Smoke composition and impact on human health and ecosystems

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Research background

Prescribed fires are used by land managers to reduce the risks from wildfire. From an alternative perspective, smoke from regular prescribed fires may have a greater impact on human communities and ecosystems than that produced by an occasional wildfire. A key issue driving this project was to understand whether the composition of smoke from prescribed fires differed from smoke produced by wildfires.

This project applied new and existing techniques to measure the contribution of prescribed burns to classical pollutants, including greenhouse gases, in smoke emissions. In addition, we measured background levels of certain components of smoke (e.g. volatile organic compounds (VOCs)) as these are emitted naturally, even in the absence of fire. Understanding the production of these compounds is important as they are involved in formation of atmospheric pollutants and affect human health.

Emissions from eucalypts

Three distinct groups of VOCs were identified during heating and combustion of leaves and stems of *Eucalyptus* species:

(1) Reactive organic compounds (acids, aldehydes, ketones, isoprene and low boiling point terpenes) were emitted at temperatures from ambient to ~100 ˚C
(2) Plant-specific isoprenoids (monoterpenes, sesquiterpenes) were emitted when heated to 200 ˚C
(3) Oxygenated aldehydes, ketones, furans and substituted benzenes were emitted when combusted at 250-300 ˚C

Before the appearance of smoke, the composition of VOCs correlated well with various naturally occurring isoprenoids. Once combustion began, a different suite of VOCs formed during pyrolysis of cellulose and lignin were detected. It is therefore likely that ratios of cellulose:lignin in fuels can be used for predicting the composition of smoke produced from a given vegetation type and condition.

Effect of smoke on human health

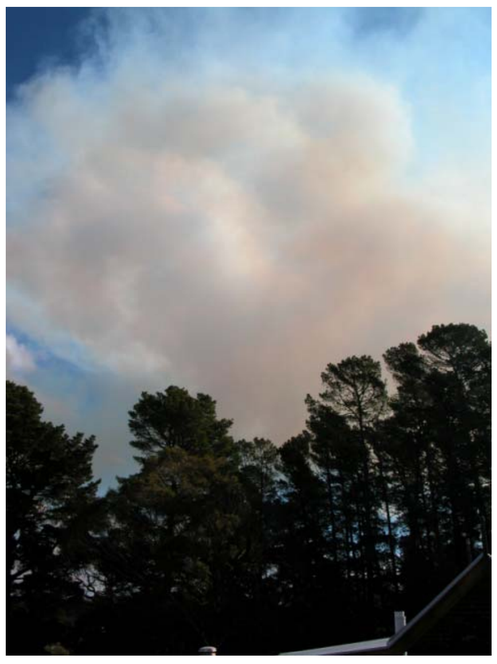
An important component of our research provided a synopsis of the information available to the general public regarding the impact of smoke on human health. Although information was limited, it was found to be accurate and that there are processes in place for annual updates. This activity facilitated related research by Monash University showing emergency department attendances were strongly associated with PM_{10} emissions from Alpine fires in 2003 but hospital admissions only weakly associated. A survey of the perceptions of local forest users did not rate the smoke produced during prescribed burning as being a major concern.

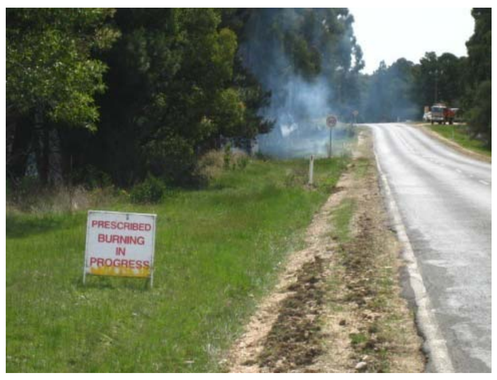
The ecology of smoke

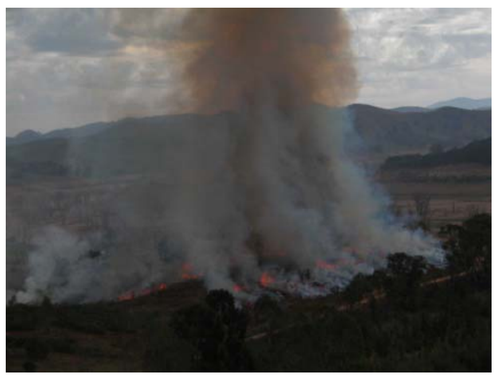
Our research also dealt with ecological and environmental aspects of bushfire smoke. For example, we quantified the loss of nutrients in smoke through oxidation of C, N and S during heating and combustion of different types of fuel (leaves, litter, bark, wood) from three forest types. We calculated that loss of N after complete removal of fuel, as might be expected from a high intensity wildfire would be:

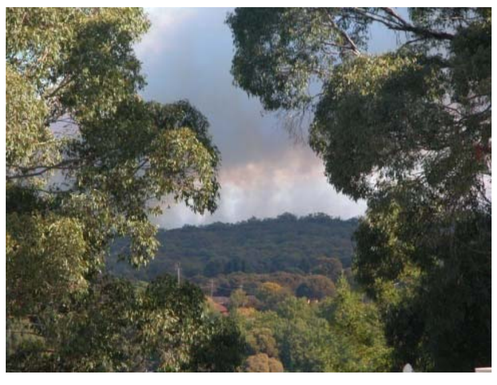
Low productivity site = **3760** kg N km^{-2}
Medium productivity site = **5810** kg N km^{-2}
High productivity site (unburnt) = **5510** kg N km^{-2}
High productivity site (burnt) = **6510** kg N km^{-2}

Low intensity prescribed fires will release less N but the compounding effect of repeated burning on nutrient loss is unknown.









Lead-End User: Mark Chladil, Tasmania Fire Service

End Users Agencies: Victorian Department of Sustainability and Environment, Victorian Department of Human Services

Research contributors: Prof Mark Adams (University of Sydney), Dr Simin Maleknia (University of New South Wales), Dr Judi Walter (University of Melbourne), Dr Maria Taranto (University of Melbourne)

Students: Dr Imma Oliveras, Ms Catherine Stephenson, Ms Vicky Aerts, Dr Rachel Tham

Collaborators: Bureau of Meteorology, University of California, Berkeley, CSIRO Marine and Atmospheric Research, Monash University

Outputs

Refereed journal articles and book chapters

Maleknia SD, Vail TM, Cody RB, Sparkman DO, Bell TL, Adams MA (2009) Temperature-dependent release of volatile organic compounds of eucalypts by direct analysis in real time (DART) mass spectrometry. *Rapid Communications in Mass Spectrometry* 23, 2241-2246.

Bell TL, Adams MA (2009) Smoke from wildfires and prescribed burning in Australia: effects on human health and ecosystems. In: *Forest Fires and Air Pollution Issues*, Bytnerowicz A, Arbaugh M, Riebau A, Andersen C (eds.), Developments in Environmental Science, Volume 8, Elsevier BV, 289-316.

Maleknia SD, Bell TL, Adams MA (2009) Eucalypt smoke and wildfires: temperature dependent emissions of biogenic volatile organic compounds. *International Journal of Mass Spectrometry* 279, 126-133.

Tham R, Erbas B, Akram M, Dennekamp M, Abramson MJ (2009) The impact of smoke on respiratory hospital outcomes during the 2002-2003 bushfire season, Victoria, Australia. *Respirology* 14, 69-75.

Oliveras I, Bell TL (2008) An analysis of the Australian literature on prescribed burning. *Journal of Forestry* 106, 31-37.

Maleknia SD, Bell TL, Adams MA (2007) PTR-MS analysis of reference and plant-emitted volatile organic compounds. *International Journal of Mass Spectrometry* 262, 203-210.

Bell TL, Oliveras I (2006) Perceptions of prescribed burning in a local forest community in Victoria, Australia. *Environmental Management* 38, 867-878.

Literature reviews and reports

Bell TL, Walters JR, Taranto MT (2006) *Smoke composition and impact on human health and plant ecosystems: a review*. Bushfire CRC report, Melbourne, 75 p.

Taranto MT, Bell TL (2006) Review of sampling and analytical methods for aerosol and gas-phase emissions in smoke from vegetation fires. Bushfire CRC report, Melbourne, 53 p.

Tham R, Bell T (2006) Bushfire smoke and human health: what types of information are available in Victoria, Australia? Bushfire CRC report, Melbourne, 20 p.

Student theses

Stephenson C (2006) Nitrogen gains and losses from the combustion of fuels of *Eucalyptus delegatensis* (Alpine ash) forest from the Victorian alpine region. Honours thesis, University of Melbourne, 102 p.

Aerts V (2007) Effects of fire on nutrient loss from different fuel types in *Eucalyptus baxteri* heathy woodlands. MSc thesis, University of Wageningen, 61 p.