciated; it will, and the only desire is to keep the vision, mission and values focused in the broadest possible base principles and avoid the trap of parochialism in dominating potential directions of the group as it expands to other states and also internationally.

Essentially an action learning initiative, "Students of Fire" forms a unique global community of practice; giving the wildland fire community means to share knowledge, experience and wisdom across agency, age group and experience levels, without discriminating. It is proposed that the learnings take the form of activities that contribute to a better understanding of wildland fire management in all its facets.

A contribution or activity may not necessarily provide an answer to a question or fire problem; it may just simply be the asking of the question itself. Learnings may take the form of personal observations and reflections, or those learnings based on experience. It could be a report on an activity undertaken by one or more Students of Fire and sharing what has been learnt.

Groupings of "Students of Fire" may also occur between those with similar or like-minded interests, or be from a particular geographical location. A key theme will be the transfer of knowledge from "Research to Practice," putting our technical knowledge gained from fire and human factors research into terms and methods that can be easily understood by firefighters and be translated back into their workplaces and out on to the fireline.

Do we need it?

Of course there is already an existing body of fire practitioners who contribute immensely to the global fire community, are currently members of IAWF, and network ideas and share information widely. So why do we need "Students of Fire?"

The answer is that we believe "Students of Fire" will be made of IAWF members who will make an additional or further commitment to inspire others to learn about fire through this unique learning communication strategy. By "others" I mean the inclusion of their colleagues or broader community members who may wish to become involved with them in a lifetime of learning about fire for a wide range of intended outcomes.

Whilst much of today's learning is based on acquisition of knowledge and skills, "Students of Fire" will be those individuals who develop attributes or attitudes and become role models in their collective work space with values such as:

- Respect
- Personal integrity and
- Personal communications

The future

The culture of blame prevalent in many workplaces inhibits our ability to share knowledge learnt on the job and stops us from becoming true learning organisations, but that is a subject for another day. By formalising Paul Gleason's vision for "Students of Fire," an opportunity to explore new ways of sharing learning through real-life case studies, story-telling and lessons learned is fully realised.

Successful project outcomes in the future would see:

- Increased IAWF membership in Australia
- Involvement of other countries and regions in Students of Fire and IAWF
- Strengthening of the current commitment of firefighters around the world to ensuring safety on the fireline, developing personal communication and leadership skills and becoming lifelong learners in the science of wildland fire prevention, behavior and suppression
- The legacy of the late Paul Gleason secured in his desire that "firefighters begin to realize the importance of being a student of fire and that (he) was able to help make that happen."

In closing

In closing I would like to publicly acknowledge the following people:
Project collaborators Roger Strickland and Alan Richardson
IAWF Executive Director Mikel Robinson and IAWF Past President Chuck Bushey; and my Wife and life time partner Robyn Stebbing, without who's support I would not have been able to participate in such a project as "Students of Fire."

If you would like to join us on the journey please feel free to make contact and share your thoughts. "Students of Fire" is an educational initiative with no commercial ties or alliances.

Thank you all for your time today.

When fire suppression training, positioning, and practice *all* fail: Advancing to a strategic doctrine for survival

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Abstract.
Safety in Wildfire Operations is made deadly by adhering to tools and tactics that are tradition bound. By anchoring ourselves to tradition, we prevent ourselves from advancing and adapting to the increasing dangers of a warming/drying planet.

Unless we advance our strategic doctrine, tactics, and tools with imaginative thinking, we will continue to lose even more people and homes to wildfire storms. What is worse is, that we will resign ourselves to negligent homicide by failing to encourage the interface dwellers, who live in the fuels, to be able to develop workable survival procedures.

A strategic doctrine must be reverted to foster an attitude of: MY LAND, MY HOME, MY RESPONSIBILITY! This is a military/homeland defense concept, that will allow interface dwellers to have a specific UNIVERSAL BLUEPRINT AND PROCEDURE to preside in ever more dangerous fire storms, and the threat of aerial wildfire attacks by terrorists. This is our future, and fire fighters will have to learn from this new fire management procedure to help the interface dwellers, when traditional methods of suppression fail. It is a survival option that must be reverted to, when all control is lost and individual Command has to revert to the individual land manager who has trained, positioned their battle space, and has a history of executing an ESCAPE FIRE inside a prepared cauldron.

Additional Keywords: hand tools, strategic doctrine, fire safety

Introduction.

The first issue to advance safety of our wild land fire fighters is to arm them with a decent hand tool system. The tools in the system need to be lightweight, easy to carry and stow, and compact in manner. The system must be safer to use overall. It must also be versatile to respond to all of the changing chores on any one fire. The tools must not be awkward or fixed. They have to break down and be folded, be able to be carried in vehicles, and be easily taken to the fire line with other protective gear. Above all, this system must be effective. It must be *universal*, or effective in all fuel types.

Secondly, from a training and procedure standpoint, this more effective tool system must be with the fire fighter at all times. Fire fighters must always carry their fire shelter, hard-hat, leather gloves, and canteens, when sent to a fire. In this manner they can always deploy their fire shelter, and be armed, and ready to protect themselves, and do the job.

However, the right tool system and the right training should not be a part of an expensive logistical system, where a fire cache attempts to marry up mobilized fire fighters with tools at a distant fire camp. This wastes money in the millions. The more traditional fire tools offered in the current GSA Wildfire Catalog (p. 9) are all obsolete, dangerous, and should be outlawed for not meeting any of the criteria needed to fight the modern day blazes.

Illustrating the problem.

Figure 1, below shows a picture of the present day tools our fire fighters are burdened with. Tradition is the excuse given to justify the use of these miserable, dangerous, and limited tools. They may be better than using a teaspoon to fight fires, but not much better. They waste manpower, money, time, and effectiveness. They tie up people and they just do not offer what is needed.

These traditional tools are outdated; all were developed at the turn of the century.

Fig. 1

We have incredible fine fire fighters, but the U.S. Forest Service Smokejumpers for example are only armed with traditional Pulaskis. When they parachute to a grass fire in Western Montana or Eastern Oregon they don't have what they need to effectively swat out the grass fires. Hence they get their jump, put in their time, earn lots of overtime and Hazard duty pay, but the fire is not caught. Since we have such fine fire fighters, we should arm them with effective tools. They return to base and jump another fire, only to lose that one also; and no one mentions that what they really needed was a better tool that would have been more effective for their needs.

Due to lack of knowledge or lack of options, fire fighters still use these GSA fire tools. The elite crews who mingle with the "fire dogs" like BLM Smokejumpers, and The Best Hot Shots, Rappellers, and Engine Crews are all switching to the new Dragonslayers Tools.

These tools should be regarded as *the* American Universal Wildfire Tool, not just for the elite

fire fighters. Several fire leaders have agreed with the idea of giving fire fighters their own set of these tools. The idea is that fire fighters take care of their own tools, and this type of *tool accountability*, or respect for the tools, would cut down on costs overall. Also, a tool cache system is way too expensive, when you are constantly moving and shipping perishable tools all over, trying to marry them up with fire fighters at incidents, where the crews have to be paid, staged, fed, and outfitted. It simply makes no sense. Plus there is no responsiveness, versatility, or flexibility with the traditional tools, which means the fire fighter is armed with single-function, awkward, and dangerous tools.

Illustrating the solution.

Figure 2, below, is a Troop Tool. It is an entrenching tool that has a push-button, blade-locking, position selector. The tool head snap-locks onto the red Universal handle, and is a long handled, angled shovel for digging and throwing dirt. It also is a better McCleod or line-scraping device. It is a stand-erect chinking and mixing device to take the drudgery out of mop-up operations.

This tool is the perfect temperate forest fire tool. It works well in the Western Conifer Forests and is also great in the Eastern Deciduous Forests because the high, 90 degree, blade set works great for simply dragging leaves down hill to form fire line, so much more effectively than a council tool or Eastern Fire Rake.

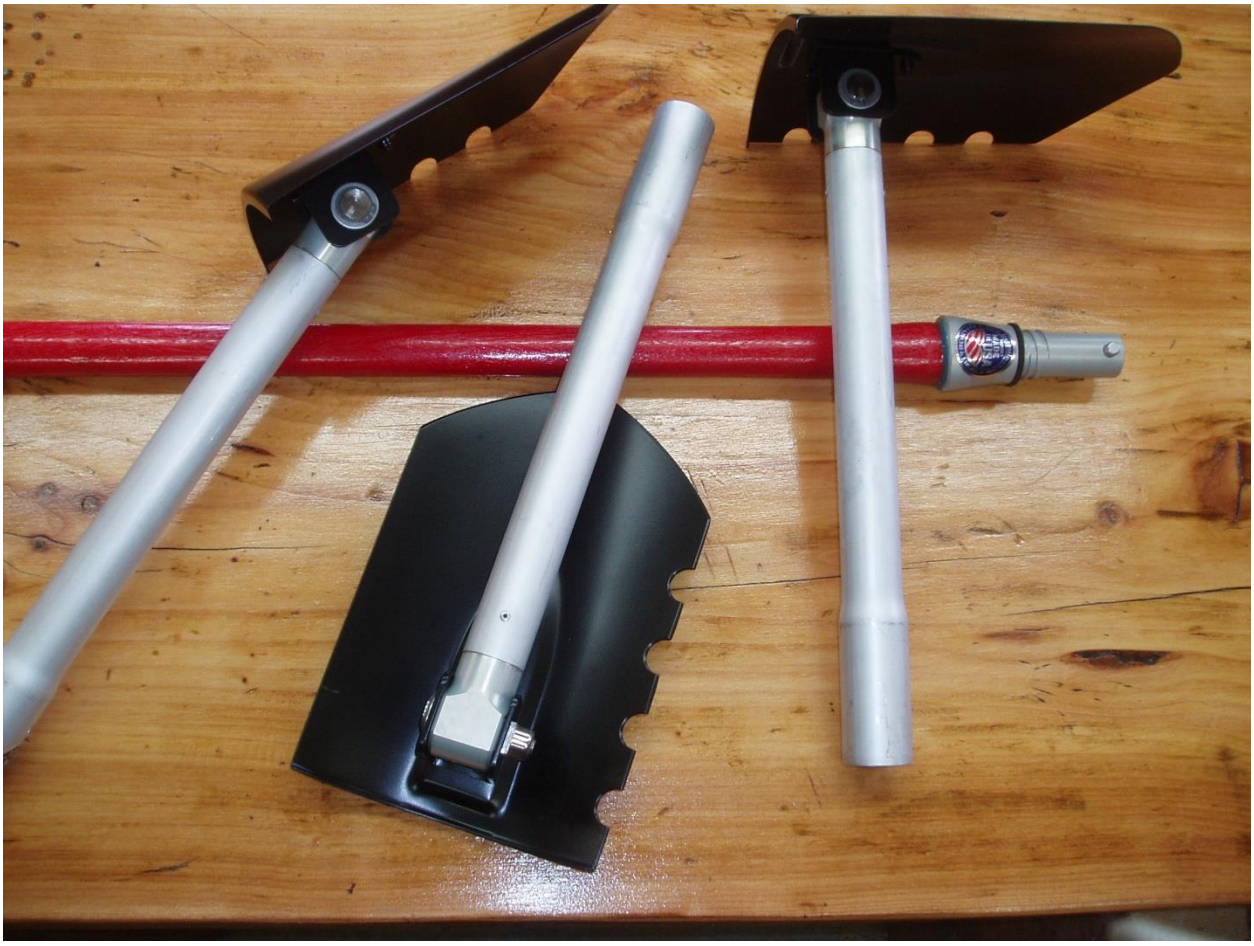

Fig. 2

This tool when used with the blade folded flat against its aluminum handle, makes a great safety

staff for actually helping the X-country traveler cross steep and bad ground by simply dragging the broad back of the blade behind the fire fighter while going down hill and simply leaning back on it to eliminate a fall. Falls to and from fires are the main accidents that plague fire fighters. The tool head is only three pounds and the handle just a bit over a pound. It stows easily in personal gear.

Figure 3, below, is the Dragon Swatter. It snap-locks onto the red, Universal Handle, and forms a long, 7 foot plus swatting tool for tough turf grasslands.

Fig. 3

It gets fire fighters standing upright/comfortable, so their faces are a long way from hot flame lengths. This helps with comfort, burn/heat safety, and dehydration. This swatter plows through brush, and molds in around rocks to kill the heat. It is flexible yet retains its footprint so it can reach under juniper or any other material to knock out flames. It does not need water, and is ergonomically designed. The rebounding action actually helps the fire fighter lift the tool. It maintains a two-foot wide footprint, and is simply the greatest answer to tough turf ground covers that cannot be easily scrapped down to mineral soil to form a hand line.

Figure 4, below, is a picture of the Universal Wildfire Kit. It contains three heads, and the Universal Handle accepts all three of the heads. The Magnum Pulaski is the Axe with the wide, six-inch, grub-hoe blade. This tool has a blade-guard that has two stainless screws in the elastic webbing. This allows the fire fighter to always be able to form an emergency handle from a sapling if the handle is ever lost, burned, or broken. (All fire fighters should carry one with a fire

shelter). In this way they are always armed, and legally able deploy their shelter.

Fig. 4

The Magnum Pulaski can have the blades replaced, as they wear out. We have crews out there now, that are on their 5th set of blades. The Magnum Pulaski has a balanced center of mass, right where the center of the handle goes. The handle, where the metal fits on to the wood itself is extremely strong. It is three times stronger than a regular Pulaski handle, and is three inches longer than a traditional Pulaski handle. Also, some 5,000 tool kits are currently being used in the field with elite crews and we have never had one of our Universal handles shear off at the place where the metal meets the wood. The handle is epoxied to the metal, and has a roll-pin to keep it from ever leaving the CNC fitting. The threaded fitting also has a spring-loaded pin that locks on the tool head. There is a rubber washer between the tool head, and the handle. It snugs up the connection, and also buffers shock from reaching the user.

Leadership Development Pathways for Incident Management Team roles

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Extended Abstract

On 4 June 2012 an Incident Leadership Framework was endorsed (in principle) by the Victorian State Fire and Flood Strategic Forum (Frye, 2012; Slijepcevic *et al,* 2012). The framework outlined a common approach for developing the skills of leadership roles within Incident Management Teams (IMT), and in this context leadership was defined as the ability to:

- ***Make decisions*** in time critical situations;
- ***Communicate*** effectively to appropriate stakeholders; and
- Lead, and ***motivate people to act***.

The Incident Leadership Framework promoted ***learning by doing***, and focused on development at four functional levels of emergency response, being: personal leadership, team leadership, incident leadership, and strategic leadership (shown in Fig. 1 below).

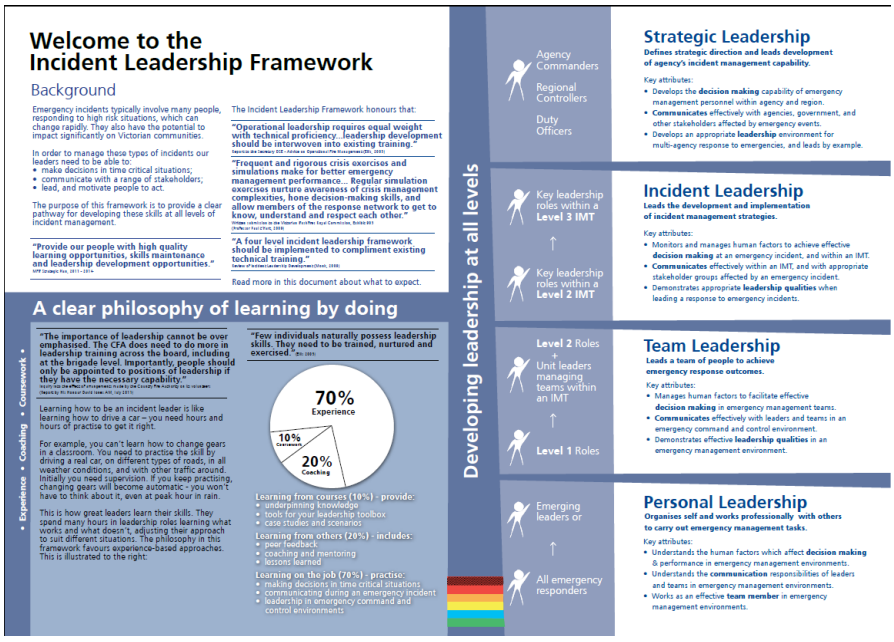

Fig. 1: Incident Leadership Framework (Version 1.0, endorsed 4 June 2012)

The leadership capabilities outlined in Fig. 1 are required for all emergency response roles, and Level 3 Incident Management Team roles are being addressed as a priority (Slijepcevic *et al,* 2012).

Mapping Development pathways for AIIMS Level 3 IMT roles

With this in mind, subject matter experts are currently mapping development pathways for the IMT roles of: Incident Controller, Planning Officer, Operations Officer, Logistics Officer, and Public Information Officer (Fig. 2, below).

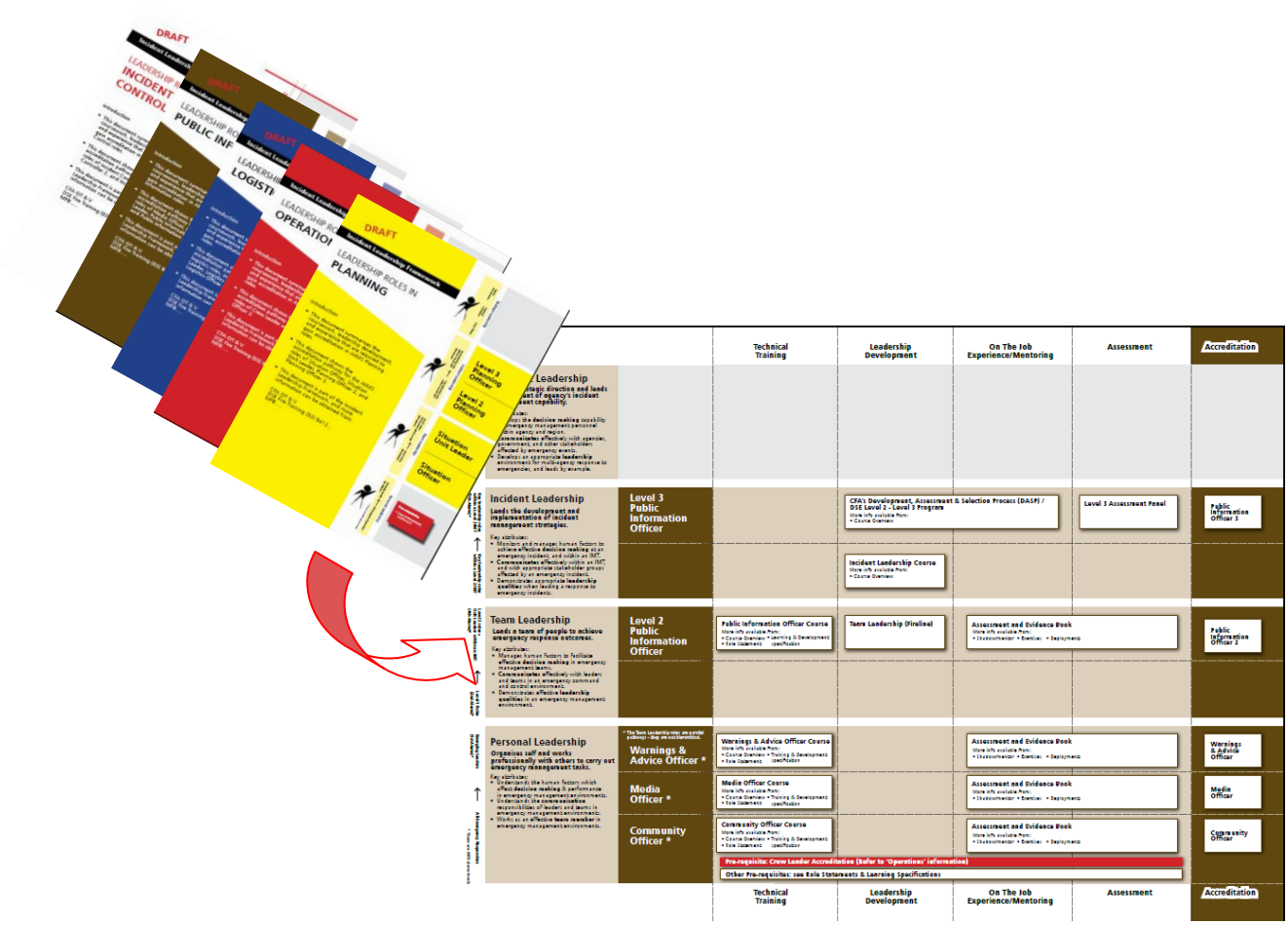

Fig. 2: Mapping development pathways for Level 3 IMT roles

The development pathways (Fig. 2) describe the technical training, leadership development, and experience that is required for each role, and there is an emphasis on applying and demonstrating skills on the job (i.e. learning by doing).

In this regard, the intent of the Incident Leadership Framework is to address the ***context*** in which skills are to be applied, using: After Action Reviews (AARs), case studies, scenarios and simulations, staff rides, exercises, coaching on deployments (including prescribed burning deployments), evidence books and mentoring arrangements. Subsequent phases of the project will also focus on resolving differences between the agencies regarding assessment and accreditation standards. For example, by

determining whether roles are endorsed or accredited, and whether those standards apply on completion of a course, or once competency on the job has been demonstrated instead. The agencies will also address whether leadership development and experience are compulsory for IMT roles, or remain optional for some roles in particular agencies. In doing so, agencies are seeking to balance their requirement to mitigate risks (by maintaining high training standards) with a requirement to roster appropriate numbers of people to IMT roles (from a limited number of available staff and volunteers).

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Wildland fire safety chapter in *Wilderness Medicine* updated

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Abstract. A chapter on wildland fires has been included in the book *Wilderness Medicine* since the inaugural edition was pulblished in 1983. The 40-page chapter "Wildland Fires: Dangers and Survival" included in the sixth edition of the book *Wilderness Medicine* published in 2012 includes the latest information on developments in the field of wildland fire safety based on research findings and real-world events. Several new photos serve to illustrate concepts presented in the text.

Wilderness Medicine, edited by Dr. Paul Auerbach of the Stanford University School of Medicine, is now available in both print (http://www.us.elsevierhealth.com/) and electronic (http://www.expertconsult.com) formats.

For additional information about the sixth edition of *Wilderness Medicine*, visit the following link: www.wildmd.com

This poster presentation is intended to provide an overview of the most recent edition of the chapter released earlier this year. For further information see Alexander (2012).

Additional Keywords: fire behavior, fire environment, wildland fire-related fatalities.

What are others saying about the *Wildland Fires: Dangers and Survival* book chapter?

"One of the best surveys on the subject of wildland fire safety that has been published in some time." Dave Thomas, USDA Forest Service (retired)

"A concise, but impressively comprehensive, account of both wildfire behavior and human behavior in the presence of wildfires." Dr. Mary M. Omodei, La Trobe University

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"Better Learn From This One": Creating a Culture of Lessons Learned in a Sceptical Workplace

Sandra Whight, Tasmania Parks and Wildlife

In land management and fire management agencies our people are operational, hands-on, mostly visual learners. So how do we manage our bushfires and emergencies? We generate reams and reams of paperwork, ideally to tell everyone what to do, then sit around in a meeting room at the end of the event to debrief what happened, and finally generate lots more paper. The traditional process of learning from incidents (even when they have gone well), doesn't seem to have been that effective. Too many debriefs just talk through what happened, not why, or how things might have been done differently. The same issues are rehashed, but do we ever really change the way we go about our business? Do we seriously challenge our operational strategies and tactics? Unless of course we are forced to change through the more brutal processes of inquiries, unfortunately too often driven by a political agenda, and demoralizing for the people involved. How many near misses do we have, and recognise "we were lucky", yet don't genuinely change our behaviour? The safety culture of high reliability organisations and lesson learned, as seen in the US particularly through staff rides, provides a good model to change how we learn and improve on our operations. However, it is important that we undertake this journey in a way that suits our culture and operational style. With the support of the Australian Bushfire Co-operative Research Centre, the Tasmanian Parks and Wildlife Service has been able make this transition. Tasmania Parks and Wildlife Service is a small organisation, less than 150 staff actively involved in fire management, looking after 2.4 million hectares of land with an annual budget of approximately 3 million dollars. Staff who had a naturally sceptical attitude to post-burn reviews, now actively seek to engage, and willingly participate in debriefs. We in management will be told which burns need to be learnt from and why. The whole workplace culture has changed, and you can do a great staff ride with eight participants and a budget of less than $400.

Tips and Techniques for Improving Learning from Events - Lessons from an Assessment of Learning from Escaped Prescribed Fire Reviews

Dave Thomas, Renoveling
Anne Black, Human Factors and Risk Management, Rocky Mountain Research Station, USDA Forest Service
Jennifer Ziegler, Notre Dame University
Jim Saveland, Human Factors and Risk Management, Rocky Mountain Research Station, USDA Forest Service

Ensuring we capture and learn from experience takes on heightened priority in a world with ever-expanding wildland urban interfaces, changing biophysical environments, shrinking budgets and a shrinking wildland fire management community.

In 2011, we held five two-day workshops at various locations around the US to explore organizational learning in the context of escaped prescribed fire reviews. The purpose of this Joint Fire Science Program-sponsored research project was to explore facilitators and impediments to learning in the context of escaped prescribed fire reviews. Each workshop drew an interagency audience with representation from all facets of fire management - from ground

personnel to local line officers to regional and national positions. Over the course of these 10 days of discussion, we developed a rich dataset and conceptual models to describe the existing and potential learning cycle in wildland fire.

Results of this pragmatic approach (based on the interaction of theory and practice) have implications for both organizational structure and culture. For example, we found widespread support for structured learning processes for all outcomes instead of restricting formal reflection to events when something goes wrong. However, improving learning has as much to do with how a review is conducted it does with the type or structure of review. The clarity and transparency of the leader's intent, the approach, tone and attitude of the review team, and the local atmosphere of trust all have significant impact on the learning environment. Organizational learning also depends upon effective transfer of lessons, which begins with understanding the target audience.

This presentation will highlight some of the practical, concrete suggestions that emerged for improving individual, group and organizational learning. These useful and thought-provoking local practices may be easily adopted by conference attendees.

Capturing and Using the Deep Smarts of Our Fire Management Elders
David Thomas, Renoveling, Ogden, Utah
Carol Miller, Aldo Leopold Wilderness Research Institute

What can fire managers, oftentimes retired, who are recognized for their on-the-job expertise gained from working over long career spans continue to teach us? How can we best learn from the experiences of our elders who were once noted for their uncanny problem solving abilities while working in our fire management organizations? And, what are some of the more successful ways to transfer these rich reservoirs of expertise to younger fire mangers still working?

We will discuss these three questions while showing the results from our analysis of 71 transcripts created from videotaped interviews with highly experienced American and Canadian wildland fire managers, fire behavior analysts and prescribed fire specialists. Each person interviewed was recognized among her peers as being very good at the fire management job they were hired to do. We will also show some of the experimental routines we developed to acquire fire manager's expertise through videotape interviews and describe the many lessons learned as our work.

This work was framed through two domains-the concept of deep smarts as modeled by Leonard and Swap (2005) and the model of high reliability organizing as described by Weick and Sutcliffe (2007).

Each transcript was studied for characteristics of deep smarts ("the ability to comprehend complex, interactive relationships and make swift expert decision") and to see if these experts possessed one or more of the five properties of high reliability organizing mindfulness.

Our analysis clearly showed that many wildland fire managers did operate effectively utilizing an HRO-mindfulness framework and that they possessed deep smarts traits. We construct a preliminary outline of what a widely accepted model of HRO-mindfulness looks like for wildland fire managers as it moves more completely from "theory to action." The results can be used to coach individuals working in high risk occupations in deep smarts and HRO-mindfulness, thus helping them to operate more safely and effectively.

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Prevention of Psychological Injury Following Critical Events: A Literature Review

Meaghan O'Donnell: BAppSc(N), BSc(Hons), MPsy(Clin), PhD, Australian Centre for Posttraumatic Mental Health (ACPMH) and University of Melbourne
Nicole Middleton, Department of Sustainability & Environment

The psychological wellbeing of bushfire firefighting and emergency operation personnel is of paramount importance. The Australian Centre for Posttraumatic Mental Health was commissioned by Department of Sustainability and Environment (DSE) to conduct a literature review that aimed to provide an understanding of best practice early intervention programs to prevent psychological injury following exposure to traumatic events. In this presentation the key findings from this literature review will be presented. The implications of these findings for DSE and its partner agencies will be examined, along with the exploration of the learning's from the review.

A New Approach to Bushfire Safety: Learning From Case Studies: Applying Human Factors Principles to Investigations of Serious Incidents

Samantha Sunderland, Country Fire Authority

Risk perception, situation awareness and decision making all require the application of precise cognitive functioning to achieve the most suitable results in incident management. The discipline of human factors supports this supposition and utilising this discipline in the serious incident investigation process further supports the development of a 'just culture'. Developing case studies from investigation reports helped drive future change and understanding not generating blame.

Our experience shows that through story telling participants are drawn into the process and able to relate their own real life experiences at various levels. Often participants will realise that it could have been them telling their story. Previously scant emphasis in the investigation process was placed upon the broader systemic human factors aspects of fireline leadership and decision making. It was identified that whilst crews were interviewed directly after an incident there were rarely interviews conducted with others responsible for managing them. Given this knowledge a case study was developed based on a specific scenario that had occurred. Initially the crew were defensive because they had felt blamed and misunderstood during previous investigations. This

required the resourcefulness and skills of facilitators skilled in human factors to educate participants in a no blame environment in order to gain buy-in. Over time, the human factors approach used by the case study facilitators to build a psychologically safe, no-blame environment, enabled the crew members to gain valuable insight into their perceptions, decisions, and actions. Those involved have since shared their story with various other groups and assisted in the preparation of the written case study. This process has helped both the crew and their audience examine their decision making processes whilst maximising opportunities for the transfer of key skills, knowledge, and a 'safety culture' rooted in genuine 'lessons learned'. Finally the process discussed is supportive of the development of a just culture that encourages people to talk about their experiences so others can benefit.

Coping Ugly in the Coordination of Large Scale Wildfire Events
Ben Brooks, Senior Research Fellow, National Centre for Ports and Shipping, Australian Maritime College b.brooks@amc.edu.au

The Coordination of large scale wildfire events is often performed with a ‘degraded’ system. Resources might not be available, crew might be fatigued, and information about the fire itself may be imperfect. Given that operation of the ‘degraded’ system might be considered normal, a natural conclusion would be to design coordination approaches that accommodate this, rather than design ‘perfect systems’. This paper uses the language of coping to explore this issue and to suggest that the use coping repertoires when combined with Rasmussen’s ‘safety space’ leads to a dynamic and flexible approach to this most difficult of tasks.

On the Front Lines of Climate Change: Extending our Narratives of Fire Strategy and Fireline Safety in the Climate-change Era
Ron Steffens, Professor, Green Mountain College

The safety of firefighters and communities is the ultimate measure of a successful wildland fire management strategy. Today, as wildland firefighters work the front lines of climate change, we must ask: If our fire regimes are changing, shouldn't we re-examine and adapt our strategies? And as we adapt strategies to these new conditions, we must also ask, Are these amended strategies meeting the state of acceptable, shared and mitigated risk that defines safety standards. As we examine safety practices amid the societal debate of carbon-management and climate change, I sense the opportunity to engage communities with the metaphor of the fireline as the front line of climate change. Our very real and risky fireline work may serve, rhetorically, as a narrative frame, blending physical work and technological magic that in turn form a kind of media, per Marshall McLuhan's definition, in which technologies extend our messages -- a car, for instance, speaks of mobility and freedom; likewise, a firefighter on the fireline carries a message of concern for people and landscapes that is extended by our acceptance of risk and the "testing" of our claims by the flames we manage. Traveling to Malawi, France, Spain, and Australia (scheduled), along with work in the United States, I've observed climate-impacted fire regimes and firefighters responding to the changing nature of fire risk. Examples vary by geography, economy, and culture. In Malawi, firefighters burn early to avoid devastating late-season fires while defusing the nation's frame as a nation of "flames." In Spain, the challenge is

to teach firefighters and communities to accept fire as a tool. In both the United States and Australia, debates over fuel management delay the work as fuels (and risks) accumulate. Many firefighters speak of their crusade -- for fire safety, having lost colleagues and community members, and for fire-based land management, to fight for habitat, wildlife, community resources, and valuable carbon stocks. These "crusades" demonstrate the unique rhetorical standing that firefighters possess -- to effectively communicate a common value ... for more strategic and safe fire management policies, a positive and essential step amid our climate challenges.

Coach as Servant
Jim Saveland, USDA Forest Service

In the 1970's, after retiring from a career with AT&T, Robert K. Greenleaf founded the Center for Applied Ethics (now the Greenleaf Center for Servant-Leadership) and wrote several essays that have become classics of the leadership literature, such as The Servant as Leader, The Institution as Servant, Teacher as Servant, and The Leadership Crisis. The concept of servant-leadership is at the heart of learning organizations and a central theme of "mission command" used in military organizations around the world. Today there is increasing recognition of the vital role that coaches can play in developing individual and organizational excellence. The development of coaches requires a complex, embodied skill set that is cultivated through a lengthy and rigorous training program. With increased popularity and ever-present budget pressures, comes the danger of watered-down training programs that simply convey a superficial overview of basic coaching principles. This paper will review the literature on servant-leadership and coaching, the synergism between the two, and suggest a set of practices for wildland fire managers to embody the principles of servant-leadership in coaching relationships. Coaching is essential as one generation of wildland fire managers "hands over the torch" to the next generation, maximizing opportunities for the transfer of key skills, knowledge, and a safety culture rooted in organizational learning. A high leverage entry point into the principles and practices of a new approach to wildland fire health, safety, and performance is integrative health and fitness coaching.

Bulldogs and Boundary Spanners: Contested Visions of Leadership, Communication and Teamwork in Emergency Incident Management
Christine Owen, Bushfire Co-operative Research Centre, University of Tasmania

Leadership, communication and teamwork, in an Australian emergency management context, has come under intense scrutiny in the Royal Commission about the 2009 Victorian Bushfires that have become known as “Black Saturday”. Part of the problem is, in part, an ideal notion that there must be an “all knowing” controller at the top of an organisational apex who is orchestrating all activity. Yet for decades it has also been reported that such an ideal is wanting. First, hierarchical models of emergency management led from the top have also been reported as only working when emergency are simple and routine. When situations escalate and become more become dynamic, flexible forms of organising where there is greater autonomy and the capacity to improvise have been reported as more effective. Yet it is at times like these that the

importance of communication and teamwork come into play to support a shared awareness of the unfolding event and in order to support a safety culture.
Yet what constitutes "good" leadership, communication or teamwork is often embedded in collectively held values and beliefs that are part of a group's shared history and culture. This shared history and observed emergency incident culture is at times doubled-edged in its support for enabling safety. On the one hand a "can-do" culture is a strength when immediate action is needed. On the other hand, such aspects of culture can at times lead to mindless, rather than mindful practice and individualist rather than team orientations.
This presentation will outline some of the findings from research investigating incident management teams in Australia and New Zealand. Research over the past six years has included interviews with 130 personnel experienced in emergency incident management; observations of real-time fire events and 18 incident management team training simulations of incident management in four states of Australia. The findings suggest a need for new approaches to how we understand the impacts of culture as well as how we enable individual and team learning to promote safety.

Efficiency AND Thoroughness
David Christenson, US Wildland Fire LLC

Recent research indicates coaching of Incident Management Teams during events is a preferred method for learning complex concepts in real-world dynamic contexts. Appreciating what people are doing that is already working well for them provides a strong foundation to build upon. The integration of mutually beneficial understandings in High Reliability Organizing, Resilience Engineering, Operational Risk Management, Human Factors and Systems Safety during events can be effective. These concepts are all forward-looking, being proactive and dynamically creating safety at even deeper levels. Yes, they also build capacity for resilience when the unexpected happens, but their special value is in avoiding disaster before it happens at all. The thoroughness required to provide safety can also create surprising efficiencies resulting in lower-cost outcomes. A case study of three Incident Management Team's management on the 2012 Whitewater-Baldy Complex in the Gila National Forest balancing efficiency and thoroughness will provide an example of results that achieve the Right Plan, in the Right Place, at the Right Time, with the Right Assets for the Right Duration.

The Protection of People and the Assets they Value Most During Severe Bushfires has Significant Spinoffs for Fire-fighter Safety
Damien Killalea, Tasmania Fire Service's Director, Community Fire Safety

Bushfires burning in Australia under extreme conditions have caused widespread and often long-lasting negative impacts on people and communities, significantly hampering their capacity to recover.
Such bushfires have also presented major challenges for fire-fighters. While the focus is usually on containing a bushfire, under extreme conditions this becomes all but impossible and often dangerous. During the 2009 Victorian bushfires for example, fire-fighting crews were involved in twenty-three non-fatal burnovers.

Two new and related concepts have emerged for fire agencies from the tragic 2009 fires: the increased focus on civilian safety, and the protection of those assets that will enable communities to recover more quickly after the event.
Supporting these two concepts is firstly, the endorsement by Australian fire and land management agencies of a suite of priorities to be pursued by fire-fighters when bushfires are burning out of control. Secondly is the development of township (or community) protection plans, which in different guises provide a broader suite of safe options for civilians than the old 'stay or go' approach, and identify specific fire protection priorities for fire-fighters during extreme events.
These approaches build fire agencies' capacity to protect what's important, build community capacity to recover from bushfires, and hence build community resilience. Such concepts are consistent with the National Strategy for Disaster Resilience.
Adoption of these new approaches provides significant benefits for fire-fighters too: less exposure to the most intense part of bushfires, and the ability to focus on what's critical when communications break down and decisions independent of incident management teams need to be made.
This presentation will explore how these concepts are being applied to reduce death and injury in fires, make fire-fighters safer, and enable communities to recover quicker post-fire.

Safety Lessons from the Alaskan Bush
Rocky Ansell

Utilization of Resources to Enhance Physical Fitness: Are you FireFit?
Katie Sell, Hofstra University
Debbie Pickersgill, Exercise Physiologist, Aspire Fitness and Rehabilitation
Bequi Livingston, Regional Fire Operations Health and Safety Specialist, Albuquerque, NM

Although most people rarely engage in arduous physical activity as part of their daily jobs, wildland firefighters know that physical fitness plays an important role in personal wellness and job performance. Physical fitness is one of the most important components of a balanced wellness program. However, fitness training approaches and programs found in many readily accessible mediums such as the internet and other electronic media (e.g., fitness apps) may not take into consideration the training needs and logistical challenges faced by wildland firefighters (especially pre- and in-season). FireFit is an interagency wildland firefighter fitness program available online (http://www.nifc.gov/FireFit/index.htm) that was created with the intent to provide the interagency wildland fire community with a comprehensive, easy-to-follow, fitness program with the ultimate goal of improving firefighter safety and health and reducing injuries. This unique program provides a basic format for a fitness program that incorporates three specific modules that address pre-season, fire-season, and post-season fitness. Each module is unique as it provides a basic fitness program 'framework', specific for each season that will enable the wildland firefighter to develop a balanced and consistent fitness program while incorporating all the essential components of fitness. The modules can easily augment existing fitness programs to encourage consistency and safety and encourages year-round fitness, injury mitigation, and promotes wellness. The FireFit program also incorporates suggestions for stress reduction, team building, and overall wellness. The FireFit task group includes representation

from the major Federal wildland fire agencies combined with each primary wildland firefighting resource (hotshots, smokejumpers, helitack, engine and leadership disciplines), as well as subject matter experts and representatives from the Missoula Technology and Development Center in Montana. This presentation will discuss the FireFit program and guidelines on how to implement this program, as well as considerations for critically evaluating the applicability of other online or publically available media-based physical fitness resources.

Measurement of Rural Firefighters at Fires
Richard Parker, Scion

Many tasks in rural fire-fighting are physically demanding and extremely hazardous. Fire-fighters are exposed to weather extremes, high physiological workloads and work for extended periods, often handling heavy tools in potentially dangerous conditions, all of which can seriously reduce performance and increase risk. This research utilises multiple streams of data (video, heart rate, GPS and other environmental sensors) to describe the physiological cost, tasks undertaken and the environment of fire-fighters attending real rural fires. The data collection ensemble enables researchers to compile resources that describe firefighter behaviour and responses in the stressful, risky conditions of rural fire operations. This data can then be used by rural fire agencies in training, task redesign and equipment revision. The data will also be incorporated into production guidelines. Data collection from fire-fighters working at real fires has been successfully trialled and further refinements are being developed. Qualitative individual auto-confrontation interview techniques, where the participant verbalises about the (video and audio) recording of their own activity, have also been trialled to better understand the processes underlying the execution of a work task.

Physical Selection Test Considerations; The Choice of New or Old
Cara Lord, Deakin University
Brad Aisbett, Deakin University
Rod Snow, Deakin University

The rebranding of volunteers as "workers" in the new Workplace Health & Safety Act (2011) has required a larger proportion of organisations to evaluate the duty of care to ensure all of their workers can work safely and competently. In instances such as this, agencies often seek out means to support methods of complying with such legislation, such as the use of Physical Selection Tests (PST). In occupations such as Australian tanker-based wildland bushfire suppression, there is no pre-existing tailored PST. Agencies must therefore investigate the options of adopting an existing PST (that was not designed for their workforce) or choosing to create a new tailor-made PST. The literature available to support the decisions and considerations of the choice between implementing a pre-existing test into an occupation versus designing a job-specific PST will be discussed in this presentation. These considerations include legalities, scientific evidence, agency capabilities and practicalities as well as the determination of appropriate cut-off scores for acceptable performance in the PST for their workers.

Validating Ideal Qualities of U.S. Wildland Fire Leaders
Alexis Lewis, Oregon State University

Dr. Vicki Ebbeck, Oregon State University

In prior research Lewis (2008) interviewed U.S. wildland fire personnel (N = 36) who had been in intense experiences, such as close calls, burnovers, and entrapments, where several had lost colleagues and friends. The conversations often highlighted the central role of leadership; consequently, the following question was posed to participants "what makes a really, good, safe, leader in fire?" The answers revealed nine main qualities and characteristics that were repeatedly mentioned and became the basis of a unique leadership model posited for the U.S. wildland firefighting setting. The nine qualities included decisive, critical thinker, open to input, self-aware, safety oriented, trustworthy, competent, broad experience, and compassionate as well as caring. Due to the qualitative nature of the original research and a desire to further explore and validate the proposed nine qualities with more fire personnel, 47 statements (e.g., "Is aware of his/her boundaris or limitations") were developed to capture the nine qualities on a 5-point Likert scale. The statements were viewed by a panel of experts for face validity and comprised an online survey that was administered nationally to 200 current and former wildland firefighters. Respondents were asked to rate the 47 statements in terms of how important these qualities were for an an ideal leader in wildland fire to possess. In addition, respondents were given the opportunity with open-ended items to add qualities they felt had been omitted but were important to include in a measure of effective leadership. Results address the relative importance of the nine proposed leadership qualities and identify the additional qualities respondents suggested. Furthermore, a brief synopsis of psychometric properties of the measure are reported in terms of factorial validity and internal consistency of the various subscales. Focus will be directed towards practical implications in terms of what fire personnel value in their fire leaders as well as potential next steps of using this measure of ideal leadership qualities to enhance the workplace environment and influence leadership training.

Additional Poster Abstracts

Sharing the Wildland Fire Defence of Buildings with the Architecture Profession

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As wildland fire safety specialists approaching retirement seek to pass on their considerable knowledge to their community, the issue of shared responsibility with those not directly engaged within the fire industry requires consideration. Defending domestic properties against wildfire has moved from being purely the responsibility of local fire authorities to one of government policy expressed in the form of increased fire protection requirements for new building approvals. A logical extension of this is for the architectural profession to become engaged and ultimately design buildings that are not only pleasant places to live in but can also defend themselves against wildfire attack. Architects, in theory, design domestic buildings with an anticipated life expectancy of fifty years, during which time they are expected to meet the requirements of their occupants. But how will the world be in five decades and what unique needs will residents have of their homes particularly in areas affected not only by wildfires but a combination of natural hazards?

Some issues for consideration include:

- Anticipated sea level rises producing a heightened demand on land use, resulting in more housing being constructed on sloping land in wildfire prone areas.
- The insurance industry no longer insuring such sites so building designs may have to offer a greater variety of design options that reflect a range of financial budgets.
- Designing homes to function during the energy transition from a petrol based grid system to as yet unrealised onsite energy sources.
- Designing architecture that incorporates strategies which minimise damage from a range of natural hazards.

Shelter, sanctuary, refuge, defence, all aspects of a building within a wildfire prone area need to be considered using the design knowledge of the architecture profession.

The purpose of this paper is to identify from an architectural perspective some of these design requirements and some problems they may encounter over the next fifty years as the world undergoes political, economic, climatic and energy transition. If wildland fire safety specialists can enlist the architecture profession we may, in the future, create housing that can survive wildfires and retain established communities which would otherwise be decimated.

Physical Conditioning for Wildland Firefighters: From Weight Room to Functional Practice

Katie Sell, Hofstra University, Katie.Sell@hofstra.edu
Debbie Pickersgill, Aspire Fitness and Rehabilitation, debbie@f-ss.com.au

The physicality of wildland firefighting, environmental stresses, and unpredictability of job assignment, demands an above average level of fitness and may predispose wildland firefighters to acute or chronic injury, especially those with inadequate levels of physical fitness, muscle

weakness or imbalance, and lack of mobility or stability. Furthermore, inappropriate or unsafe physical training practices may lead to joint, muscle, and other soft tissue injuries, which could be avoided through correct and safe exercise selection and program implementation. Numerous and often population-unique physiological, biomechanical, psychological and logistical factors influence physical training practices and opportunities across difference wildland firefighting disciplines (e.g., hotshots, smokejumpers, helitack, engines and leadership crews). Consequently, safe physical training practices and appropriate, functional exercise selection is imperative for optimizing the potential benefits of in-season and off-season conditioning on performance and injury risk.

This presentation will provide suggestions on using occupational task movement patterns and load carriage to guide assessment and exercise choices that can be safely implemented in a strength and conditioning program to enhance fitness and rate of recovery, and reduce injury risk. These exercise suggestions will focus on appropriate exercise and program progressions, integration of neuromuscular conditioning, and optimization of health-related, injury risk reduction, and physical training in a time-efficient manner. Safety considerations and sample pre-season and in-season programs will be discussed, along with implications for individual firefighters as well as those serving as trainers for a department or crew. Position statements and pre-requisite guidelines for intermediate and advanced strength and conditioning practices such as the implementation of extreme conditioning programs or training for events such as the World Firefighter Games, will also be discussed.

Quad Bikes at Fires – A Safety Dilemma?
Eddie Staier, Tasmania Parks and Wildlife Service, Eddie.Staier@parks.tas.gov.au

Since quad bikes became widely used as a recreation and work tool in the mid 1990's they have been used at bushfires and planned burns, as vehicles to access marginal terrain, to assist with either ignition or suppression of fires. Over the last decade access to quad bikes by the community has become easier. This has led to an increase in accidents and fatalities. Most of these have occurred in either recreational or agricultural uses. The Parks and Wildlife Service in Tasmania have reviewed the latest safety research, and accident statistics. It has concluded that the use of high risk vehicles (quad bikes) in the high risk business of fire management is a hazard that it is not prepared to accept. Fire management staff are currently looking at substitutions for quad bikes. This poster presentation will review a brief history of quad bike usage in fire management, discuss why quad bikes are used for fire management, discuss some of the safety issues and statistics associated with quad bikes and look at other vehicle options for fire management "is the quad bike the most suitable piece of equipment for the job?".

Introducing Burnover Protection for Passeneger Vehicles
Rob Walker, Manager Rural Operational Support, AFAC, robert.walker@dcs.qld.gov.au

Introducing Burnover Protection for Passenger Vehicles - Rob Walker - Abstract. Rural fire services throughout Australia have recognised the health and safety implications of installing thermal cabin protection in fire appliances and the enhanced level of occupant survivability provided to crews trapped in 'burnover' situations. 'Burnover' cabin protection focuses on

excluding radiant heat energy from entering the appliance cabin by using internal reflective fire curtains to stop radiant heat penetrating through the glassed sections of the cabin. Research confirms that roof mounted external water sprays are also crucial in providing window protection and maintaining cabin tenability during exposure to high bushfire temperatures. During Australia's "Black Saturday" bushfires in 2009, the survival of three Country Fire Authority (CFA) fire-fighters trapped in a 'burnover' was directly attributed to the protection provided by the fire curtains and water spray system fitted to their fire appliance. Unfortunately the civilian population represents the majority of bushfire related deaths in Australia with research confirming that many of these fatalities were vehicle related, including 16 deaths occurring in or near motor vehicles in the "Black Saturday" bushfires. Despite the recognised benefits of thermal cabin protection fitted to fire appliances, the development of passenger vehicle cabin protection has attracted little interest, possible due to the logistical and technical issues associated with insufficient internal cabin space and the lack of water for cooling sprays. However an innovative approach to passenger vehicle cabin protection has resulted in the development of an external fire cover which encapsulates the cabin with a heat reflective, fire resistant fabric to form an effective safety barrier between the occupants and the bushfire's radiant heat. This external cover can be rapidly deployed, either partially or fully over the vehicle, in anticipation of an approaching fire front and the vehicle can be pre-positioned to provide maximum shelter from combustible fuel loads as well as ensuring easy access to the vehicle when required. This technology has the global potential to improve survivability for both civilian and fire crews in bushfire emergencies and prove existing cabin protection systems obsolete.

Assessing and ranking the flammability of ornamental species in WUI (SE France)

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Fire risk is high in Wildland-Urban Interfaces (WUI) and WUI fires, burning the surrounding ornamental vegetation, are often transmitted to structures. Thus, to be able to use fire-wise species in such locations, the assessment and ranking of the flammability of ornamental plant species are required.

The flammability of seven species, among those most frequently planted in hedges in SE France, was studied, under laboratory conditions, at two levels: live leaf and litter. Leaf characteristics (FMC, mass, surface, volume, S/V ratio) were measured and the flammability parameters (ignition frequency, time-to-ignition, flaming duration) were recorded using an epiradiator as burning device. The Gross Heat of Combustion (GHC) was measured by calorimetry. The flammability parameters (ignition frequency, time-to-ignition, flaming duration and initial flame propagation) as well as the bulk density of the undisturbed litter samples were recorded during burning experiments performed on a fire bench.

Regarding live leaves, burning experiments showed that Phyllostachys sp. and Photinia fraseri had higher ignitability (along with Pyracantha coccinea) and sustainability and were characterized by low FMC whereas Pittosporum tobira and Nerium oleander had lower ignitability and were characterized by high GHC. Prunus laurocerasus and Cupressus sempervirens had lower sustainability and were characterized by low S/V ratio.

Regarding litters, Cupressus sempervirens and Pyracantha coccinea (high proportions of scale-leaves and/or fine particles and high bulk density) presented higher sustainability, ignitability (high ignition frequency), along with Photinia fraseri, and lowest combustibility (low flame propagation) along with Pittosporum tobira. The latter, characterized by high proportions of debris, coarse particles and evergreen leaves, was the least ignitable (high time-to-ignition) along with litters of Pyracantha coccinea and Nerium oleander, and had lower sustainability along with those of Phyllostachys sp. and Nerium. Litters of Prunus laurocerasus, Photinia fraseri and Phyllostachys had better combustibility (high proportions of debris) and the latter was also quick to ignite.

Hierarchical cluster analysis performed on the flammability parameters recorded during both types of experiments ranked the seven species in four distinct clusters from the most flammable (Phyllostachys sp. and Photinia fraseri) to the least flammable (Pittosporum tobira and Nerium oleander); the other species displaying two groups of intermediate flammabilities (Prunus laurocerasus-Pyracantha coccinea and Cupressus sempervirens).

Further flammability experiments on the whole plant are needed and the highly flammable species should not be used in hedges planted in WUIs in SE France.