

PROGRAM D



ASSESSING FIREFIGHTERS' EXPOSURE TO AIR TOXICS IN BUSHFIRE SMOKE

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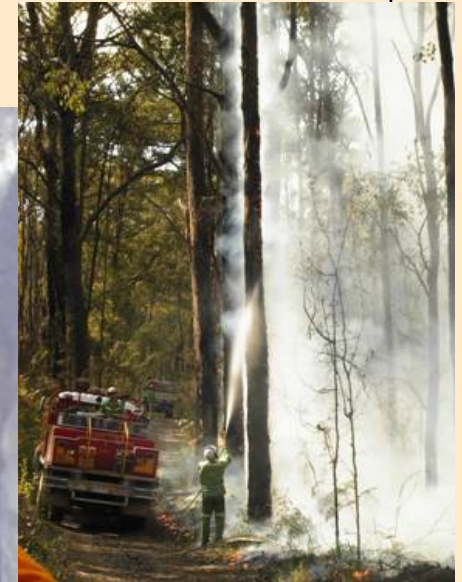
Dane Hansen

Bushfire CRC and RMIT University, VIC

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Firefighting Work Environment



BUSHFIRE SMOKE

- Carbon monoxide
- Respirable particles
- Aldehydes
- Volatile Organic compounds





What do we know?

United States

1. USDA Forest Service Pacific Northwest Research Station

Reinhardt, T. E. and Ottmar, R. D. 2004. Baseline measurements of smoke exposure among wildland firefighters. *Journal of Occupational and Environmental Hygiene* 1(9): 593-606.

2. National Institute for Occupational Safety & Health

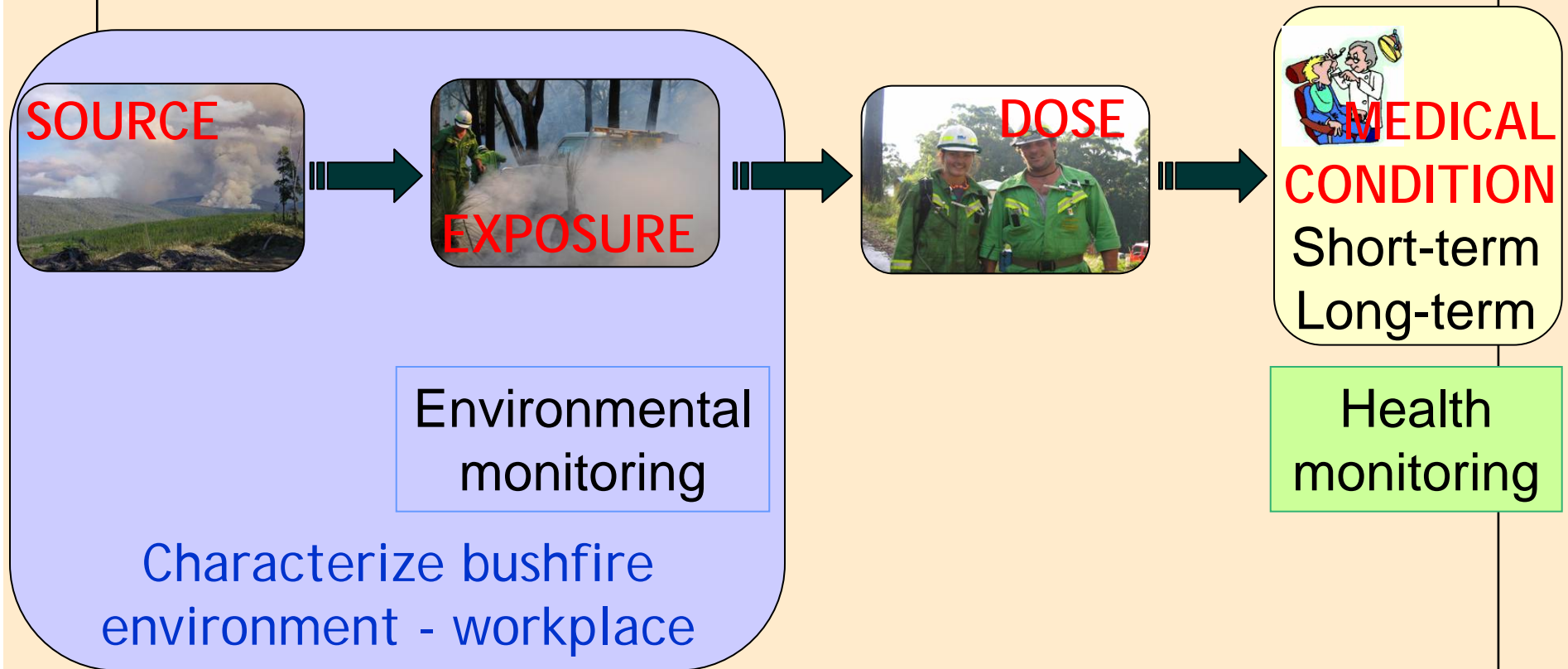
Health Hazard Evaluation Reports: Kelly (1992), Reh et al. (1992, 1994)

Australia - Project Aquarius

Brotherhood, J. R., Budd, G. M., Jeffery, S. E., Hendrie, A. L., Beasley, F. A., Costin, B. P. and Wu, Z. E. 1990. Fire Fighters Exposure to Carbon-Monoxide during Australian Bushfires. *American Industrial Hygiene Association Journal* 51(4): 234-240.

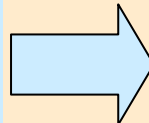


Risk Assessment Framework





Occupational Exposure Standards

- ❖ Occupational exposure standards (ASCC)
 - Exist for a range of air toxics
 - Not 'no-effect' level
 - Best used to assess quality of work environment
 - ❖ TWA - Time-Weighted Average concentration
 - 8-hour working day, 5-day working week
 - Sedentary work activity
 - ❖ STEL - Short-Term Excursion Limit
 - for those compounds with acute effects
 - ❖ Review OES for bushfire fighting work environment 
- Varying work shifts
 - Off-shift exposures
 - Heavy workload
 - Fatigue & heat stress
 - Mixture of pollutants



Methodology

Sample within the breathing zone of firefighters

- Key tasks
- Fuel types
- Fire types
- Various agencies





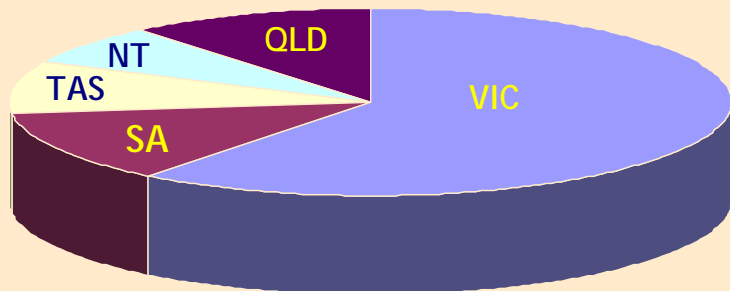
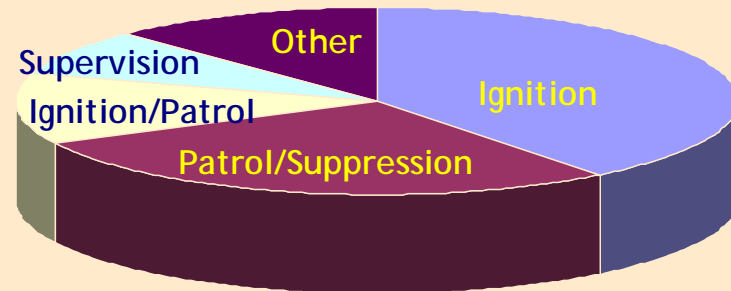
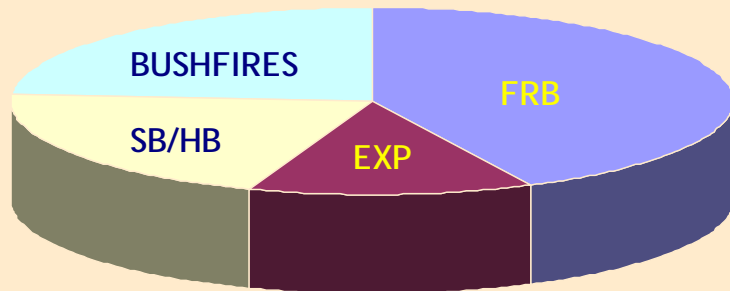
Methodology

Additional sampling equipment set up on vehicles



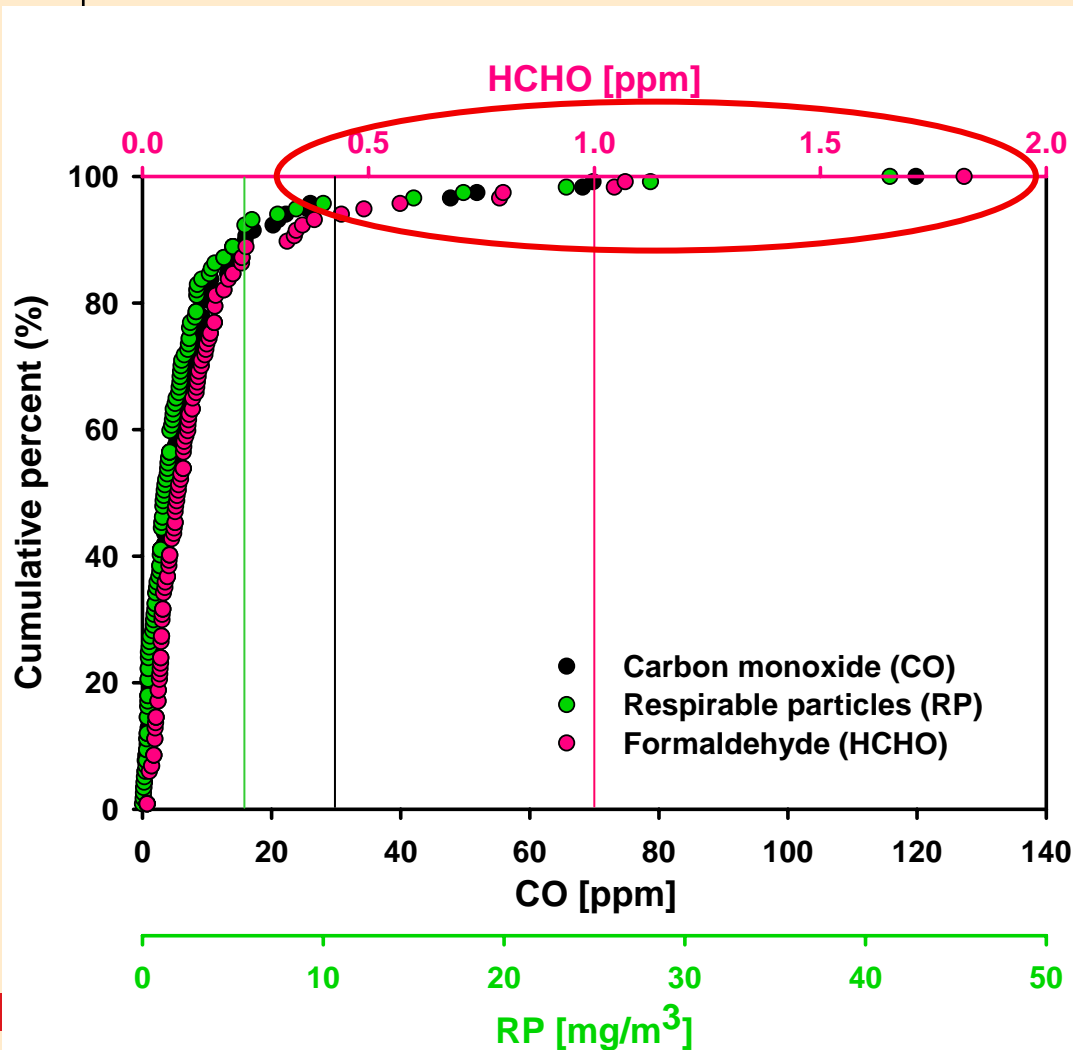


Field Monitoring - Sample Distribution





Results - Variability Among Samples

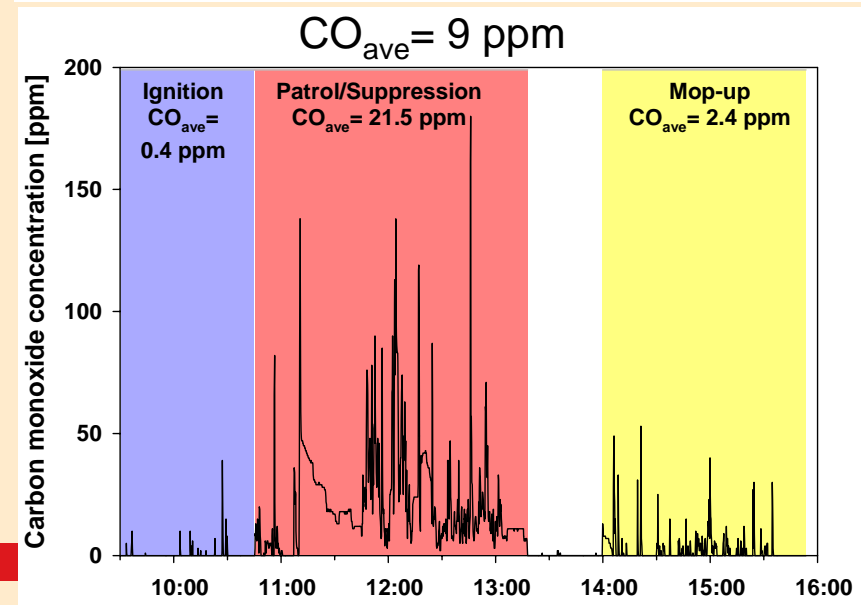
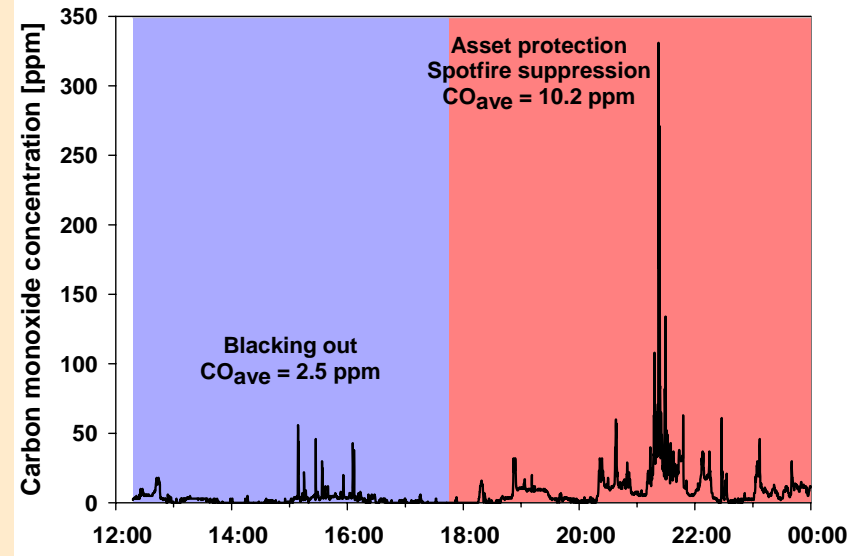
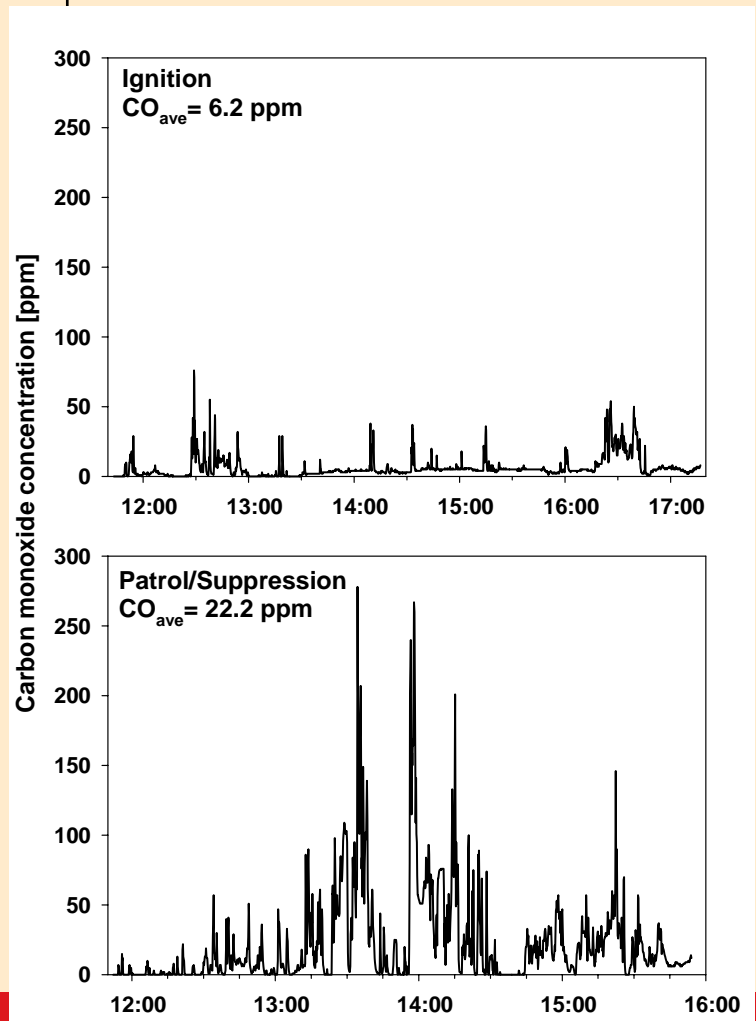


Drivers

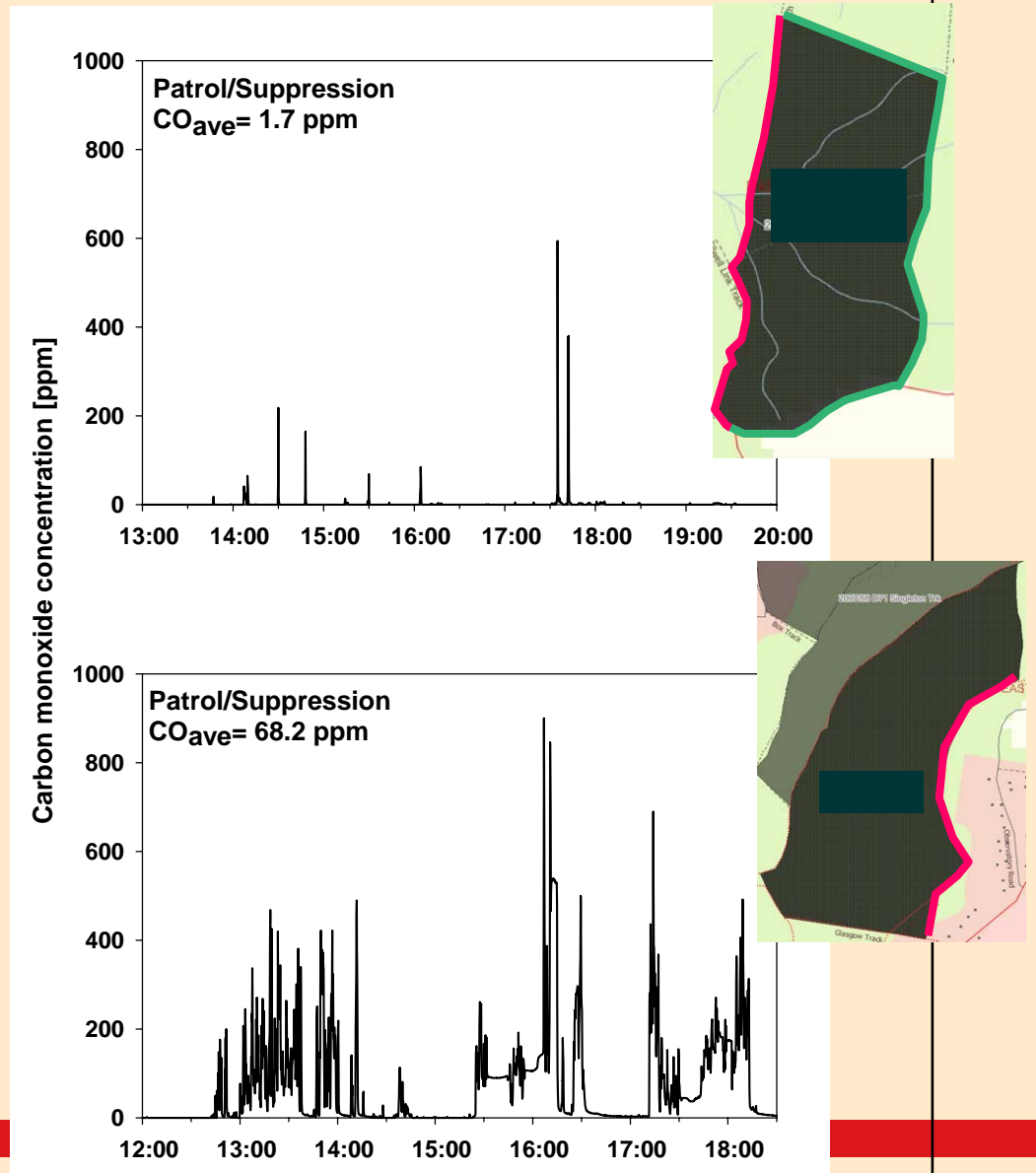
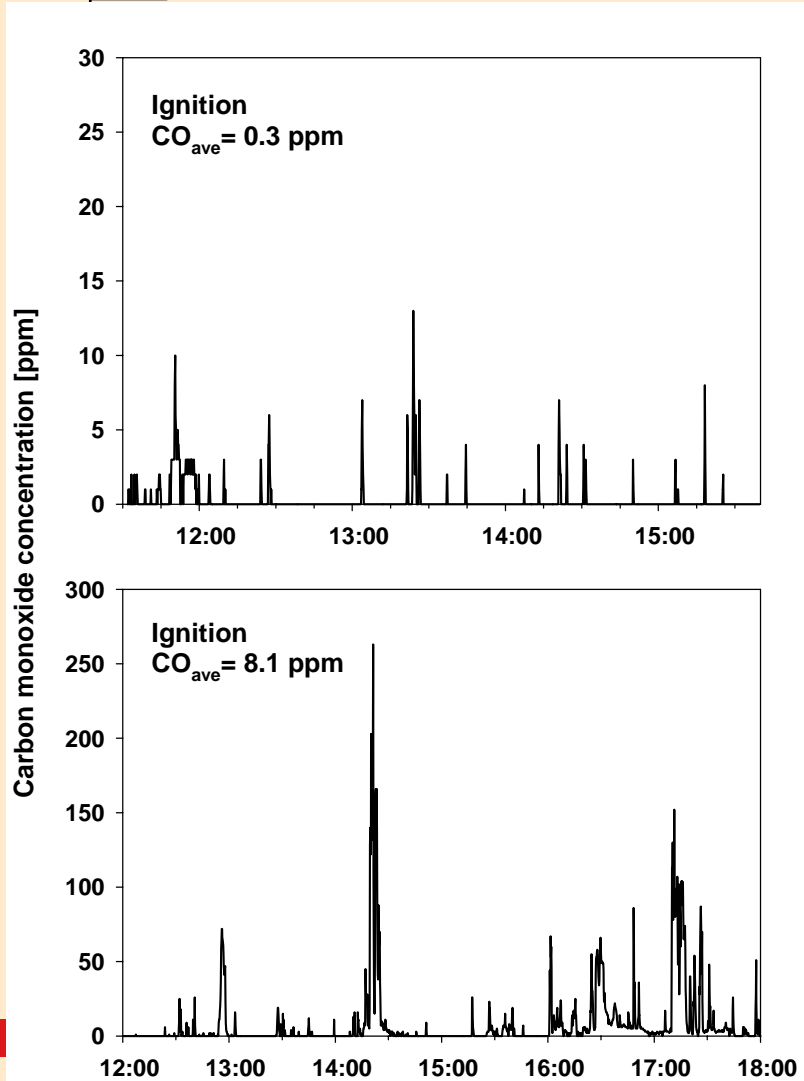
- Work activities
- Burn conditions
 - Terrain
 - Fire stages
 - Fire types
- Fuel characteristics
 - Fuel type
 - Fuel moisture
- Meteorology
 - Wind speed/direction
 - Inversions



Work Activity



→ **Burn Conditions**



→ CO Exposures - Carboxyhemoglobin Levels

Variables that affect COHb levels:

- CO concentration in air

Exposure measurements

- Exposure duration

Data-loggers

- Work activity (ventilation rate, CO diffusion rate)

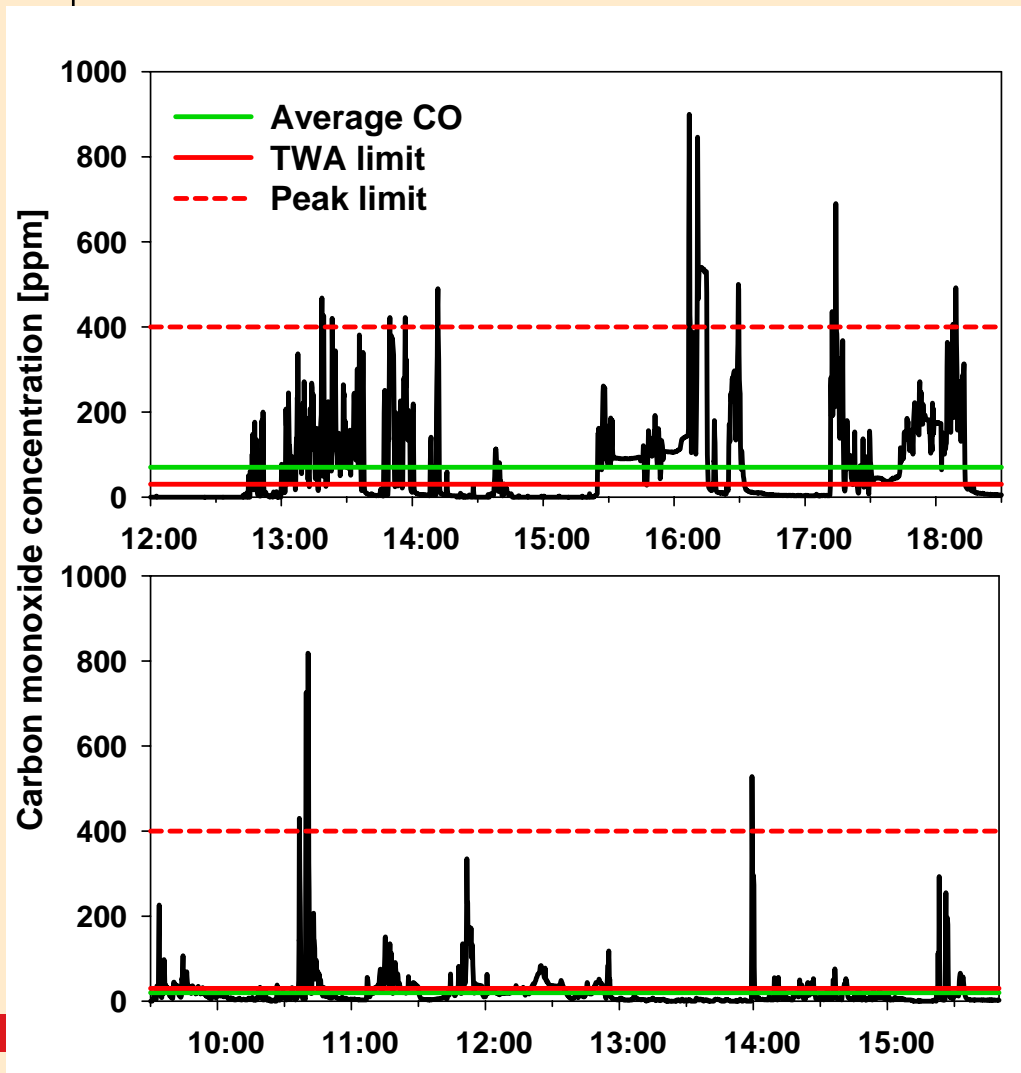
Physiology assessment – Project D 2.1

- Background COHb level

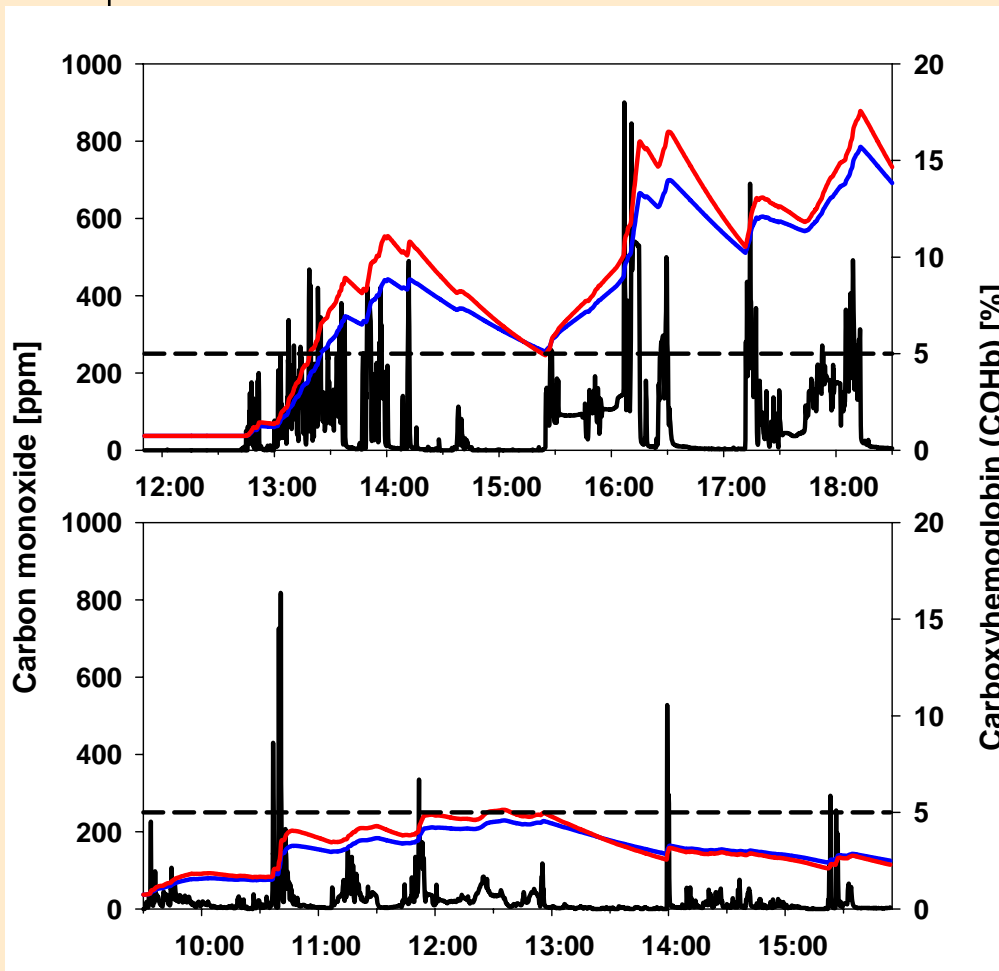
Endogeneous production - 0.4-0.7%

Smoking (1 pack/day - 5-6%; 2-3 packs/day - 7-9%)

→ Carbon Monoxide



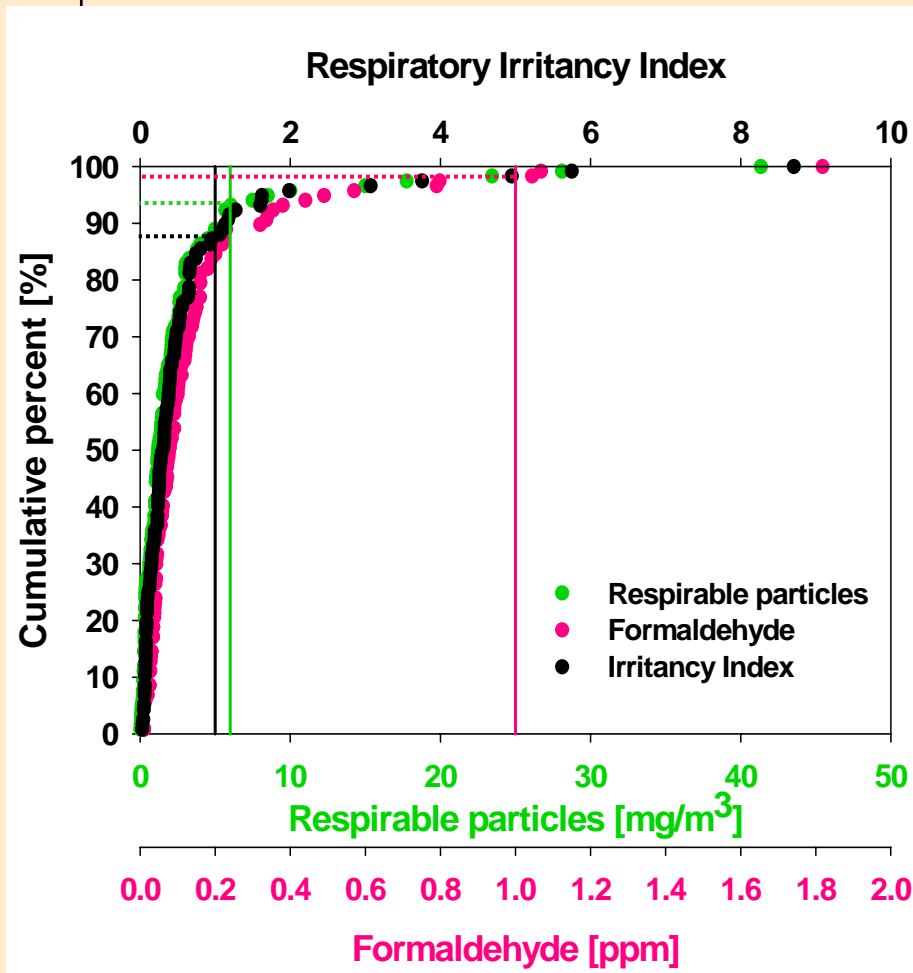
→ Carbon Monoxide



COHb [%]	SYMPTOMS, EFFECTS
5%	Potential for adverse cardiovascular effects
5-10%	Effects on performance of tasks requiring vigilance and on reaction time, potential headaches, dizziness, reduced work capacity
10-20%	Slight headaches, dizziness, slight breathlessness on exertion
20-30%	Slight to moderate headaches, nausea
30-40%	Severe headaches, vertigo, nausea



Respiratory Irritants



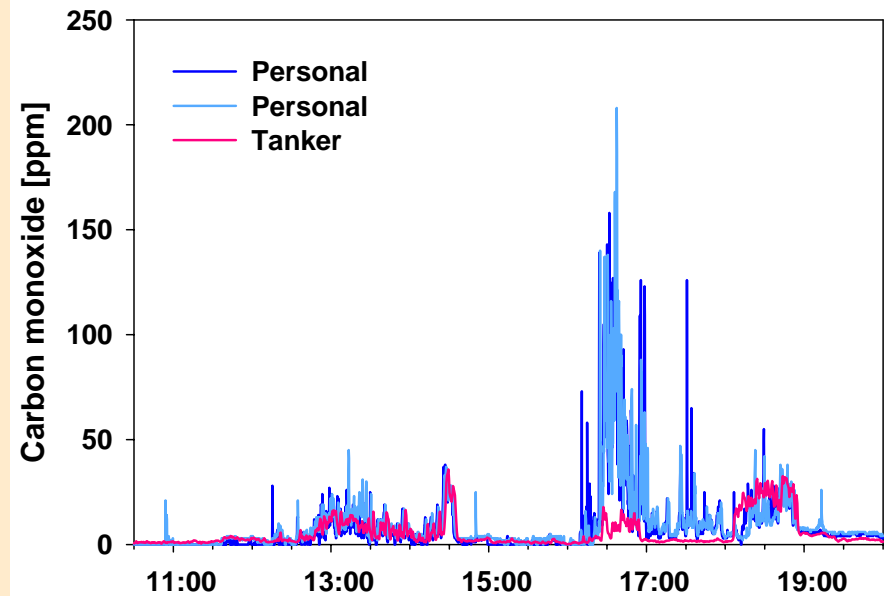
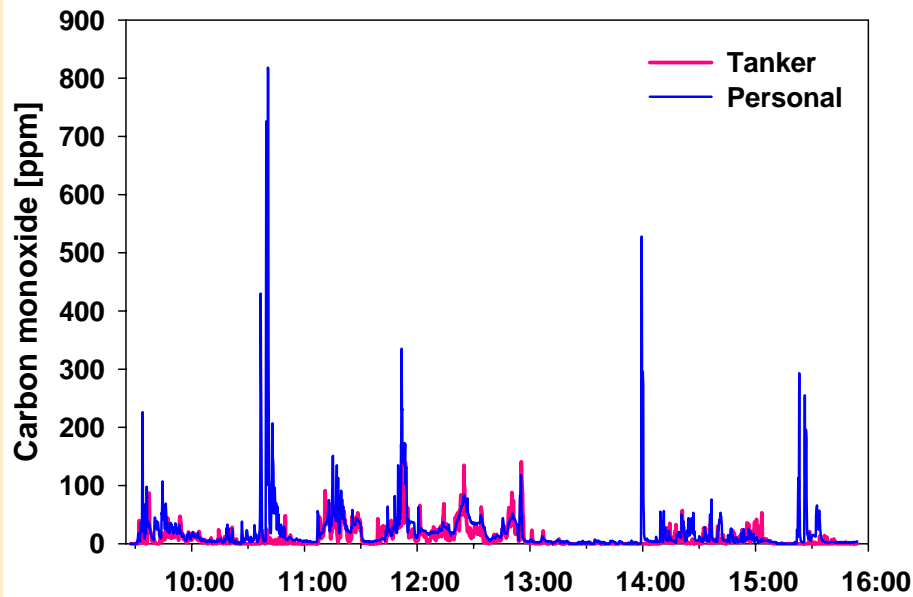
$$\text{Irritancy Index} = \frac{[\text{HCHO}]}{1 \text{ ppm}} + \frac{[\text{Particles}]}{6 \text{ mg/m}^3} < 1$$

Potential health effects

- Nose and throat irritation
- Difficulty breathing
- Exacerbation of respiratory or cardiac illnesses
- Impaired lung function

→ **Personal versus Vehicle-mounted Sampling**

	Personal	Tanker
CO _{ave}	21.0	10.6
	8.0	5.2
	9.2	
CO _{max}	820	170
	160	35
	210	



→ Exposure Assessment

- ❑ Majority of exposure levels below OES
- ❑ Exceedances (average & peak)
 - *CO and respiratory irritants*
 - *Small %, short fraction of time*
- ❑ Major drivers of high exposures
 - *Work activity: Patrol/Suppression > Ignition*
 - *Burn conditions: Terrain, lighting pattern*



Potential Control Strategies

- ❖ Operational level: Task assignment and rotation (mix high/low exposure tasks; assign firefighters to specific tasks)
- ❖ Hazard Awareness Training: explain situations where exposure to air toxics is likely to be high and how exposure risk can be minimized
- ❖ Equipment:
 - use of respiratory protection
 - use of personal exposure sensors



SUMMARY

Environmental monitoring

- Primary step in evaluation of working environment
- Personal samples rather than 'static' samples
Ensure unbiased and representative samples
- Limitations
 - Limited amount of samples*
 - Bushfires - Tanker based crews*
 - No assessment of the received dose*



SUMMARY

Next step . . . Assessing dose received

- Use of ventilation rates, workload, exposure durations to assess dose received
- Biological monitoring - takes into account differences between individuals in uptake, metabolism and excretion of toxics

ex. COHb monitoring in exhaled breath

. . . Assessing health effects



SUMMARY

OHS standard appropriate for the fire ground

- Altered workshifts
- Heavier Workload
- Bushfire smoke particles

*Chemical composition & physical characteristics
determine biological effect*

- Interactive health effects - exposure to multiple toxic compounds



Future Directions

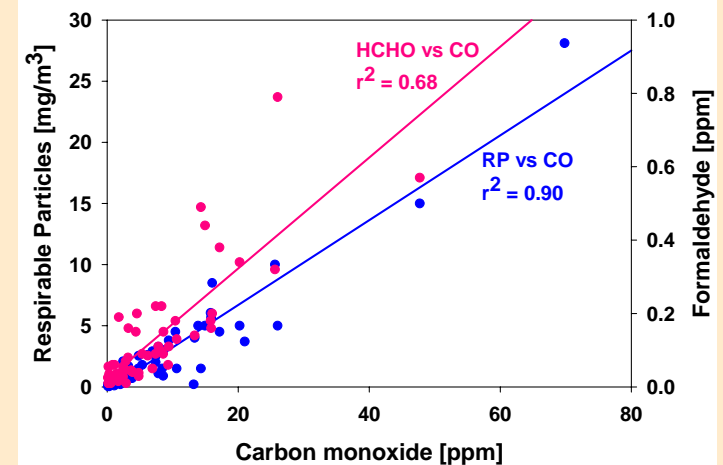
Develop an OHS toolkit

❖ OHS regulations and standards

❖ Personal exposure assessment

- Characterising the risks (exposure levels)
 - Assessing the risks (Risk matrix)
 - Mitigating the risks (Residual risks)
- ⇒ Simplified on-going monitoring program, e.g CO monitoring during 1 fire season

❖ Post Incident reviews of the effectiveness of the applied OHS strategy





ACKNOWLEDGEMENTS

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We also thank the different agencies for their help and participation in the monitoring process