ADVANCING WILDFIRE RISK MANAGEMENT PRACTICES FOR THE HIGH COUNTRY

SLIDE 1... TITLE

So far in this series of talks:

- I have highlighted some significant issues with the way that we assess and understand bushfire risk,
- then Jason has gone into detail on wind-terrain interactions and on foehn winds, and
- now I would like to show you how we can bring everything back together again in a manner that leaves us better able to mitigate bushfire risk.

MORE KEY ISSUES

In my first talk I listed six key issues that arose from our work. I would now like to add three more to that list:

SLIDE 2... ISSUE 7

7) A solid understanding of the risks from wildfire in and around the high country must take into account the factors recognised by our studies.

SLIDE 3... ISSUE 8

8) During wildfires, it is important that observers are able to correctly identify the features of these phenomena, to allow rapid and appropriate responses.

SLIDE 4... ISSUE 9

9) Better decision-support tools can be developed to support bushfire operations.

It is perhaps best to address these by considering how we do our business. We can do this with:

- fire suppression,
- fire behaviour prediction and
- risk assessment.

FIRE SUPPRESSION

In fire suppression the area that I will address is the work of the Situation Unit in the Planning Section of the Incident Management Team. This work covers:

- weather monitoring,
- issuing watchouts or red flag warnings and
- improving weather and terrain intelligence.

-----WEATHER MONITORING

SLIDE 5... BRINDABELLA HRB PSYCHROMETER

A key result from our work concerns the monitoring of weather on the fireground. We have all been guilty of the **sin** of taking a "one size fits all" approach to this. We may set up one or two automatic weather stations on a nearby hill or we ask a number of sector leaders to pull out their Kestrels every hour or so. The worst approach is to take the data from a regional BoM AWS and use our experience to **extrapolate** it to the fireground.

Take just one of our research findings – wind flow across rugged terrain, as Jason discussed. Depending on circumstances we may, or may not, have lee-slope eddies dominating the area, with channelled flows in the lower slopes. The research gives guidance, but the need is clear for a structured approach to field observations, addressing the known uncertainties. With tasked field observers, and air observers keeping a weather eye out as well, we can work safely in complex terrain.

SLIDE 6... 2 BURNS 2 WINDS

The big issue here is predictability. We are quite accustomed to taking BoM observations and extrapolating them to the fireground. We know that, assuming a simple atmosphere, the dry adiabatic lapse rate requires a one degree drop in temperature for every additional 100 metres of altitude. Less people know that, assuming a constant dew point, the relative humidity roughly doubles for every additional 1200 metres altitude.

We know that fire danger is a function of, among other things, the difference between the values of temperature and relative humidity. Assuming constant winds, a rise in altitude will clearly cause FDI to fall quickly.

But the atmosphere is not that simple. If there is a subsidence inversion, the dew point may fall rapidly above, say, 1500m. Then the FDI will rise with altitude, sometimes rapidly.

And that's all assuming constant winds. Firstly, the prevailling wind does change with altitude. Secondly, as just discussed, different parts of the landscape can have different winds due to terrain effects. Meso-scale effects such as foehn winds and low-level jets can be present. Thermal winds can be an additional source of variation.

The message is clear:

SLIDE 7... MESSAGE

If things are "mild" handle weather as usual, otherwise get smart. Look for discrete events that can cause rapid changes. Observers, and the staff they report to, must know what to look for and how to react.

...WATCHOUTS AND RED FLAGS

SLIDE 8... MEMORY JOGGER

Our industry has long used a system of watch-outs, to alert crews to the potential or actual occurrence of dangerous situations. Crews are trained in this and given *aides-memoire*.

- **Weather: stay informed**
- **Actions: must be based on fire behaviour**
- **Try out: escape routes**
- **Communications: maintained**
- **Hazards: heavy fine fuels and steep slopes**
- **Observe changes: in weather**
- **Understand: your instructions**
- **Think clearly, be alert**

SLIDE 9... SPECIFIC WATCHOUTS

Specific watchouts are in use in most locations to focus crew leaders on local problems.

3. The wind changes speed or direction

4. The weather gets hotter or drier

8. Unfamiliar with weather and local fire behaviour

9. Frequent spot fires occur over your control line

17. The potential of the fire has not been assessed

SLIDE 10... CUSTOMS FLIR

Our research has produced a fairly extensive list of watch-out situations. This list also has a relatively technical basis. Our concern is that, if forced channelling takes control of a corner of a fire upwind of crews, then we avoid conversations like this...

“Control, this is Firebird 123. I’m reporting a forced channelling event making the fire dangerous upwind of Sector Mike, over.”

“Firebird 123 this is Control. What the hell did you just say?”

We need to reach a skill level where this is what happens...

“Control, this is Firebird 123. I’m reporting a forced channelling event making the fire dangerous upwind of Sector Mike, over.”

“Firebrid 123 this is Control. Can you confirm an actual watch-out? over”

“Affirmative, but based on what I’m seeing I’d also like to suggest a red flag for Sector Mike, over.”

“Received a red flag for Sector Mike, and will advise Incident Controller and Mike Leader of need for urgent action. Thanks. Out to you....”

Red Flag Warnings are used overseas to indicate a high level of concern for events that may threaten operations.

It is clear from our work that there is a need to consider the development and implementation of a set of red flags for dangerous fire drivers in and around the high country. I would like to remind you all of the number of extremely dangerous fire situations in the high country in the last decade. A reading of the material from the Royal Commission makes it clear that we need to know how to react to intelligence of the form “all hell has broken loose”.

SLIDE 11... URGENCY LIST

We propose a four-tiered scale of urgency for any observation, ranging from highly significant to requiring verification.

SLIDE 12... PHENOMENA LIST

This covers observations made of a range of phenomena, many of which have come onto the agenda through our work.

SLIDE 13... RED FLAG LIST

From this a list of, currently, 33 watch-outs arises. These in turn may (or may not) lead to one of a list of ten proposed Red Flag Warnings:

1) Plume-driven fire
2) Conditions conducive to plume-driven fire
3) Passage of dry slot over fire
4) Thunderstorm
5) Wind change
6) Channelling event
7) Intense spotting
8) Dew point depression event
9) Foehn wind
10) Unusual combustion

Of these, one requires attention from the IMT as an abolute priority, four require treatment as a highest priority for the IMT, and the remainder are a high priority.

...IMPROVING WEATHER INTEL

So how do we get a better handle on the complexities of fire weather over the high country?

Clearly the starting point in answering this question rests with the Bureau of Meteorology. Already a number of BoM staff have started using our research outcomes to improve their service delivery. Jason's review paper on mountain fire meteorology has proven very useful here, and the more detailed papers have also been well received.

SLIDE 14... LOW-LEVEL JET MAP

Most if not all fire weather forecasters will be able to recognise that there is a low level jet over the alpine area, for example. The challenge is to get their clients – us – to the point where a telephone briefing can include this element of the weather and have it and its implications understood by all parties.

Where the phenomenon is of a large scale it will be resolved by the numerical weather models, and will be embedded in the daily forecasts. Where it is just smaller in scale than the resolution of the models it may be manually added by the duty forecaster, whose experience would suggest, yes a low-level jet is likely under this configuration. And a telephone briefing would include a discussion of that decision.

Yet smaller-scale events, such as lee-slope eddies will not be resolved, and it is up to the fire agencies to recognise their occurrence and implication. Obviously a discussion with the duty forecaster would ideally include a confirmation of the potential drivers of such fine-scale events.

SLIDE 15... DRY SLOT

Some events may not be open to inclusion in the forecasting cycle. As an example, as the day evolves the water vapor imagery may show a dry slot forming upwind of a running fire. A clued-up forecaster may elect to alert the fire agency of this, perhaps as a red flag condition. There may well be a general indication of the likelihood of this in the latest aerological diagram, but here the devil is in the detail.

Aerological diagrams are one aspect of weather observation that the fire services need to work on. The amount of wisdom that they contain is quite extraordinary. They are a vital tool for understanding a number of the events that HFR has studied. To this end we have prepared some aids to working with aerological diagrams, available for consideration on our web site.

SLIDE 16... AEROLOGICAL

What can we get from an aerological diagram? For our current specialised fire purposes the list includes:

- The ventilation index, relevant to smoke dispersal during a hazard reduction burn.
- The lifted index, a guide to thunderstorm potential.
- The likelihood of a dry thunderstorm, should a storm occur.
- The Haines Index and the vastly superior Continuous Haines Index developed by Graham Mills during his CRC work.
- Fuel Moisture Content
- Fire Danger Index

SLIDE 17... AEROLOGICAL.HTM

We have developed tools to assist with getting value out of them. Truly a valuable thing.

...IMPROVING TERRAIN UNDERSTANDING

Many of our studies required the analysis of terrain data. We needed a cross-border dataset of suitable resolution. For this we chose the Shuttle Radar Terrain Mission dataset, provided by NASA on-line. This gave us a digital elevation model of the high country from the Abercrombie River to Kilmore Gap and Tasmania.

We manipulated the data using a number of algorithms, and used the results in our studies. Some interesting findings from this are:

SLIDE 18... ELEVATION

We were able to consider the definition of the high country. To many it means the bits with snow gums and such-like, but this makes little sense from a landscape perspective. We could have used an elevation cut-off, but that arbitrarily removed much of interest to us.

SLIDE 19... RUGGED

We found that by defining “rugged” we could identify a large tract of rugged terrain that gave sensible guidance to us.

SLIDE 20… LIGHTNING IGNITION

As well as these products, the terrain analysis also yielded maps of areas prone to lightning ignitions, based on a paper that I wrote in 1992. Comments from NSW fire controllers suggest that this map works rather well. The green areas on the map are those where ignitions could be expected if there is lightning striking the ground and the fuel is dry enough to carry a fire.

SLIDE 21… LOCAL RELIEF

We also produced maps of local relief. We have analysed historical lightning ignition swarms and have found that those ignitions tend to cluster along the rugged spine of the landscape. Thus these maps could prove useful in future mass ignition events.

FIRE BEHAVIOUR PREDICTION

Our research findings contain many common threads. These can be consolidated into guidance on the best approach to predicting the behaviour of a wildfire in and around the high country.

SLIDE 22… HOW TO…

The first consideration is the level of escalation. Small or medium fires rarely need this sort of prediction due to their short time-frames. Plume-driven fires are beyond the scope of current models. Advice given to the IMT during the recent Tea Tree Fire in the Tinderry Ranges was based on applying a typical rectangular impact footprint – twenty kilometres by fifteen - ahead of the then building plume-driven fire. This advice proved sound.

Thus large or very-large fires are where the need lies.

For these we need to consider the three species of fire: flat, undulating and rugged. Flat fires are quite amenable to the tools carried by every fire controller in the paddock. For undulating fires there are four goals:

1. assess the uphill runs for the potential for spotting.
2. assess the downhill runs for the potential for containment.
3. assess wind – terrain interaction for the potential for erratic fire behaviour.
4. predict arrival times at assets under threat.

For rugged fires there are two key considerations: firstly the **low likelihood of containment** and secondly the significant **potential for a plume-driven fire to evolve** under certain circumstances.

These elements have been brought together into a set of flowcharts to guide decision-making.

Additionally by critically examining the tools used for calculating fire danger and for applying wind and slope correction factors we have made the prediction process easier to quality control.

RISK ASSESSMENT

SLIDE 23... BURNT ASH FOREST

The major advances in public safety to arise from our work will be in risk assessment. We have shown that it is no longer acceptable to base risk assessments on sets of hypothetical fires modelled purely on surface phenomena. It is evident that there will be significant increases in assessed risk in certain sites, such as:

FIRSTLY, ecological assets on downhill runs near channelling-prone sites, which are being devastated by extreme fire behaviour, contrary to accepted wisdom.

SECONDLY, built assets downwind of channelling-prone sites, where major wildfires are producing “firestorms” involving tornadoes, ember storms, fireballs and other phenomena. Once activated, normal risk mitigation measures cease being effective.

THIRDLY, ecological communities suffering from a lack of unburnt patches, which should serve as refugia, inside landscape-scale wildfires. Once mild, downhill runs stop occuring due to fire scale or the prevalence of lee-slope eddy winds these patches cannot occur.

FINALLY, assets suffering from attack by ember storms as opposed to ember attack. Linescans have shown where these attacks are prone to occur, and their association with plume-driven fires.

SLIDE 24... CHANNELLING MAP

Given that some of the triggers for key weather events are a fixed part of the landscape the risk downwind of them is difficult to mitigate. Such triggers include escarpments that create mountain wind waves and lee slopes that generate channelling. A key point here is that, once a fire near a trigger site has escalated, fuel is not a major contributor to the unfolding of events.

TOOLS

In order to facilitate the implementation of our research findings, we have done the following:

SLIDE 25... PAPER

- An exhaustive and growing set of peer-reviewed papers in scientific journals

SLIDE 26... POSTER

- A large set of posters presented at the 2007 and 2008 AFAC/BCRC annual conferences, and made available on the CRC website.

SLIDE 27... MAP

- A major set of terrain analysis map products available on the HFR website.
- A library of material being developed on the HFR website.

SLIDE 28... POSTER ON NON-DIURNAL WX

- Technical material, in a poster form, to aid teaching of key concepts such as the Transition Model, fire modelling flowcharts, smoke plume interpretation, analysing an aerological diagram and predicting thermal belt evolution.
- Detailed guidance on how to observe fireground weather in complex terrain.

SLIDE 29... LIBRARY

- A detailed set of tools to aid ground observers, air observers and situation unit analysts in detecting critical events happening and the correct and timely response to those events.

CONCLUSION

The short, three year span of the HFR project allowed us to raise more question than we have answered. We will nevertheless continue to tackle these goals in the coming years to improve public and environmental protection.

SLIDE 30... CONCLUSION 1

Environmental sustainability in the high country cannot be achieved unless the processes associated with plume-driven fires are fully included.

The potential **impacts of wildfres on the communities** around the high country cannot be mitigated until some socially difficult risk treatment questions are considered. The effects of violent pyro-convection must be factored into our planning.

The effective use of the **intellectual property** that HFR, and its collaborators, have developed will involve a serious level of committment from the end users represented here today. It turns out that wildfire management in the high country is a challenging technical business, more so than many are happy to accept. We are willing to do the hard yards to get the skills out there.

SLIDE 31... CONCLUSION 2

Many of those involved in wildfire risk management will continue to champion their preferred view of the processes involved. While these may be valid views in the context within which they were developed, we have found unequivocably that the big impacts from wildfires arise from poorly known, very technical processes that we must prepare ourselves to tackle. Collectively we must have a pool of specialists able to interpret the three-dimensional atmosphere and its interactions with the terrain and any real or hypothetical escalated fire burning on it.

We are throwing down the gauntlet.