Understanding exposures to air toxics during firefighting of bushfires in the rural urban interface

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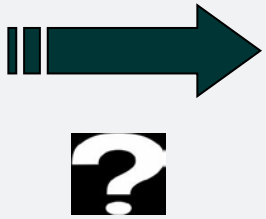
OBJECTIVE



Assumptions:

- no SCBA
- no firefighting within structures

What are the exposure risks?
What are the potential health impacts (acute & chronic)?

RESEARCH APPROACH

EXPOSURE

ELEMENTS

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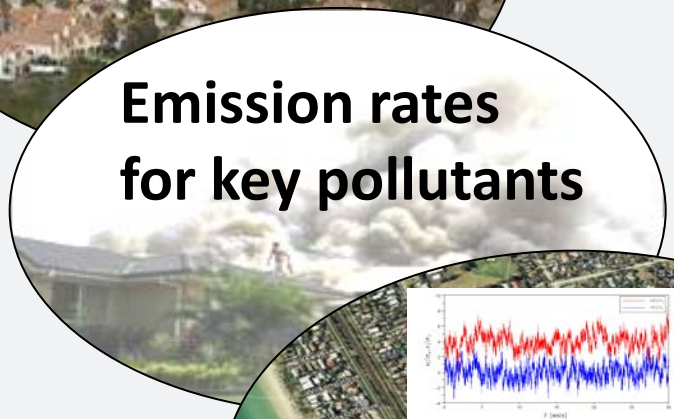
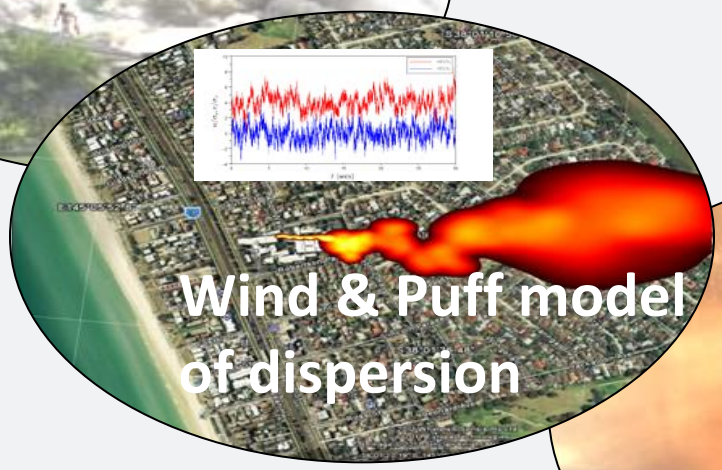
Inventory of combustible materials



Literature data
Experimental data



I. FUEL

→ Inventory of combustible materials

Complex mix of vegetation and other fuels

- House structure
- House contents
- Surrounding elements
- Vehicles
- Sheds

Complex spatial distribution of materials

SPATIAL DISTRIBUTION OF COMBUSTIBLES

Finite number of point source emissions characterised by

- a scale,
- material, hence emission type,
- estimate of emission rates

Significant variability in:

- type, amount and material composition of items present at the RUI
- spatial distribution of materials
- elemental composition of materials
- presence of fire retardants in materials

II. EMISSIONS

Literature data
Experimental data

Combustion products

- Nature/toxicity
- Emission rates

Factors

- Nature of fuel/material
- Ventilation
- Temperature
- Fire geometry

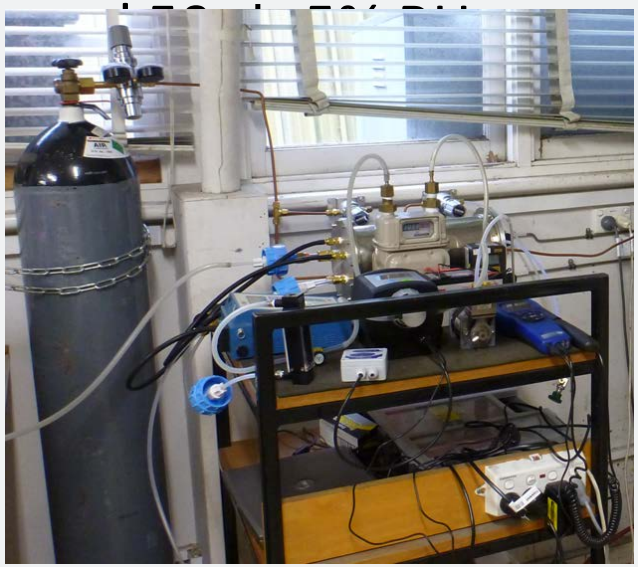
EMISSIONS – COMBUSTION PRODUCTS

- Cone calorimeter tests
  - Identify **key air toxics**
  - **assess emission rates** for gaseous and particle species from burning various types of materials **relative to wood**
  - **well-controlled conditions**

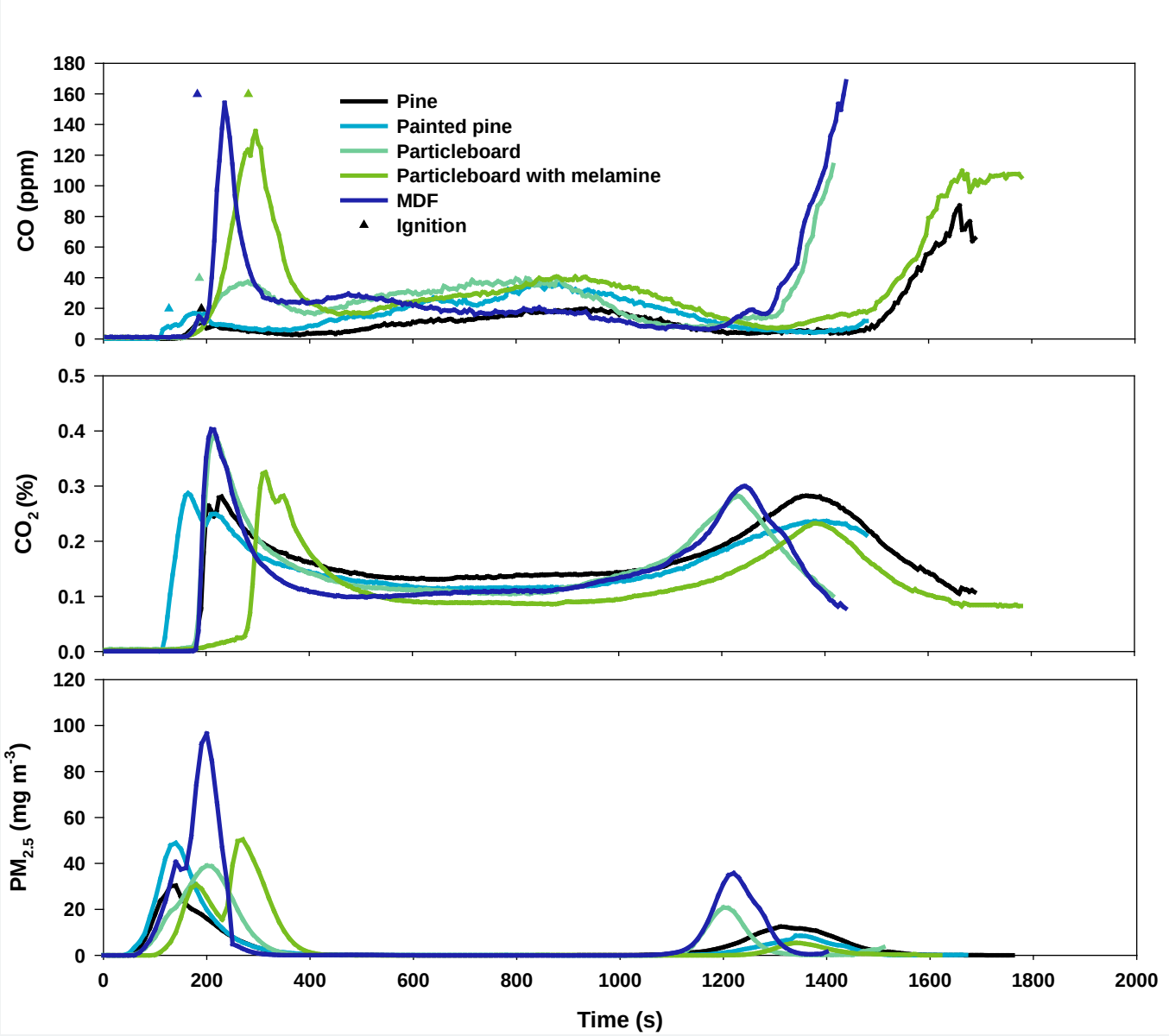
Materials
Pine
Painted Pine
Particle board (PB)
PB with melamine
MDF
Carpet
PUR foam (2 types)
Polyester insulation
Polystyrene cladding
Plasterboard

CONE CALORIMETER TESTS - DESIGN

- Exhaust flow: 0.024 m^3 s^{-1}
- Irradiance level: 25kW m^{-2}
- 100 × 100 mm samples conditioned at 23 ± 2° C

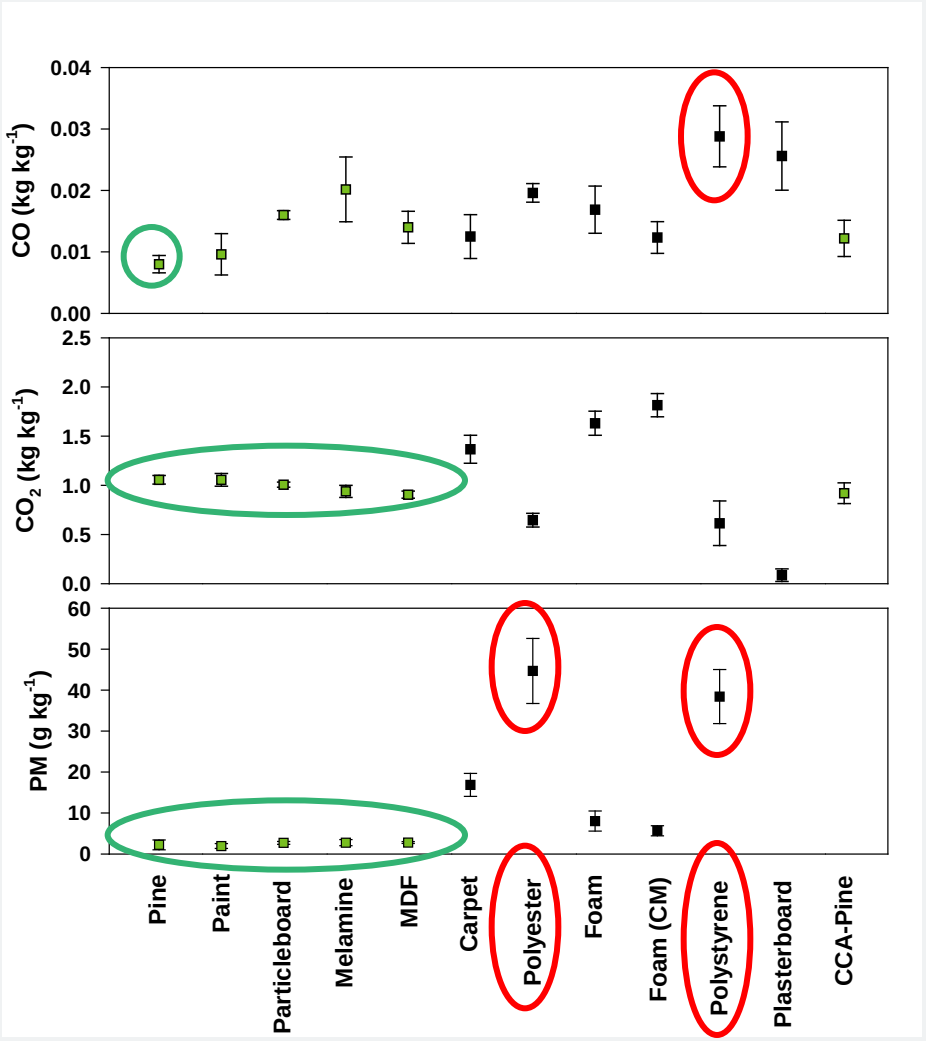


TIME SERIES ANALYSIS OF CO, CO_2 AND PM: WOOD-BASED PRODUCTS

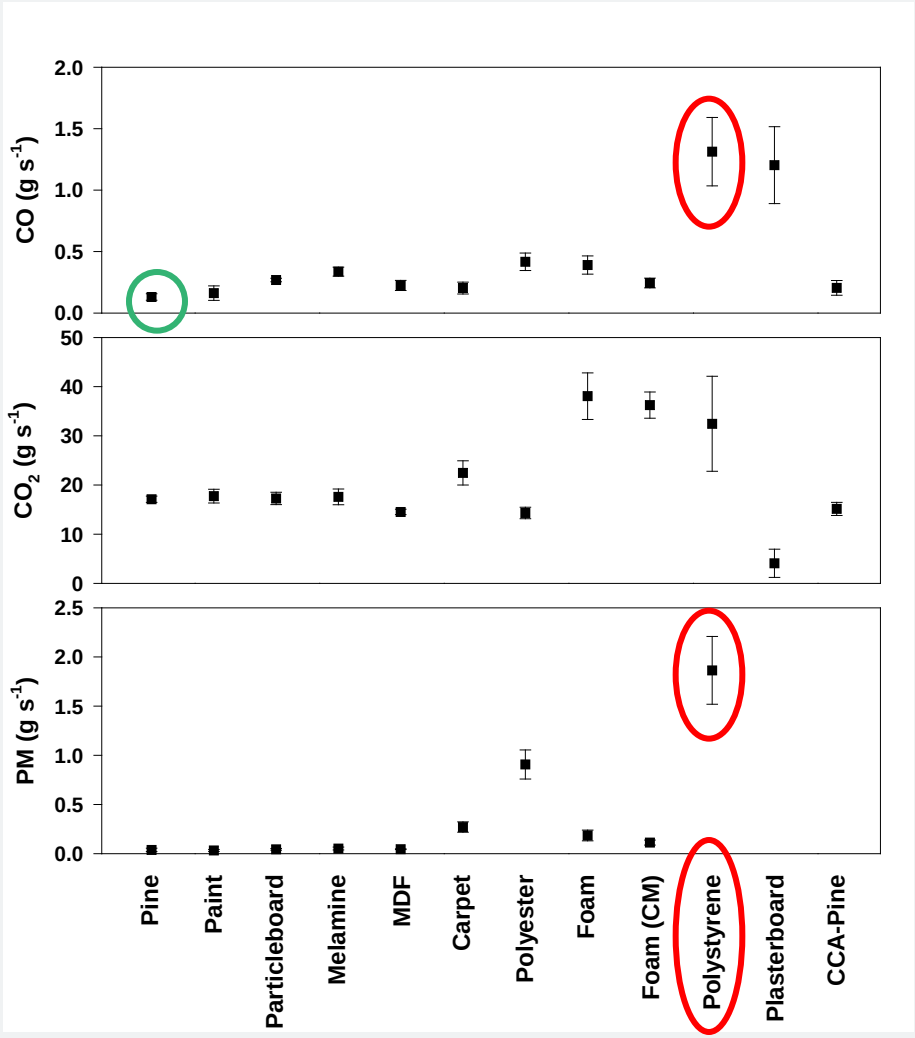


EMISSIONS OF CO, CO_2 AND PARTICLES

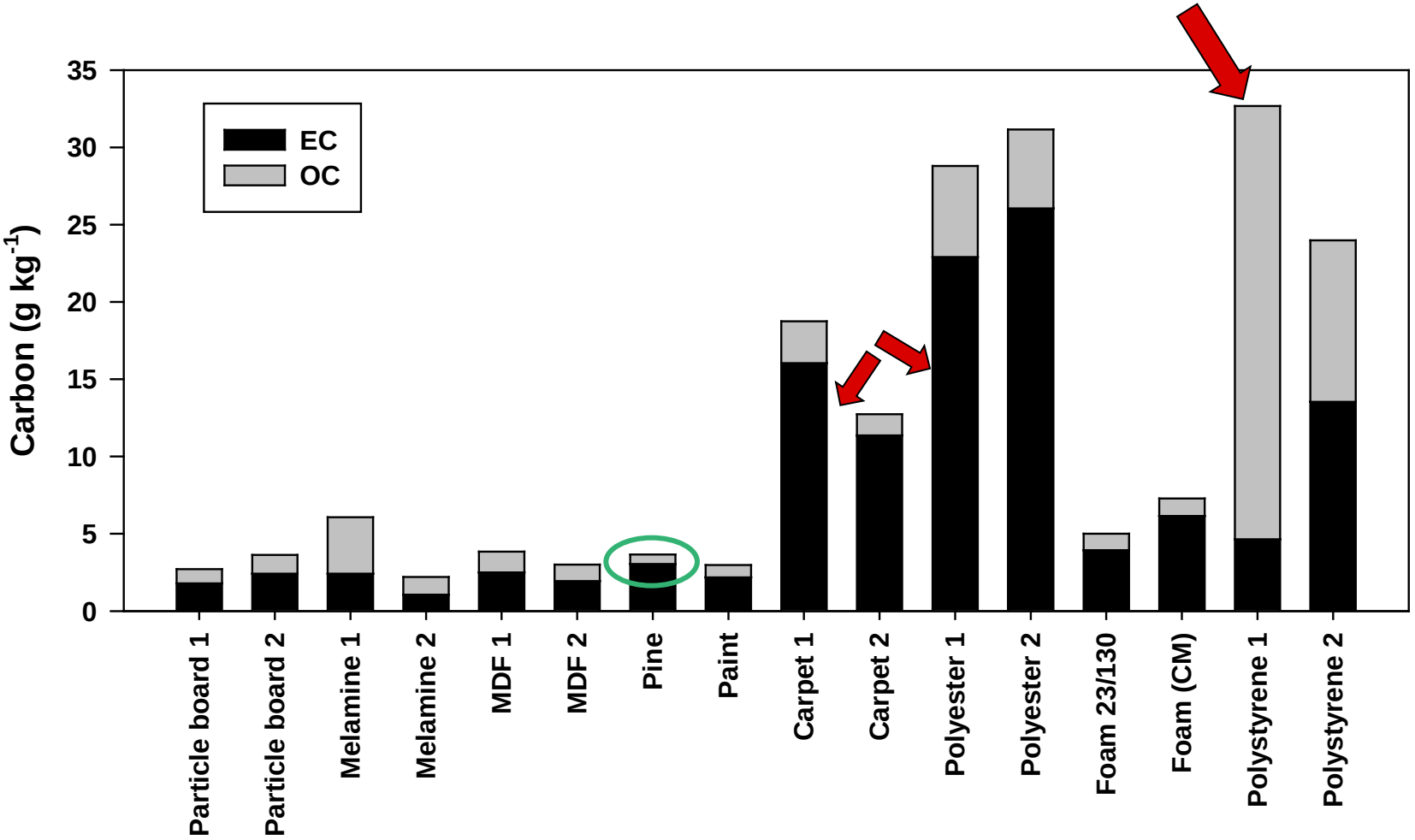
Emission factors (g/kg)



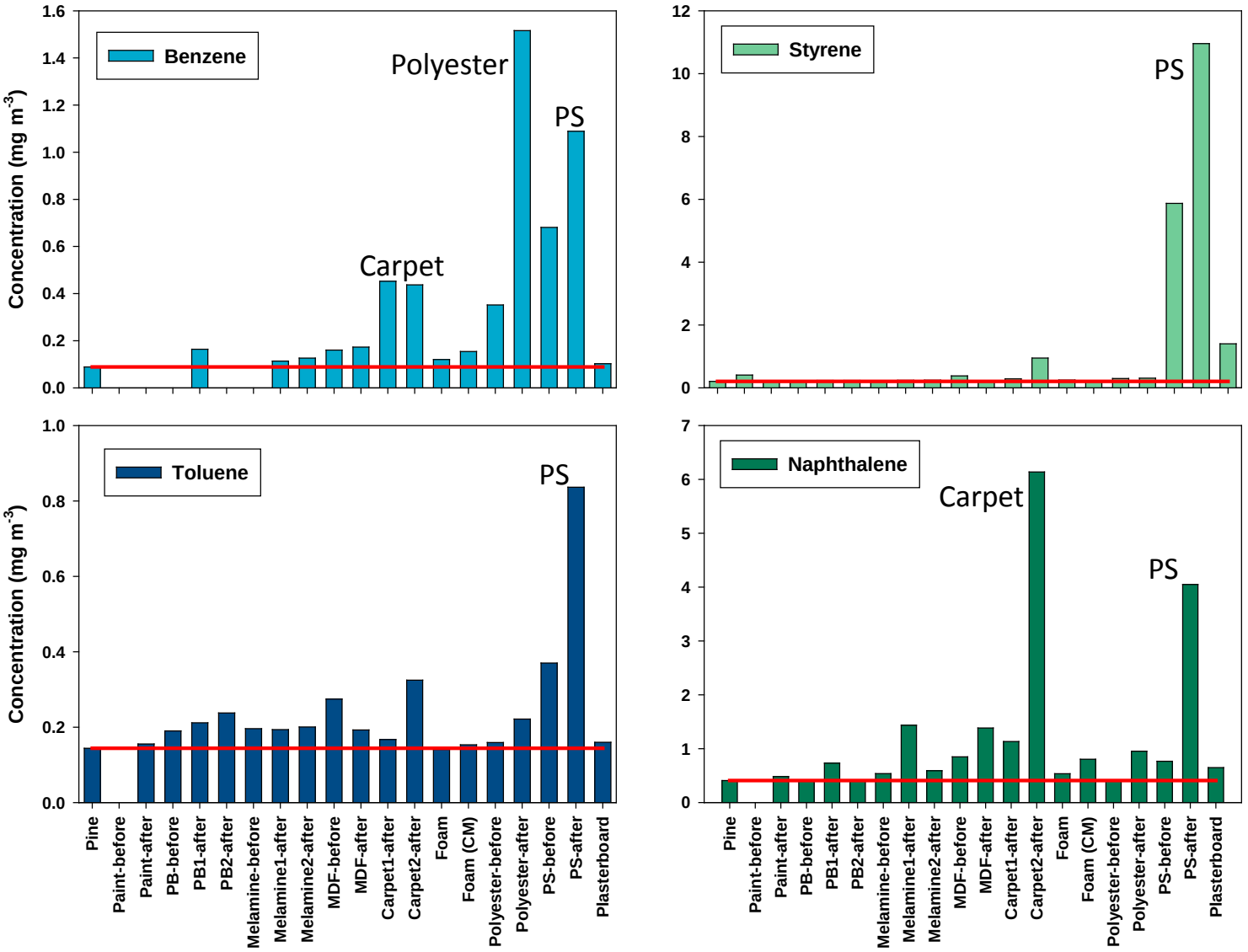
Emission rates (g/s)



ELEMENTAL AND ORGANIC CARBON



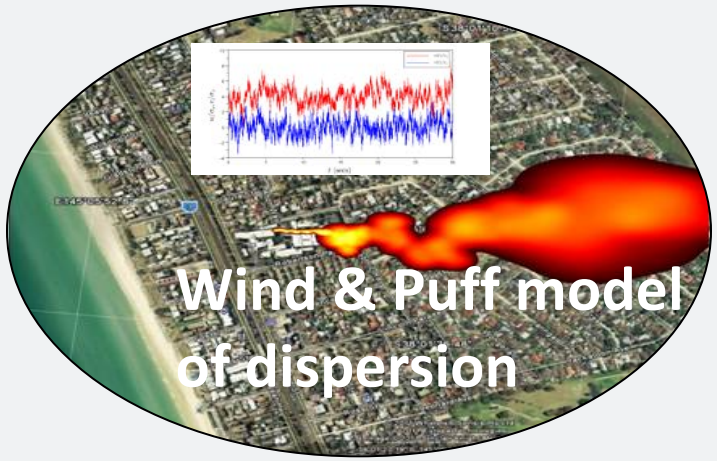
VOLATILE ORGANIC COMPOUNDS



UNCERTAINTIES

- Variability in fire conditions : **ventilation** and **temperature** have an effect on composition and amount of combustion products emitted
  - ⇨ **Variability in emission factors**
- Fire geometry – influence on emission yields
- Pure materials vs. mixture of materials

III. DISPERSION

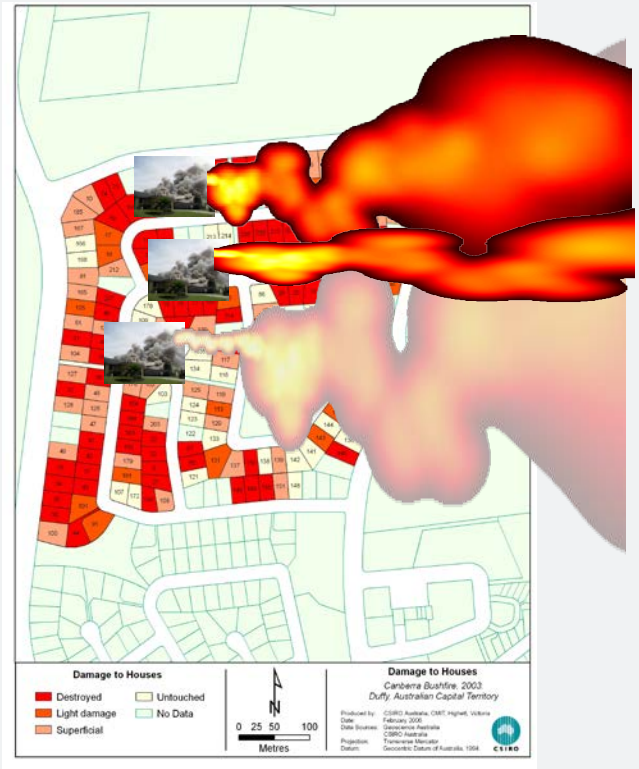


Combustion products

Exposure/Ground concentration

PUFF-GENERATED PLUMES

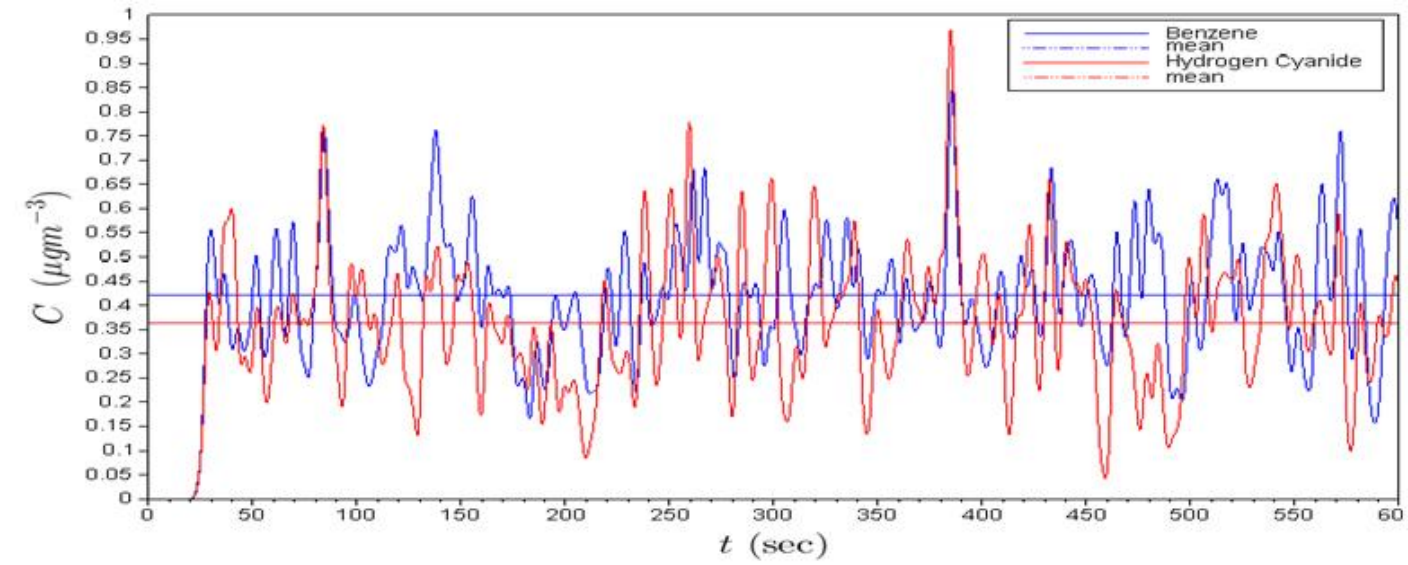
- Finite number of point source emissions characterised by
  - a **scale** (single burning house or cluster, e.g. suburb)
  - **material** (heterogeneity)
  - **emission type**
  - estimate of **emission rates**

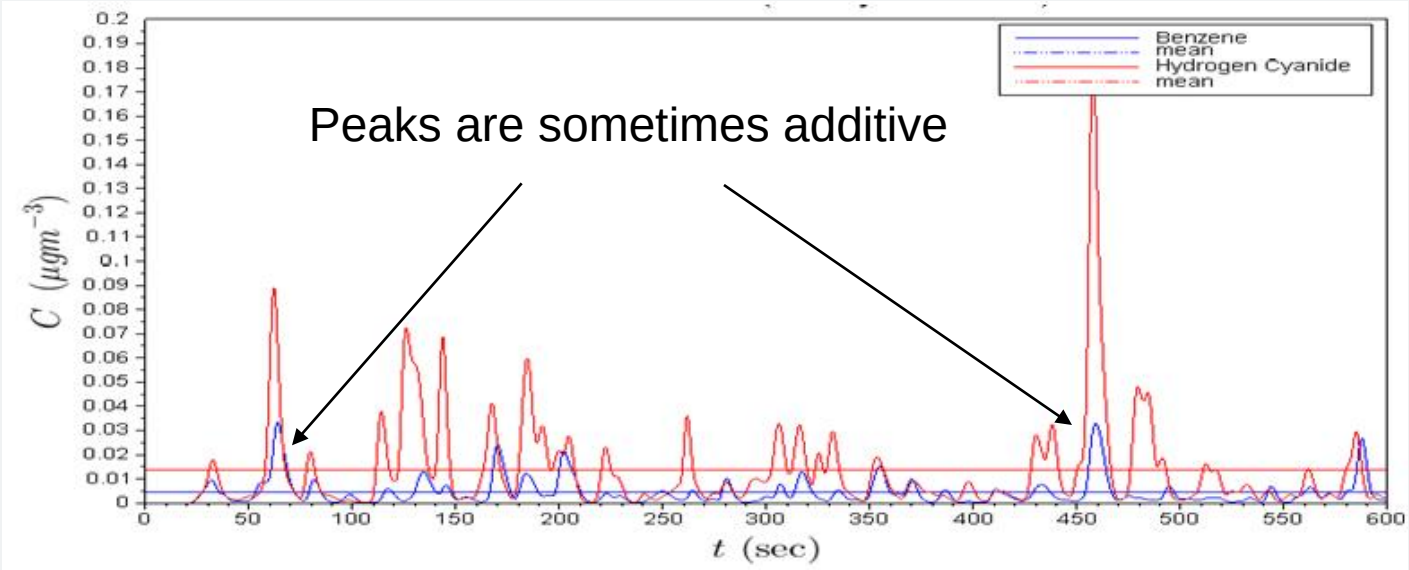


- Puff-generated plumes from multiple point sources coupled with complex of winds at source emissions – need **canopy characteristics**

- High time resolution for near field peak concentration exposures (1-min, 15-min)

MODELLED EXPOSURE CONCENTRATIONS





IV. EXPOSURE ASSESSMENT

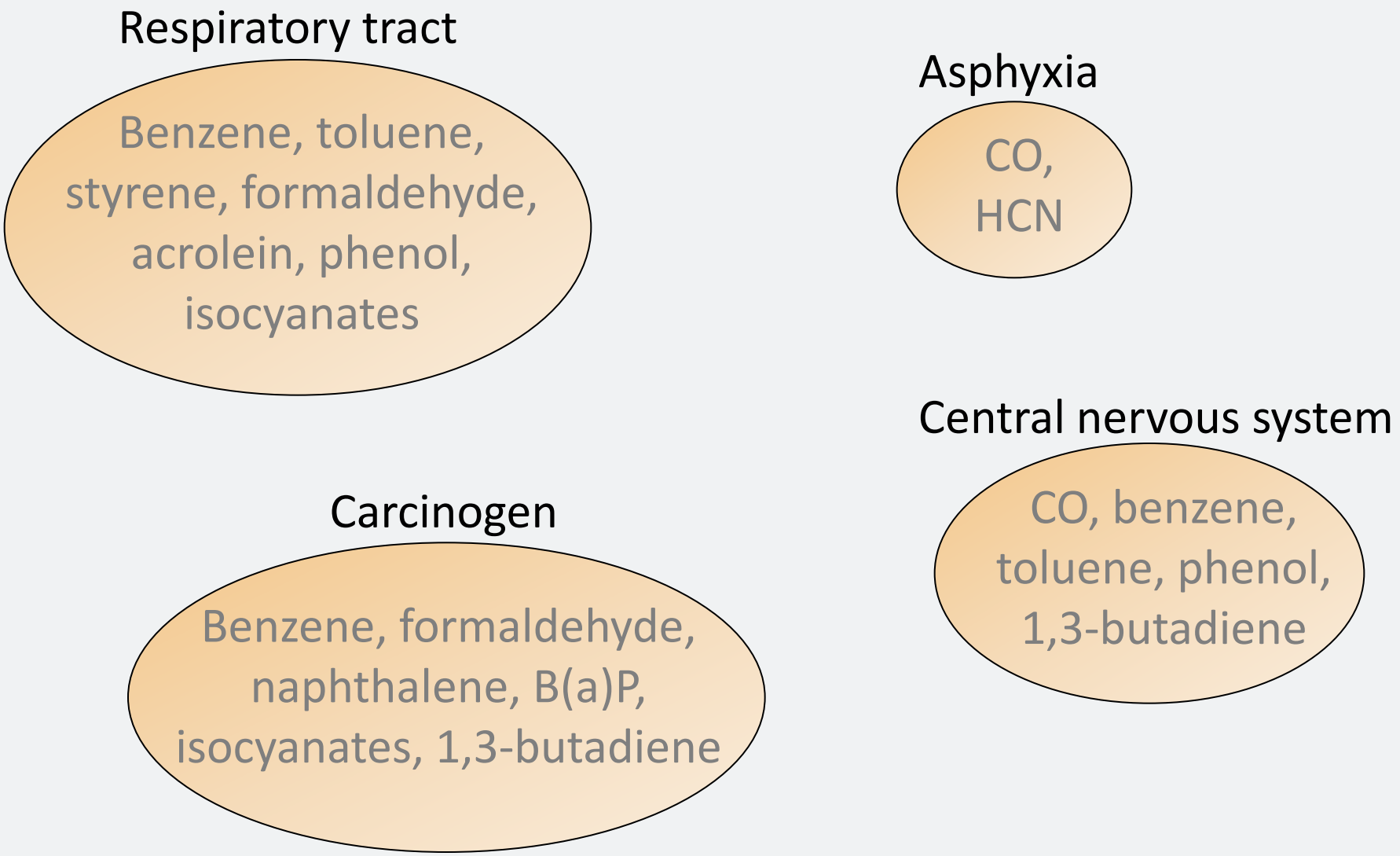
Compare modelled ground concentrations of key pollutants to occupational exposure standards

MODELLED GROUND CONCENTRATIONS

New dispersion model technique:

- Provides ground concentrations for a range of pollutants at short-time resolution
- Allows for peak, short-term and average workshift exposure assessment
- Takes into consideration exposures to a mixture of air pollutants which may have additive or synergistic effects

TARGET ORGANS



AIR TOXICS – HEALTH EFFECTS

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Air toxic	TWA (mg/m^3)	Health effect
CO_2	9000	Changes to respiratory patterns
CO	34	Asphyxiant
HCN	11 (peak)	Asphyxiant
NH_3	17	Respiratory irritant
NO	31	Hypoxia at high concentrations
NO_2	5.6	Respiratory irritant
HCl	7.5 (peak)	Severe irritant
SO_2	5.2	Irritant
Hydrocarbons	3.2 (benzene)	Irritant; asphyxiant; carcinogen
VOCs	1.2 (formaldehyde)	Irritant; probable carcinogens
PAHs	52 (naphthalene)	Irritant; probable carcinogens

EXPOSURE ASSESSMENT - UNCERTAINTIES

- Emission estimates for materials burnt and their spatial distribution within the RUI
- Firefighters' activities and position in relation to the smoke plume - **Detailed information on tactical approach in fighting bushfires at RUI**
- Changing meteorological conditions

⇨ Develop a useable set of scenarios

⇨ Compare modelled exposure concentrations to previously measured exposures at structural fire incidents

CURRENT OUTPUTS

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Posters

- AFAC/BFCRC conference 2010: Smoke impacts at the rural-urban interface
- AFAC/BFCRC conference 2011: Emissions from fires at the rural-urban interface
- AFAC/BFCRC conference 2012: Rural Urban Interface – Integrated emissions and smoke dispersion from burning buildings

Fire note

- Identifying smoke impacts from bushfires extending into the rural-urban interface

Reports

- Inventory of major materials present in and around houses and their combustion emission products (2011)
- Design of experimental burns (2011)
- Models for dispersion and exposure prediction of combustion emission products (2011)
- Toxic emissions from fires at the rural urban interface - Desktop study (2011)
- Electronic nose application in burning urban fringe (2012)
- Smoke and VOC dispersion integration in the burnt rural urban interface (2012)
- Exposures to toxic emissions from fires at the rural urban interface – Progress report (2012)

ADDITIONAL MONITORING

- Large scale burns – Agency involvement
  - Shed burn (determine materials)
  - Room burns with house contents
  - Facility to conduct burns

Input into model

- Exposure measurements at training and/or structural fires
  - Personal
    - **CO, HCN, NH3, H2S (Draeger monitor)**
    - PM
    - VOCs & Aldehydes
  - Area sampling

Validation of model

RESEARCH OUTPUTS/APPLICATION

- Communication Strategies
  - Final report – scenario based exposure assessment
  - Practical guide on exposure estimates – how fast does the risk escalate

THANK YOU

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