EFFECTS OF BUSHFIRE SMOKE ON FIRE-FIGHTERS AND THE COMMUNITY

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Where there's fire there's smoke (and people)!

- Fighting fires is a workplace and the fire-fighter OHS must be protected
- Bushfire smoke in Australia - composition and the factors of influence (fuel type and load, fire intensity, weather etc) are unknowns
- Bushfire fighting practices in Australia - impact on exposure unknown
- Previous research limited (largely by USDA Forest Service)
Objective 1

Measure, evaluate and control the personal exposures of Australian bushfire fire-fighters to air toxics

- Assess exposure levels to air toxics in regards to Occupational Exposure Standards (OES)
- Identify key factors that determine exposure levels
- Identify areas of unacceptable risks

© Develop risk reduction strategies

Objective 2

Measure and evaluate the exposure of communities to bushfire smoke, in particular during extensive prescribed burning seasons
Bushfire Smoke - What is it?

- Complex mixture of toxic air contaminants (gases & particles)
- Key toxic species - literature review & experimental burns with different fuels

Bushfire Air Toxics & Health Effects

- Carbon monoxide
- Aldehydes
- Volatile Organic Compounds (VOCs)
- Respirable particles

- Aggravation of respiratory and cardiac conditions
- Impaired lung function
- Eye/nose/throat irritation
- Carcinogens
How to Sample Air Toxics?

Criteria

- Comfortable, easy to wear, light weight
- Robust to withstand the harsh field conditions
- Specific to selected air toxics
- Supported by reliable chemical analyses

Personal Monitoring Devices
Sampling Procedure

- Quantitatively sample *bushfire air toxics* in the *breathing zones* of randomly selected fire fighters
  - Key tasks
  - Fuel types
  - Fire types

- Brief interview at the end of each sampling
  Tasks and reactions to smoke

Burns and Fires Attended

<table>
<thead>
<tr>
<th>Location</th>
<th>Fire type</th>
<th>Burn area</th>
<th>Vegetation</th>
<th>Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>NE Victoria</td>
<td>FRB</td>
<td>50-500 ha</td>
<td>Eucalypt</td>
<td>6</td>
</tr>
<tr>
<td>Dandenong, VIC</td>
<td>FRB</td>
<td>5 ha</td>
<td>Eucalypt</td>
<td>6</td>
</tr>
<tr>
<td>Deer Park, VIC</td>
<td>FRB</td>
<td>5 ha</td>
<td>Grassland</td>
<td>3</td>
</tr>
<tr>
<td>Ngarkat CP, SA</td>
<td>FRB/Exp</td>
<td>240 ha</td>
<td>Mallee heath</td>
<td>11</td>
</tr>
<tr>
<td>TWP, NT</td>
<td>Exp</td>
<td>3 ha</td>
<td>Tropical forest</td>
<td>6</td>
</tr>
<tr>
<td>Moondarra, VIC</td>
<td>Accidental</td>
<td></td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>Kinglake, VIC</td>
<td>FRB</td>
<td>150 ha</td>
<td>Eucalypt</td>
<td>4</td>
</tr>
<tr>
<td>Kinglake, VIC</td>
<td>Slash burn</td>
<td>33 ha</td>
<td>Eucalypt</td>
<td>6</td>
</tr>
<tr>
<td>NE Tasmania</td>
<td>FRB</td>
<td>200 ha</td>
<td>Buttongrass, heath</td>
<td>4</td>
</tr>
<tr>
<td>NE Tasmania</td>
<td>Heap burn</td>
<td>140 ha</td>
<td>Eucalypt</td>
<td>4</td>
</tr>
</tbody>
</table>
Personal Exposure Levels by Work Activity

1. Lighting - using a hand-held drip torch

2. Patrolling -
   • maintain the fire within the boundaries of the burn
2. Patrolling -
   • Put out spot-fires (hose or hand-tools)

3. Supervising

4. Observing - researchers
**Carbon Monoxide Exposure Levels**

- **Maximum CO concentration [ppm]**: 0, 200, 400, 600, 800, 1000, 1200, 1400
- **Excursion limit**

**Work activities**
- Average CO concentration [ppm]:
  - Lighting
  - Patrolling
  - Lighting/Patrolling
  - Supervising
  - Observing

**Data-logger Record of Firefighter's Exposure to CO**

- **Spot-fire suppression using a rake-hoe**
- **Excursion limit**
- **NOHSC STEL**
- **NOHSC TWA**

**Time of day**
Personal Exposure Levels: RP and HCHO

- **Average HCHO concentration [ppm]**
  - 0.0
  - 0.2
  - 0.4
  - 0.6
  - 0.8
  - 1.0

- **Proposed TWA**
- **NOHSC TWA**

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Work Activities

<table>
<thead>
<tr>
<th>Work Activities</th>
<th>Average Respirable particle concentration [mg/m³]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lighting</td>
<td>0</td>
</tr>
<tr>
<td>Patrolling</td>
<td>2</td>
</tr>
<tr>
<td>Lighting/Patrolling</td>
<td>4</td>
</tr>
<tr>
<td>Supervising</td>
<td>6</td>
</tr>
<tr>
<td>Observing</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>12</td>
</tr>
</tbody>
</table>

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**Personal Exposure Levels to VOCs**

- **Major VOCs at higher levels for the patrolling crews**
- **Total VOC (TVOC) levels higher for the lighting crew**
  - added presence of several alkanes (fuel used in drip torches)

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**Average concentration of VOCs [mg/m³]**

<table>
<thead>
<tr>
<th>VOCs</th>
<th>Lighting</th>
<th>Patrolling and suppressing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benzene</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Toluene</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Acetic acid</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Phenol</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2-Fluorohyde</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Xylenes</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>TVOCs</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
**Exposure Levels by Fuel Type**

- Eucalypt forest (NE VIC)
- Eucalypt forest (Dandenong)
- Grassland
- Mallee Heath
- Tropical forest (NT)

**Average concentration of CO [ppm] and RP [mg/m³]**

**Exposure Levels by Fire Type**

- Fuel reduction burns
- Experimental burns
- Slash/Heap burns
Pollutant Correlation

Summary

- Variability among exposure levels
- Higher exposures (sometimes exceeding occupational exposure standards) in certain tasks and with certain fuels.
SUMMARY

- CO - elevated short-term exposure levels
  - sensor, screening method
- Respiratory irritants - irritation, but also potential to cause long-term health effects
  - Task rotation, face masks or respiratory protection
- Urban particles - health effects known; determine whether bushfire smoke particles (composition) are similar to urban particles and see whether similar health effects can be expected

Community Exposure
**Major pollutant: Particulate matter**

NEPM $PM_{10}$: 50 $\mu g/m^3$ (1 day)  
NEPM $PM_{2.5}$: 25 $\mu g/m^3$ (1 day)

Elevated PM levels associated with

- Coughing, wheezing, difficulty breathing
- Eye and nose irritation
- Increased hospital admissions for respiratory disease and heart problems
- Increased mortality in individuals with pre-existing cardiopulmonary diseases
- Decreased lung function among schoolchildren

**Community Impact from Bushfire Smoke**

<table>
<thead>
<tr>
<th>Location</th>
<th>$PM_{10}$ ($\mu g/m^3$)</th>
<th>Immediate increased medical impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>California (1987)</td>
<td>&gt;150</td>
<td>Asthma: 40% COPD: 30%</td>
</tr>
<tr>
<td>Darwin (2000)</td>
<td>80</td>
<td>Asthma: 240%</td>
</tr>
<tr>
<td>Singapore (1997)</td>
<td>80</td>
<td>Asthma: 19% Rhinitis: 26%</td>
</tr>
<tr>
<td>Indonesia (1997)</td>
<td>1600</td>
<td>Asthma: 150%</td>
</tr>
</tbody>
</table>

NEPM $PM_{10}$: 50 $\mu g/m^3$ (1 day)  
NEPM $PM_{2.5}$: 25 $\mu g/m^3$ (1 day)
THANK YOU

We thank the following agencies for their help and participation in the monitoring process:

DSE, CFA, CFS, DEH, NT Bushfire Council, Territory Wildlife Park, Forestry Tasmania, CSIRO Sustainable Ecosystems, ENSIS.