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Fire note

bushfire CRC

AUSTRALASIAN FIRE AUTHORITIES COUNCIL

Background briefings on emerging issues for fire managers from AFAC and Bushfire CRC.

Smoke and the Control of Bushfires

Smoke from bushfires, and from prescribed fires that may be lit outside the bushfire season, can raise environmental and human health issues.

Air quality concerns, expressed by people living in cities and towns, provide an added dimension to the management of both prescribed fires and, to an extent, bushfires. So too do concerns about smoke damage to certain agricultural crops such as grapes, and the safety related concerns of motorists and airline operators.

As well as its impacts on the wider community, smoke can also directly impact on those involved in the management of a fire, such as fire-fighters and aircraft operators.

The fire and land management agencies who are partners in the Bushfire CRC and the Australasian Fire Authorities Council have identified the better management of smoke as one of the more important issues confronting bushfire managers in Australia and New Zealand.

Background

Cities and large towns generally experience two forms of air pollution. The first comprises fine particles in the air. The second type is a photochemical 'smog', which tends to be worse in summer and is caused by the interaction of sunlight with a mixture of water vapour, and vehicle and other industrial pollution. In most cities motor vehicles are the most significant source of pollution, particularly in summer. They can contribute more than half of all nitrogen oxide emissions, up to half of all volatile organic compounds, around a quarter of airborne particles and almost all the carbon monoxide emissions.

Commonly after clear, cold nights, or with a stable atmosphere, temperature inversions result in warm air higher in the atmosphere trapping pollutants in the layer of colder air closer to the ground. These inversions can sometimes last for several days, causing 'scummy' brown hazed horizons until dispersed by wind or rain.

Emissions from fires depend on the type, moisture content and structure of the fuel being burned and on the intensity of the fire. Once emissions from the burning process are released, the transport and dispersion of the smoke is dependent on the height of the smoke plume rising from the fire, the wind profile, the stability of the atmosphere and the nature of the properties of the smoke itself.

UNDERSTANDING THE TERMS

- **Smoke** comprises the visible airborne by-products of combustion and is composed of water vapour, particulates (tar, ash, carbon, unburnt fuel fragments), and gases (CO_2, CO, N_2O, S_2O, NH_3, CH_4, NO_x, ozone and other non-methane hydrocarbons). On average, the amount of smoke produced by a fire represents between 1.5 and 2% of the quantity of fuel burnt. (Vines et al. 1971).
- **Particulates** result from incomplete combustion and the proportion of fuel that becomes particulate matter is about 0.44% for high-intensity fires burning under very dry conditions and about 2-4% for low-intensity fires under mild weather conditions (Evans et al. 1976).
- **Prescribed burning** is the controlled application of fire, under specified environmental conditions, to a predetermined area and at a time, intensity of heat, and 'rate of spread' required to achieve planned resource management objectives. Examples include 'fuel reduction burning' and 'ecological burning'.

Smoke from burning vegetation may affect human health primarily through the inhalation of tiny particles that can increase the prevalence of a range of respiratory and cardio-vascular conditions.

In order to better manage smoke from prescribed fires, and to better prepare the community for the impacts of smoke from bushfires, fire and land management agencies need access to sophisticated modelling and predictive technology. Agencies would like to be in a position whereby they had the ability to predict the quantity of fuels that are likely to be consumed under specific burning conditions, in a given vegetation type. From a smoke management perspective the model should also have the capacity to simulate the spread and behaviour of fires under heterogenous terrain and fuels, and changing weather conditions. The complexities of such a model are clearly significant, particularly when fires extend over significant areas. Much work has been done in relation to such modelling however, both in Australasia and overseas, and several of the current projects the Bushfire CRC is involved in will considerably advance this work.

Once the smoke has been generated, further complex models are required to predict the transport and dispersion of the smoke. The height of the plume rising from the fire, the prevailing atmospheric conditions, the nature of the smoke particles themselves, and the presence of other fires in the region are all matters requiring consideration. Such models should be able to predict particulate emission factors and source strength, and be able to address fire behaviour, fuel chemistry and ignition techniques. The models would need to be able to be aggregated upwards to the landscape, state and regional scales. Again, the issues are clearly complex with most work in this latter field having been undertaken in the United States, more recently in Australia and most recently in South-East Asia.

Further smoke related issues arise in terms of the impacts of smoke produced from relatively frequent, low intensity prescribed fires, as opposed to the amount and type of smoke produced from relatively infrequent, high intensity bushfires. The contribution of various types of fires in terms of particulate matter released (particularly those affecting human health – dioxins, irritants and carcinogens), greenhouse gases, photo chemically active gases and ozone-depleting chemicals are all areas warranting considerable further investigation. As does the regular exposure of firefighters to various kinds of smoke, and their respiratory health and safety.

Beyond human health matters, other smoke related ecological and environmental issues arise. These include the contribution of various types of fires to greenhouse gases in the atmosphere, the extent of the loss of nutrients through the oxidation of carbon, nitrogen and sulphur during the combustion process, and the role smoke plays in the regeneration of vegetation through, for example, the promotion of seed germination.

Smoke and the Use of Prescribed Fire

While there is a general acceptance within the community of smoke generated by bushfires, smoke generated from prescribed fires (often lit outside the declared fire danger period, and under stable atmospheric conditions) can cause considerable criticism of the land managers, agencies and governments concerned. The effect smoke has on visibility, human health and on greenhouse gas emissions are all matters that can be subject to adverse comment.

The severity of a bushfire depends on topography, weather, fuel type and structure, and the condition of the available fuels. Fuel is the only one of these factors over which a land owner, or a land manager can exert some control. 'Fuel reduction burning' is the only practical method of reducing fuel levels over large areas.

The strategic manipulation of the overall fuel hazard in an area, by careful burning in periods of reduced fire danger, can moderate the fire behaviour and the potential for 'spotting' from an advancing bushfire, reduce bushfire damage and allow safer bushfire control activities.

Fuel reduction burning is the controlled application of fire, under specified environmental conditions, to a predetermined area and at a time, intensity of heat, and 'rate of spread' required to achieve planned resource management objectives. The aim of fuel reduction burning is to strategically reduce the fuel hazard to assist with subsequent bushfire suppression.

In addition to the use of fire to reduce fuel loads, the managers of Australasia's parks and forests have come to more fully appreciate that the presence, frequency or absence of fire is a vital consideration in terms of the maintenance of the health of many ecosystems. Indeed fire is a complex phenomenon. On the one hand it must be managed to protect human lives and assets. On the other, it must be used to meet important biodiversity objectives.

This apparent paradox however, in terms of the management of natural areas, needs to be seen in the context that:

- All fire, and indeed the absence of fire, has an ecological dimension;
- Prescribed fires undertaken for ecological purposes can also provide some asset protection; and
- Both rely on prescribed burning to achieve planned resource management objectives.

The further development and refinement of meso-scale meteorological modelling, which can be used to predict the likely smoke impacts of prescribed fire, will considerably assist fire and land management agencies with this important aspect of bushfire and ecosystem management. Reliable, site-specific information could see, for example, agencies igniting a burn a few hours earlier or later than planned with the resultant smoke being diverted from populated areas. Similarly, the lighting of burns under less stable atmospheric conditions (which would see smoke carried aloft and dispersed at altitude by stronger upper winds) may, despite the 'burn control' problems this can cause, become better able to be considered.

Smoke and Bushfire Control

Once a bushfire starts, fire agencies must deal with the prevailing fuel and atmospheric conditions, and forecast weather conditions as they work to bring the fire under control. From a smoke management perspective however, the ability to more accurately model the likely path of the fire, and the nature and dispersion of the smoke it generates, would provide better early warning for communities that are likely to be affected, and greater certainty in planning fire control operations.

An extreme example of the impacts of smoke was seen during the devastating bushfires in south-eastern Australia in 1939 when smoke from the fires appeared over New Zealand a few days later. More recently, in March 2001, a bushfire on King Island in Bass Strait caused significant smoke pollution over Melbourne for three days, with street lighting becoming necessary in parts of the city on one afternoon.

Some nine months later, over Christmas/New Year 2001/02, extensive fires in New South Wales again resulted in smoke impacts in New Zealand. And in January 2003, widespread fires in southern New South Wales saw Australia's federal parliament shrouded in smoke on several occasions.

In terms of the impacts of smoke on fire control operations, an analysis of the largest fire to occur in Victoria since 1939 (the 2003 Alpine fires) observed "…The long duration of the fires and the huge volumes of smoke they generated became a significant operational consideration. It was not uncommon for either the location where the aircraft were based and/or for the area where they were required to operate to be 'smoked-in'. Strategies such as locating the (aircraft) fleet….(considerable distances from the fire)…were implemented to ensure operationally availability for both the alpine fires and (for) any other fires reported elsewhere in the State…"

Bushfire Smoke and Community Safety

When vegetation burns there will generally be considerable smoke produced. The surrounding air is providing oxygen for the combustion process and the atmosphere may fairly quickly become unstable near the fire. Smoke can become a major irritant making it harder to breathe and upsetting the eyes, nose and throat. Visibility is sometimes reduced to almost zero. In thick smoke the air closest to the ground will be the cleanest and easiest to breathe.

Many people killed during bushfires die while attempting to make a late evacuation from their home or some other place of shelter. They are killed in cars either on the road or in open paddocks. Some are killed by radiant heat or as a result of road accidents as they, and/or others become disoriented in the poor visibility.

Bushfire Related Smoke and Climate Change

One of the more vexed issues facing scientists and the wider community is the possibility that human activity is contributing to climate change. Smoke from bushfires, and more particularly smoke from prescribed fires, is increasingly viewed as further adding carbon dioxide, other greenhouse gases, and particulates to the atmosphere, and as such further contributing to global warming.

As with much of the science associated with climate change however, the story is more complex. New vegetation that establishes following a fire is invariably vigorous, and generally 'locks up' considerable quantities of carbon. Similarly, any contributions to global warming that might result from prescribed fires must be balanced against the potential global warming impacts of more frequent and more intense bushfires that will occur in the absence of the strategic use of prescribed fire.

The climate change debate is clearly a complex one and, in the context of bushfires, must also be viewed in conjunction with the nature of much of Australia's, and some of New Zealand's native vegetation. Much of this vegetation has a complex evolutionary and dependent relationship with fire. Fire has been part of these environments for tens of thousands of years and much native flora and fauna remains dependent on it in various ways. Further, current climate projections suggest that the threat fire poses in most summers to life and property will remain real. The relative contribution of smoke to the atmosphere, from both wildfire and from the use of prescribed fire, is a key theme of Bushfire CRC research activity.

The Bushfire CRC and Smoke

The Bushfire CRC is involved in a number of projects that are designed to improve the understanding of a range of key smoke related issues. These projects include:

Project B2.1 Behaviour of Smoke Plumes and hazes from Rural or Urban Fires. This project is designed to enhance existing models of smoke movement and to better integrate them with other meteorological tools. The project has already seen the considerable enhancement of an earlier 'Smoke Dispersion Forecasting Service', which is available to fire and land management agencies via the Bureau of Meteorology's website. Use of the Service requires some familiarity with weather forecast construction and the assumptions inherent in them and an ability to interpret the forecast output. In many situations this will involve some interaction with Bureau of Meteorological forecasters. To assist agency personnel in the use of the Service a self-paced, PC based, interactive CD-ROM has been produced and distributed to agencies in mid-2004. Further training of key agency personnel in the use of the Service is planned in 2006.

B2.2 Smoke Composition from Prescribed and Wildfires and Health. This project is better quantifying the contribution of prescribed fires and wildfires to atmospheric particulate matter, classical pollutants, greenhouse gases, photo chemically active gases and ozone-depleting chemicals. In time this work will lead to evaluations of the relationship between various prescribed burning regimes and the probability of large bushfires. The project is also examining aspects of the impact of smoke on human health.

D2.2 Air Toxics Exposure and Management. This project will identify the key air toxic species in bushfire smoke and provide the capability to measure, evaluate and control the exposure of firefighters and rural and semi-rural communities to these toxics. It will develop and apply capabilities for measuring the personal exposure of firefighters to a wide range of air toxics in different fire scenarios, such that air toxics exposures can be evaluated in the field and controlled where necessary. The project focuses on both short-term risks from exposure to air toxics in bushfires and long-term risks from ongoing exposures to carcinogens and lung irritants.

D4 Respiratory Health of Firefighters. This project is investigating the respiratory effects of bushfire combustion products, as well as the efficacy of the current standard issue smoke masks. The study focuses on the smoke effects of vegetation fires in eucalypt and savannah. Most previous research in the field has looked at smoke generated by fires in northern hemisphere deciduous and conifer forests.

More details of specific CRC related research projects are available from the CRC, or can be found at www.bushfirecrc.com

Further Reading

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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.

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