FIRE NOTE

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EFFECTIVENESS AND EFFICIENCY OF AERIAL FIRE FIGHTING IN AUSTRALIA

SUMMARY

In recent years, considerable attention has been given to suppressing bushfires with aerial fire bombing. While the public has strongly identified aerial programs with successful bushfire suppression and called for greater investment in technologies that support this approach, public policy makers and fire agencies have been keen to more fully understand the costs and the effectiveness of using aircraft for firefighting operations. Bushfire CRC research examined the practical effectiveness and economic efficiency of aerial firefighting in Australia.

This research aims to help fire agencies identify the most effective combination of suppression resources for minimizing the impact of bushfires.

The effectiveness of aerial fire suppression is complex, depending on many factors, including:

- Aircraft travel time
- Distance from fire
- Aircraft characteristics
- Drop characteristics
- Ambient conditions
- Availability of ground support resources
- Fire intensity
- Fire size
- Fuel type
- Pilot skill
- Suppressant agent used
- Organisational and infrastructure arrangements.

In addition, maximizing use of limited capital and operational resources is one of the major challenges for all fire and land management agencies, which are often faced with the need to rapidly evaluate a range of fire suppression options under highly pressured situations.

BUSHFIRE CRC RESEARCH

Various methods were employed by Bushfire CRC researchers to explore the effectiveness and efficiency of aerial suppression techniques, including the following approaches:

- Suppression operational research data was collected during recent fire seasons from state and territory rural fire and land management agencies in Australia and New Zealand; and also the current best practice from relevant literature. Data were collected from more than 500 fires where aerial suppression were used. There were 76 and 32 fire reports from forest and grass fires respectively that were suitable for detailed analysis.
- A series of aerial suppression experiments on stubble fires were conducted near Cambridge, Tasmania, to determine the effects of suppression drops on fire behaviour in stubble fuels. The experimental results were also used to develop and test methods for evaluating the effectiveness of aerial suppression. The suppression experiments were conducted in

ABOUT THIS PROJECT

The effectiveness and efficiency of aerial firefighting in Australia was investigated under two Bushfire Cooperative Research Centre projects, including Project A3.1: Evaluation of Aerial Suppression Techniques and Guidelines (within Program A: Safe Prevention, Preparation and Suppression), and Project C5: Bushfire Economics (within Program C: Community Self-Sufficiency for Fire Safety).

Bushfire CRC researchers involved include Matt Plucinski of CSIRO Sustainable Ecosystems, Jim Gould of Ensis-CSIRO Bushfire Research Group, John Handmer, Director of the Centre for Risk and Community Safety, RMIT University, and Gaminda Ganewatta, a former research fellow at the Centre for Risk and Community Safety, now at Deakin University.

paddocks of barley stubble, and drop pattern tests were undertaken in a paddock of short grass – ideal for developing and testing methods for aerial suppression evaluation.

- Researchers made field observations and measurements of fire bombing effectiveness at fire sites in Victoria and New South Wales, as well as through Project FuSE Aerial Suppression Experiments in South Australia. Data were collected on the location and timing of drop placement, drop coverage, fuel, fire behaviour, weather and ground suppression efforts.
- Researchers interviewed firefighters involved in suppression operations that featured aircraft during fires in Victoria, New South Wales, Tasmania, Queensland and New Zealand, and collected surveys on water bombing effectiveness completed by Air Attack Supervisors.
- The economic effectiveness of aerial suppression was studied using a "cost plus loss" approach (cost of suppression plus fire losses) within the limits of readily available data. The research compared aerial fire suppression with ground-based firefighting techniques such as dozers, tankers and hand crews, and also compared the economic efficiency of different aerial suppression techniques against one another. The operational cost of different suppression methods were estimated using data from the Victorian Country Fire Authority (CFA) and National Aerial Firefighting Centre (NAFC).

KEY FINDINGS

Effectiveness

1. Aerial suppression can be effective in providing support to ground crews and improve the probability of first attack success by up to 50 percent or more if the FFDI (Forest Fire Danger Index) is in the low, moderate and high classes. (Note: FFDI estimates on Black Saturday were classed as "extreme".)
2. When the FFDI is in the very high class, and time to first attack is less than half an hour, aerial suppression can provided substantial support to ground crews and increase the probability of first attack success from little chance (1 to 10%) to medium chance (33 to 66%).
3. For an aircraft to provide effective assistance it must be available at call, rapidly dispatched with minimal travel and with logistical systems in place. Air operations must be effectively integrated into the incident management structure and competent personnel need to be available to direct the operation.
4. The use of aircraft for first attack until ground resources reach the fire event produces the best outcome. But a combination of fuel management, ground crew support and aerial firefighting resources are all significant in increasing probability of first attack success.

Efficiency

1. The use of ground resources with initial aerial support is the most economically efficient approach to suppression.
2. Sole use of aircraft is economically justified in the event of other suppression resources being unable to reach a fire event within a reasonably short time period compared to aircraft.
3. Very large fixed wing air tankers such as DC 10s or 747s are a cost disadvantage, particularly for first attack – when fires are small and where water drop accuracy is required. To date, these very large air tankers have not been tested in the rural-urban interface for asset protection. Operationally, they are currently only used on continuous vegetation fires. Expensive dedicated aircraft carry high overheads making their cost-efficiency contingent on a high level of operational use.
4. The critical condition for the economic efficiency of aircraft is their ability to reach and knock down a fire well before ground crews. This buys time for ground forces to arrive and complete the containment, an advantage which is much greater in remote or otherwise inaccessible terrain.

COMPARING SUPPRESSION TECHNIQUES: A SUMMARY

Research conducted by Professor John Handmer and Dr Gaminda Ganewatta and published in a Bushfire CRC report, *The Cost Effectiveness of Aerial Fire-fighting in Australia*, noted that the use of aircraft requires large capital and operational outlays. After examining these costs, the report concluded that if a fire is located close to suppression resources, it makes economic sense to use ground methods for containment line construction. However, when it is difficult for ground resources to respond in a short time, the initial use of aerial resources until ground resources reach the fire makes economic sense.

Aerial suppression versus ground approaches

Assuming an arbitrarily selected 5000-metre fire front moving at a rate of 10 metres per minute, and assuming the response time is the same for each suppression approach, dozers (which are moderate at line-building but cheap to operate) were the most efficient, followed by tankers, hand crews and helicopters. Assuming, however, a 30-minute response time for helicopters and two hours for other ground suppression resources (and that aerial support operates until ground resources arrive) the use of aircraft may have an economic advantage. In this scenario, helicopters were the most efficient approach, followed by dozers, tankers and then hand crews.

Comparison of different aerial techniques

A simulation compared the use of DC10s, Boeing 747s and high volume helicopters, using a 20,000 metre fire front as a model. The results showed that helicopters perform better than the air tankers considered. Although capable of carrying large volumes of water, air tankers require a longer turn-around time to refill water or retardants.

SUPPRESSION DROP EFFECTIVENESS

The drop effectiveness guide developed by Bushfire CRC Project Leader Matt Plucinski acknowledges that drops may not reach their intended target if they are affected by unexpected wind drift, made in poor visibility conditions, or have been dropped too high due to difficult terrain. The research shows that the main considerations for assessing suppression drop effectiveness of suppression chemicals are placement, coverage and effect on fire behaviour.

Findings from Plucinski's research indicate in nearly all cases aerial suppression drops are of limited value without timely follow up from ground suppression resources. Unsupported drops that are quickly burnt around or spotted over are ineffective and will have very limited influence on slowing the fire. Suppressant drops are often used to knock down flames ahead of ground resources that follow behind, extinguishing residual flames and mopping up. This tactic can enable faster rates of line construction than either resource type working alone and may allow ground crews to work on sections of fire edge that would be too intense for them to safely suppress alone (though they should not rely on aircraft for safety). In Australian forests, Aerial suppression alone cannot provide the detailed attention required to mop up burning and smouldering fuels, which can cause containment lines to fail. This task can only be achieved from the ground. More information can be found in two Fire Notes (Issue 38 and Issue 1, respectively covering drop effectiveness and the use of chemicals).

Consideration should also be given to the impact of different additives on aerial suppression drop effectiveness. Most aerial suppression drops contain chemical additives, although drops containing only water are occasionally used for direct attack, particularly when fires are near waterways or there are concerns about the environmental impact of chemicals. Chemical additives fit into three classes:

1. Foam surfactants – Designed primarily for direct attack, foams aid the wetting of fuels by lowering the surface tension of the water and assisting saturation.
2. Water enhancers – Designed primarily for direct attack, water enhancing gels contain substances that slow evaporation and increase adherence to fuels.
3. Long term retardants – Designed to be laid ahead of the fire, long term retardants inhibit flame combustion and remain effective after the water they originally contained has evaporated.

Thus, an effective line-building rate is relatively low, while their operational costs are substantially higher compared to the high-volume helicopters used in the simulation. It is also important to recognize that the operational cost of air tankers may be higher in Australia than the US data used in this study and that they are less manoeuvrable than helicopters.

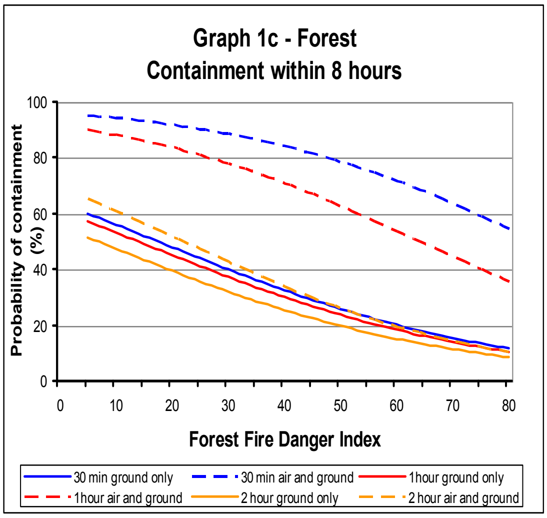
RESEARCH IN ACTION

Fire containment initiative

An ongoing piece of research being conducted by the Bushfire CRC has produced a *Fire Containment Guide: A guide to the probability of fire containment with ground and aerial firefighting resources*. The document has been produced by Dr Matt Plucinski of the Bushfire CRC and CSIRO Sustainable Ecosystems to assist fire managers in making sound decisions about the use of aerial firefighting appliances under different fire danger conditions in different parts of Australia. (Underpinning the guide is recognition of the importance of first attack in checking a fire before it builds.)

The *Fire Containment Guide* was developed from surveys of more than 500 fires that occurred in a range of locations in Australia between 2004 and 2008, with the use of heavy, medium and light helicopters or single engine air tankers (fixed wing fire bombers) as firefighting resources. The data on each fire included an expert assessment of whether fire containment could have been achieved within 2, 4, 8 or 24 hours, and as such, the guide helps predict the probability of fire containment within this period using ground resources alone compared with ground and aerial suppression resources working together. Predictions are given for forest, grassland and shrub environments. There is also an interactive computer version of the guide – the 'Fire Containment Calculator' – which can use additional information about flame height and area already burnt to provide a more accurate and up-to-the-minute assessment of probabilities.

Fire managers can use the guide by selecting the relevant graphs for fuel type (forest or shrubland or grassland), and then get the estimated probability of fire containment by considering a range of factors. They must estimate the time between detection and first attack by either ground or aerial resources,



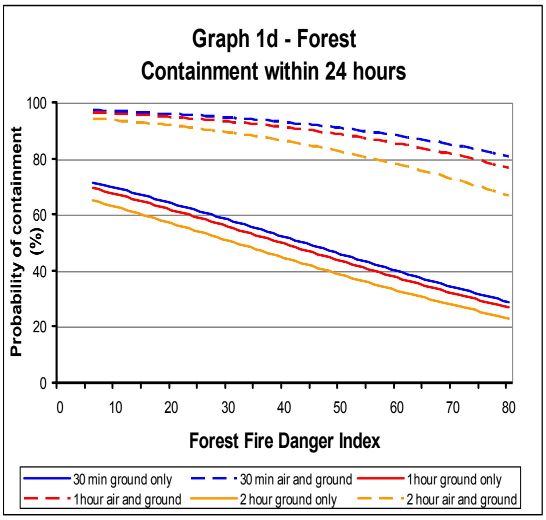


Figure 1: Examples from the *Fire Containment Guide*, which helps to predict the probability of fire containment within 2, 4, 8 or 24 hours using ground and aerial firefighting forces, for different environments.

including the time taken for resources to leave base and travel to fire. They factor in the maximum fire danger index rating predicted for the day of the fire. Graphs or tables allow them to obtain probability estimates for containment within 2, 4, 8 or 24 hours, giving them an indication of their chance of success. (See Figure 1 above.)

The probability of containment – as provided by this guide – can be used to guide a range of decisions about the deployment of firefighting resources. It can be used to help assess the potential benefits and costs of using firefighting aircraft, and help prioritise the deployment of aircraft when there are multiple fires.

This guide will be used in the 2009-10 fire season in southern Australia and will be subsequently reviewed by users.

A guide to drop effectiveness – also developed by Dr Plucinski – was produced and aimed to outline key criteria for assessing aerial suppression drops in terms of the major considerations for their effectiveness, namely placement, coverage, and effect on fire behaviour. (See "Suppression drop effectiveness" sidebar for more information.)

FUTURE DIRECTIONS/ LIMITATIONS

1. The Bushfire CRC will assist in the evaluation of a very large air tanker to be used in Victorian in bushfire season 2009-10. The focus of this evaluation will be on its ability to suppress a fire and to more broadly integrate with other fire fighting operations. This research will be shared with other fire agencies in Australia and internationally the US.
2. There was very little data collected on aerial suppression providing direct property protection. There are a number of anecdotal cases where aerial suppression has saved homes, but data availability limited the application of a full cost-benefit analysis.
3. There was insufficient data to fully examine the effectiveness of aerial suppression on different fire intensities and in different fuel types. Additional information on fire behaviour and fuel conditions at the fire will improve the interpretation of the predicted probability of first attack success. The collection of operational data has continued over recent fire seasons.
4. There was insufficient data to conduct detailed analysis on the effectiveness of aerial suppression on grass fires. Future research could complement the existing data set by targeting more fire types including grassland fires, urban interface fires, remote area fires, extended attack fires in catchment areas, and plantation fires.

BUSHFIRE CRC AERIAL SUPPRESSION OUTPUTS/MORE INFORMATION

Fire Containment Guide: A guide to the probability of fire containment with ground and aerial firefighting resources (and Fire Containment Calculator).

Ganewatta G., Handmer J. (2009) *The Cost-Effectiveness of Aerial Firefighting in Australia.* Bushfire Cooperative Research Centre, Australia.

Plucinski M., Gould J., McCarthy G., Hollis J. (2007) *The Effectiveness and Efficiency of Aerial Firefighting in Australia, Part 1.* Bushfire Cooperative Research Centre, Australia.

Fire Note (Issue 38) – Assessing Aerial Suppression Drop Effectiveness.

Fire Note (Issue 1) – Using chemicals in firefighting operations.

Fire Update (Issue 22) – Fighting fires from the air in season 2007/8

Fire Update (Issue 17) – Research at the fireground

Fire Update (Issue 11) – Fighting bushfires from the air

To read these and other documents in relation to aerial suppression of bushfires online, visit www.bushfirecrc.com

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AFAC is the peak representative body for fire, emergency services and land management agencies in the Australasia region. It was established in 1993 and has 26 full and 10 affiliate members.