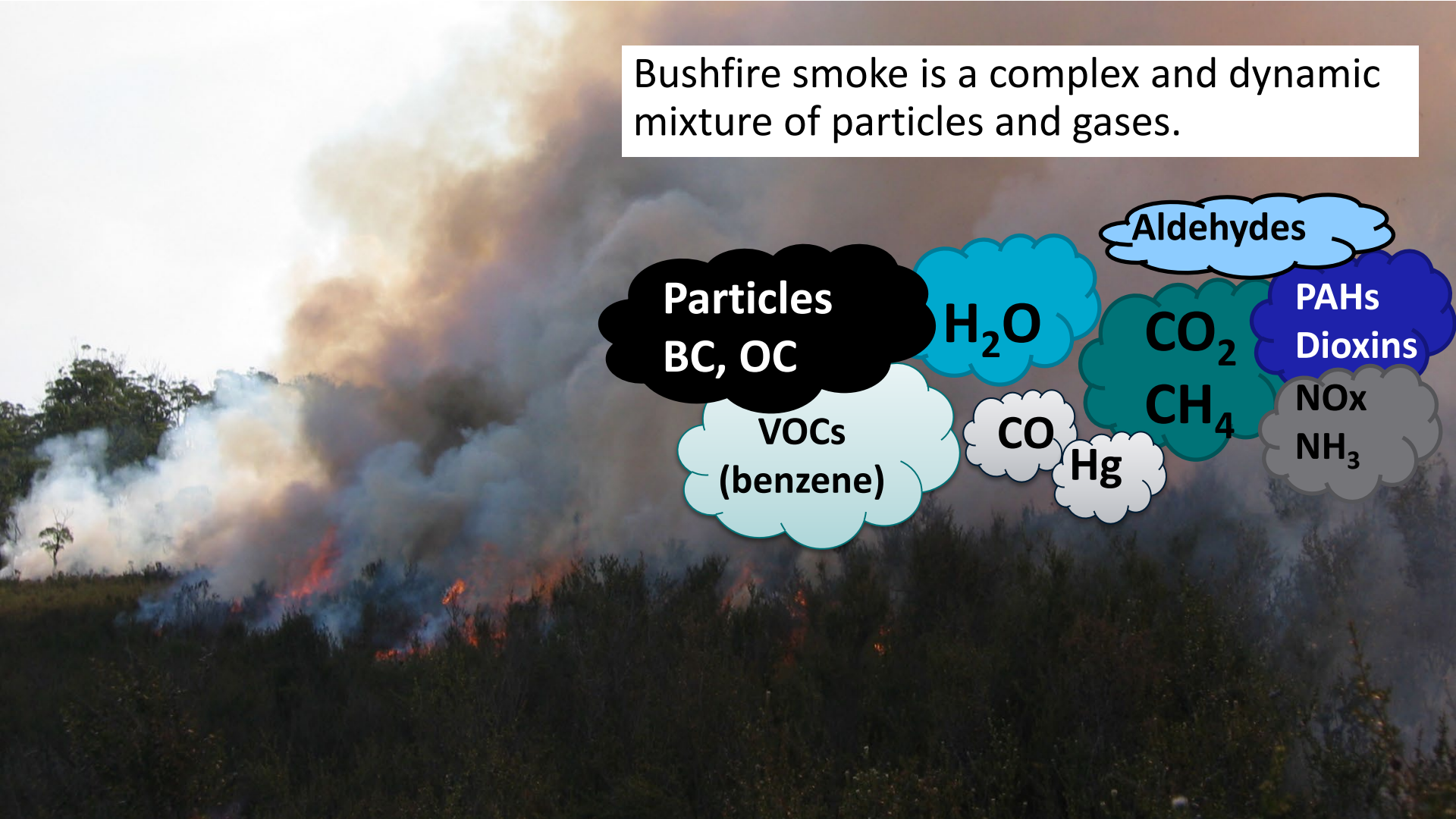
Smoke on the fire line

What can firefighters learn from smoke research for health management?

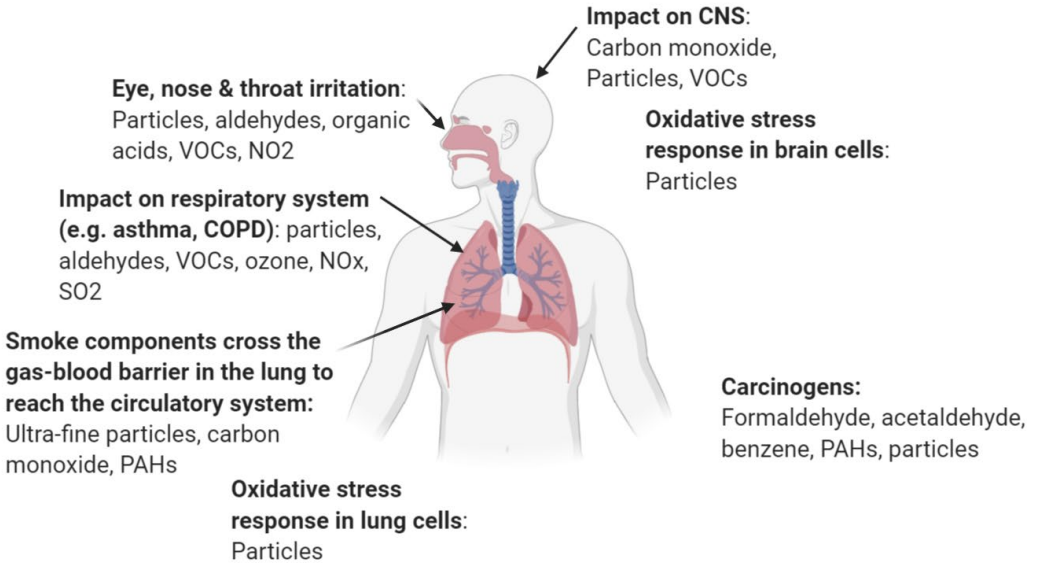
Fabienne Reisen | 2024 Fire Summit, Melbourne 26-27 June 2024

Bushfire smoke is a complex and dynamic mixture of particles and gases.



How can bushfire smoke impact health?

- **Acute** – brief exposure (from seconds to hours) to high/very high concentrations of a toxic chemical
- **Sub-acute** - accumulation of chemicals or their metabolites in the body
- **Chronic** – prolonged or repeated exposure over many days, months or years
- **Cumulative** - exposure to multiple toxins present in bushfire smoke resulting in additive and/or synergistic health effects




Hazard
Exposure
Health impact

What factors drive smoke emissions?

- Fire characteristics
- Fuel characteristics
- Combustion conditions
- Weather conditions

EFs for pyrogenic species emitted from various types of biomass burning.

Species	Savanna and grassland			Tropical forest			Temperate forest			Boreal forest			Peat fires			Agricultural residues		
	average	SD	N	average	SD	N	average	SD	N	average	SD	N	average	SD	N	average	SD	N
CO2	1660	90	31	1620	70	9	1570	130	39	1530	140	14	1590	150	6	1430	230	29
CO	69	20	50	104	39	16	113	50	47	121	47	22	260	23	6	76	55	39
CH4	2.7	2.2	49	6.5	1.6	13	5.2	2.8	37	5.5	2.5	20	9.1	1.5	6	5.7	6.0	20
VOC	5.1	5.9	14	5.6	1.5	4	13.4	11.8	13	6.0	2.9	8	*21*	-	*0*	7.6	8.0	12
Benzene	0.33	0.22	19	0.38	0.05	4	0.42	0.17	17	0.57	0.21	7	0.87	-	2	0.27	0.19	17
Toluene	0.19	0.14	17	0.23	0.04	4	0.27	0.15	16	0.35	0.11	6	0.45	-	2	0.17	0.10	17
Formaldehyde	1.23	0.65	16	2.40	0.63	3	2.04	0.70	16	1.75	0.40	4	1.07	0.44	3	1.8	0.6	8
PM2.5	6.7	3.3	20	8.3	3.3	9	18.5	14.4	29	18.7	15.9	5	18.9	2.3	3	8.2	4.4	18
OC	3.0	1.5	15	4.4	1.9	5	10.9	7.2	13	5.9	2.5	3	14.2	-	2	4.9	3.6	20
BC or EC	0.53	0.35	18	0.51	0.34	8	0.55	0.36	14	0.43	0.21	4	0.10	-	3	0.42	0.28	24

Andreae (2019) Atmos. Chem. Phys., 19, 8523–8546, https://doi.org/10.5194/acp-19-8523-2019

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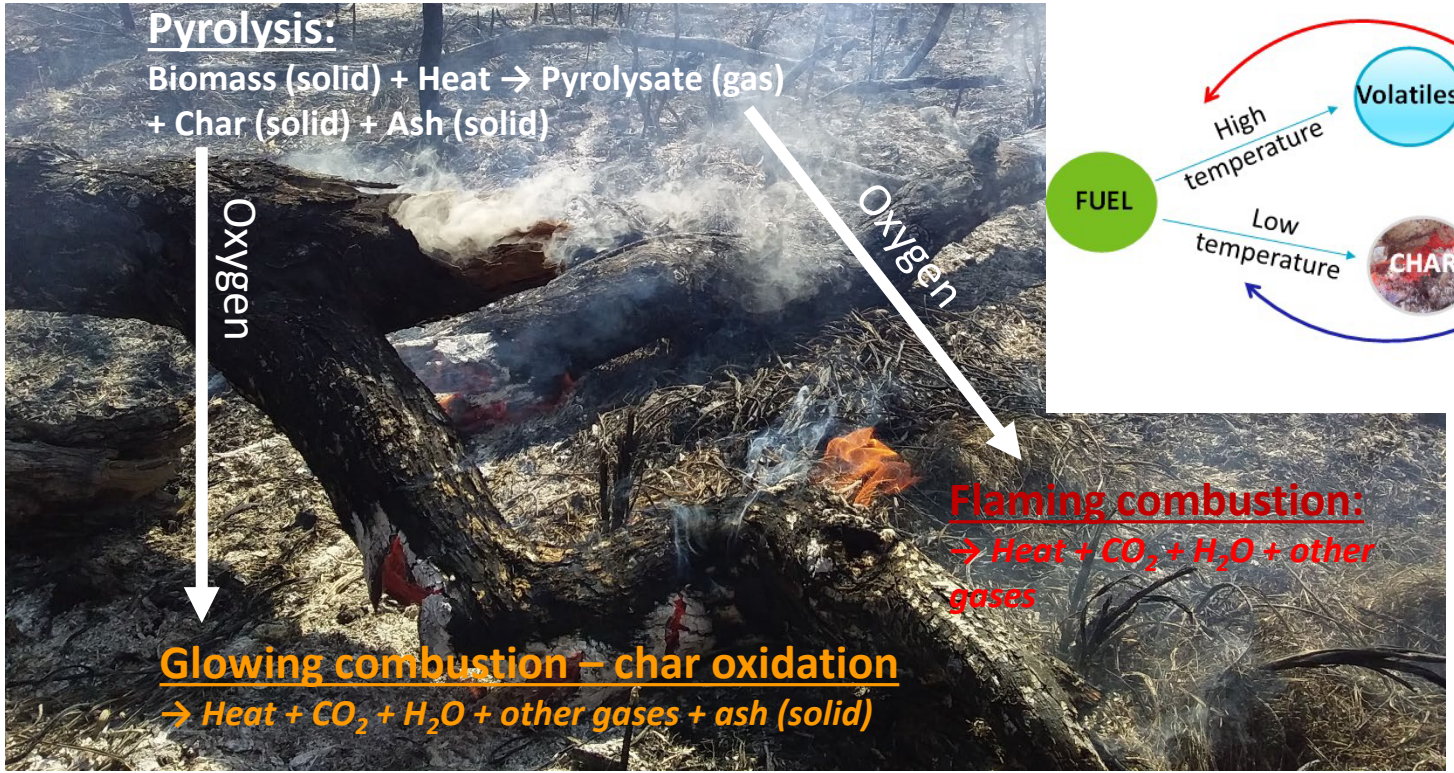
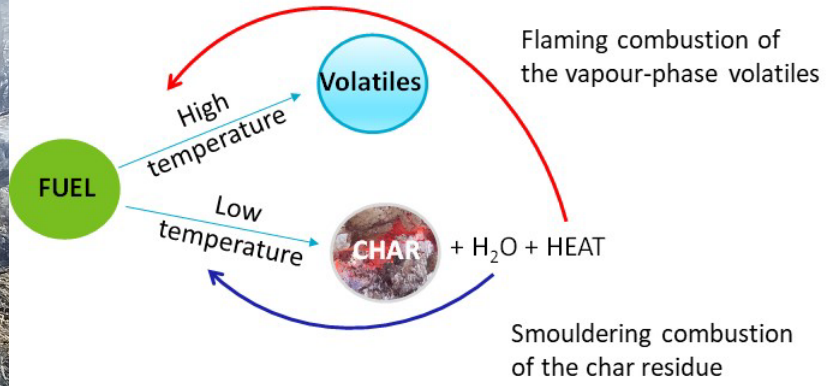
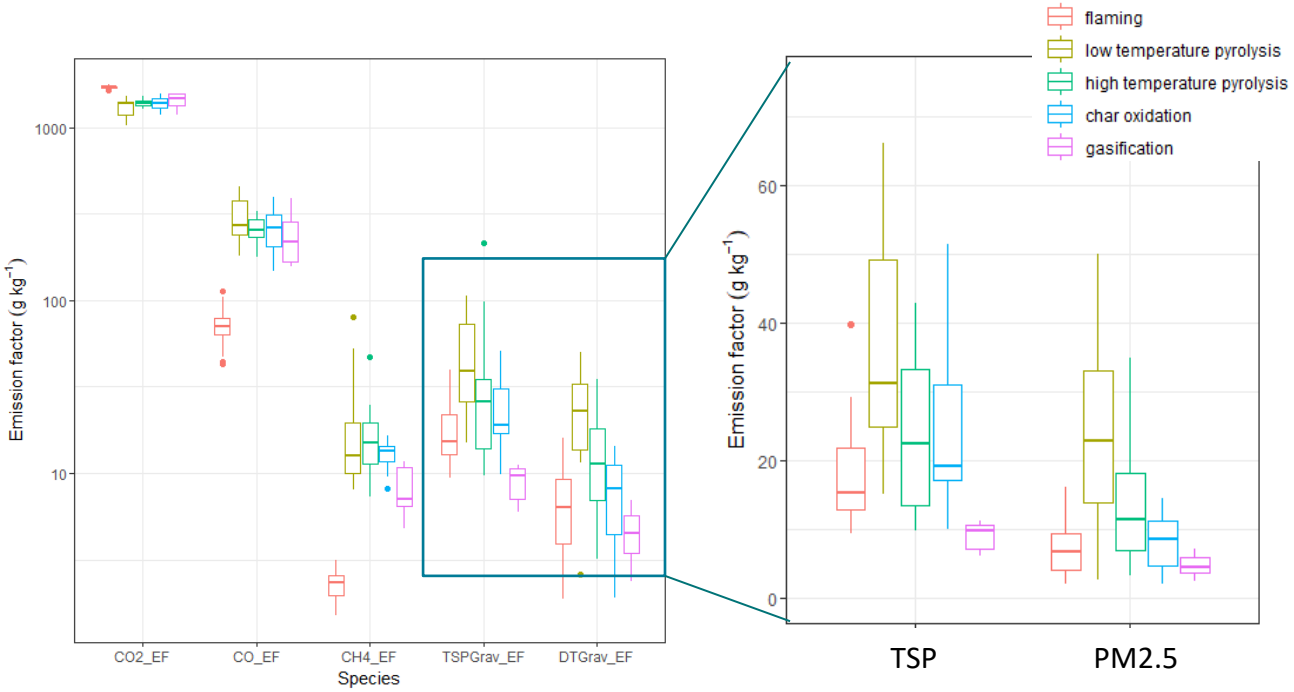
Combustion conditions



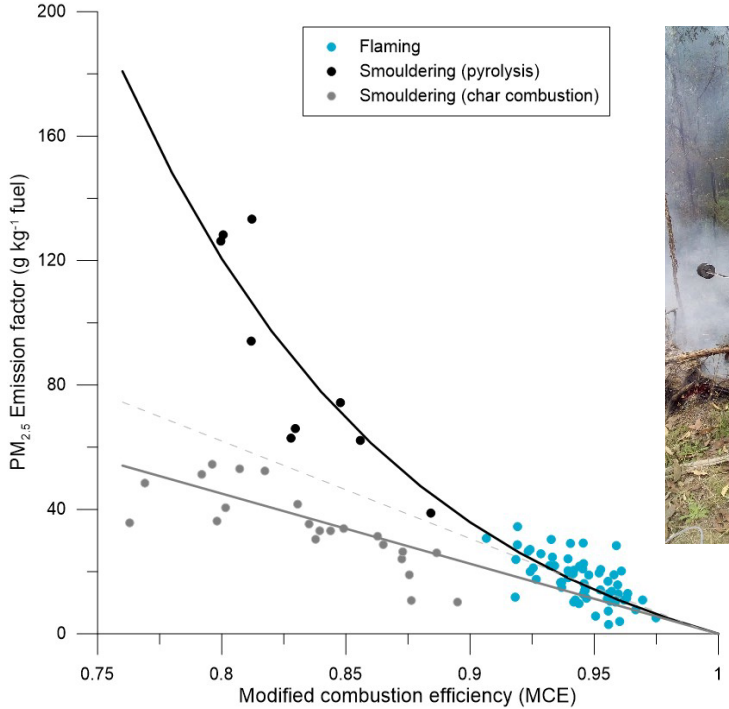


Emissions as a function of combustion process

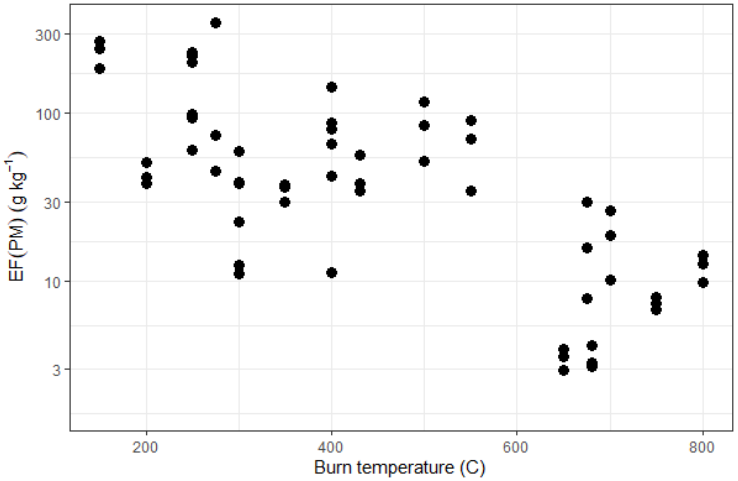


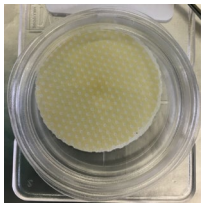
Particle emissions and composition driven by combustion efficiency and temperature

Increasing PM



Increasing CO





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What factors drive exposure?

- Work activities
- Proximity to fire/smoke
- Ignition pattern
  - Edge ignition
  - Central ignition
  - Hand vs aerial
- Topography/Terrain
- Fuel characteristics
  - Fuel type
  - Fuel moisture
- Meteorology
  - Wind speed/direction
  - Inversions

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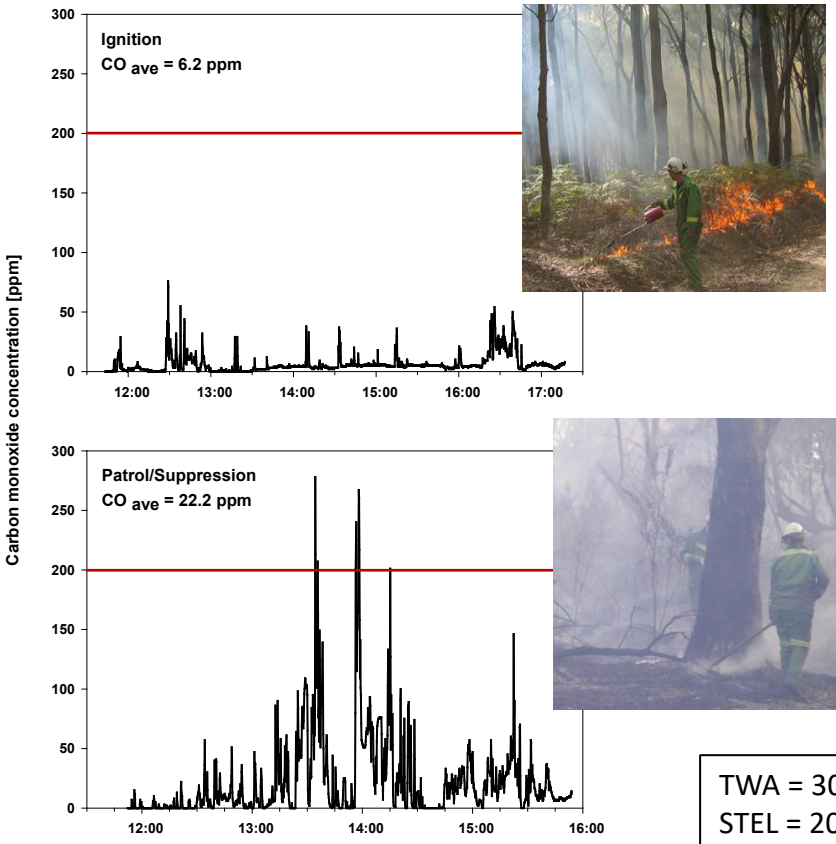
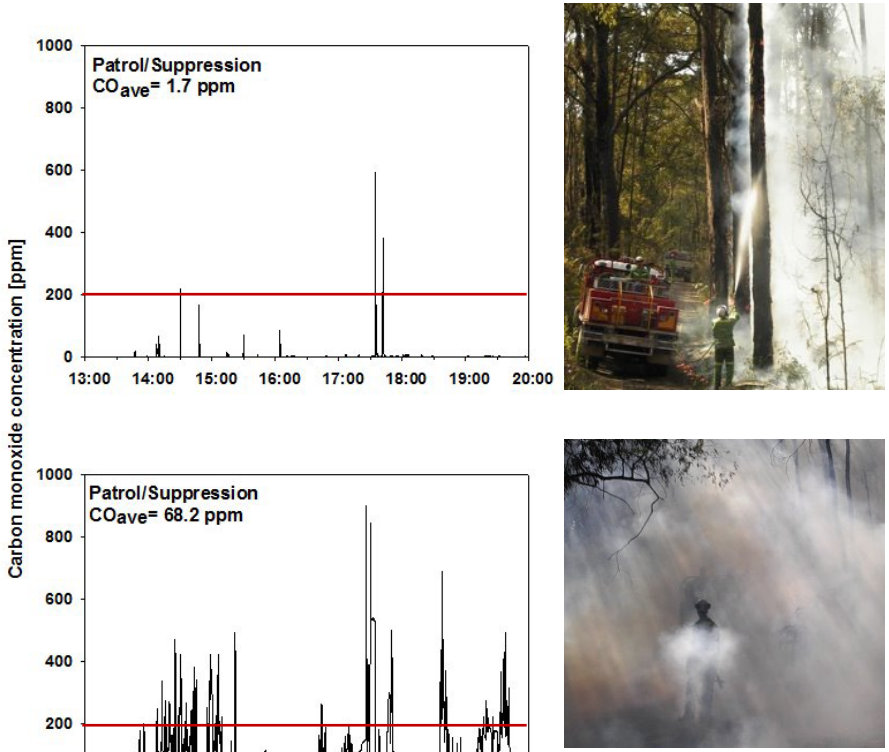
Work activity

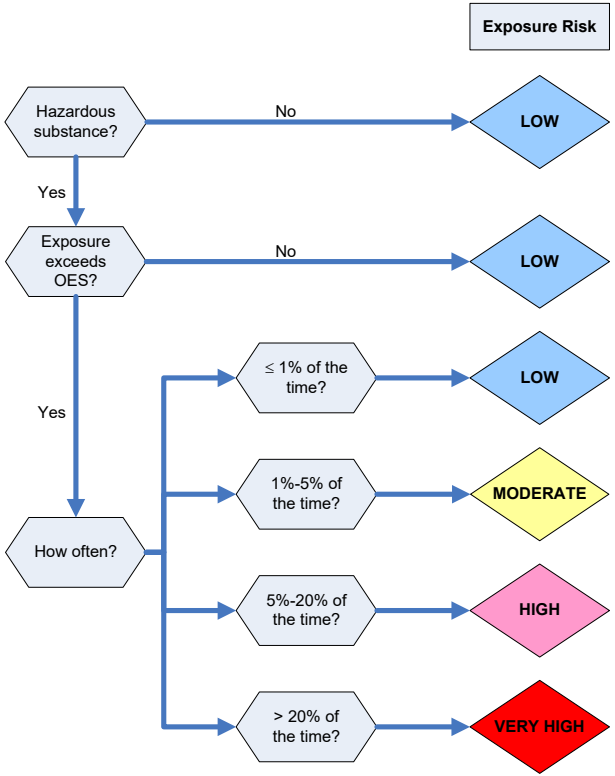


TWA = 30ppm
STEL = 200ppm

Burn conditions



Exposure Risk Assessment Methodology



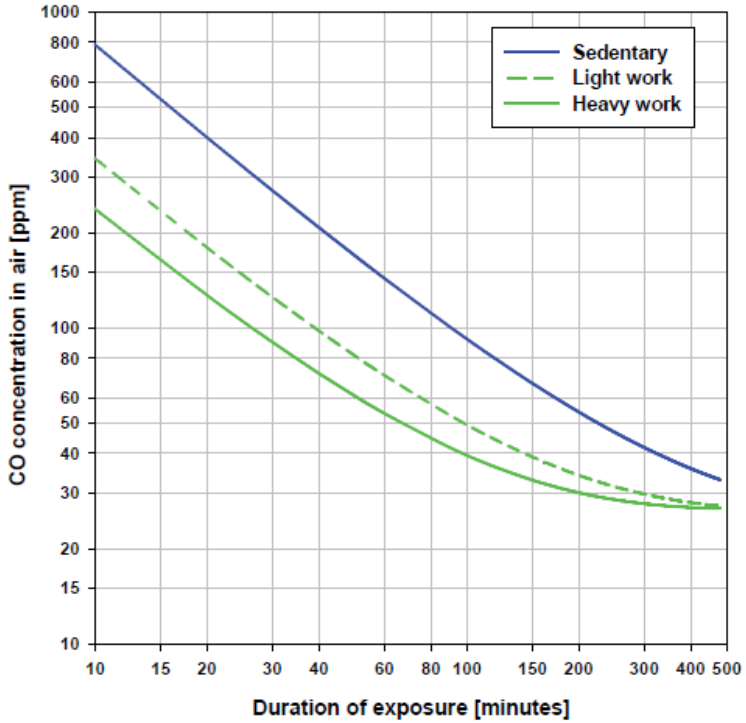
Adapted from American Industrial Hygiene Association rating scheme (Hawkins et al. 1991)

https://volunteerfirefighters.org.au/wp-content/uploads/2020/02/AFAC-managing-bushfire-smoke-exposure.pdf
https://www.bushfirecrc.com/resources/product/smoke-exposure-management-fire-ground-reference-guide

Other factors to consider

- Longer work shifts
- Heavy or strenuous work

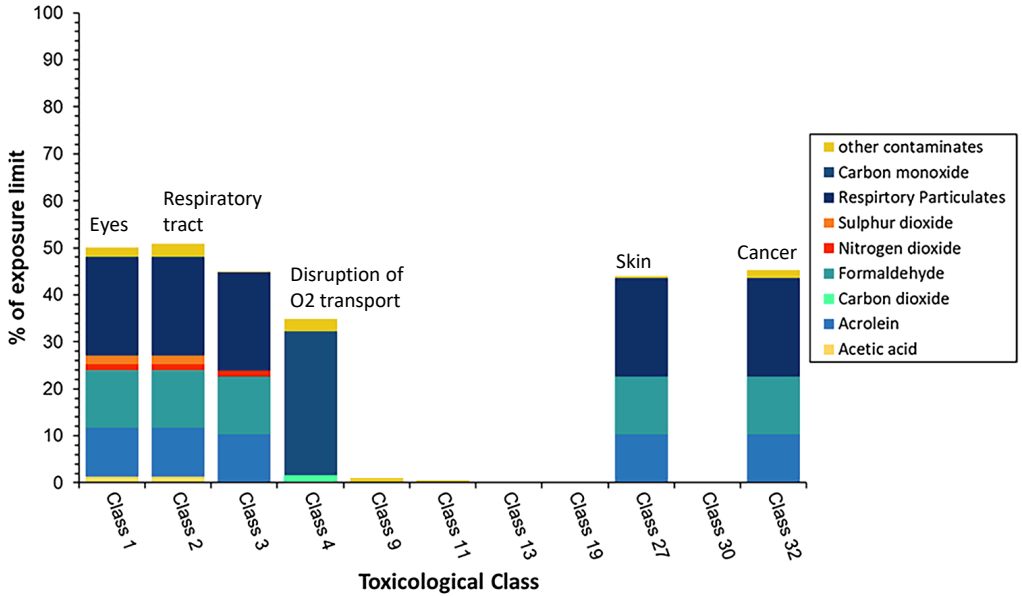
Length of time to achieve 5% COHb at various CO exposures and work activity levels



Other factors to consider

- Longer work shifts
- Heavy or strenuous work
- Additive/synergistic health effects

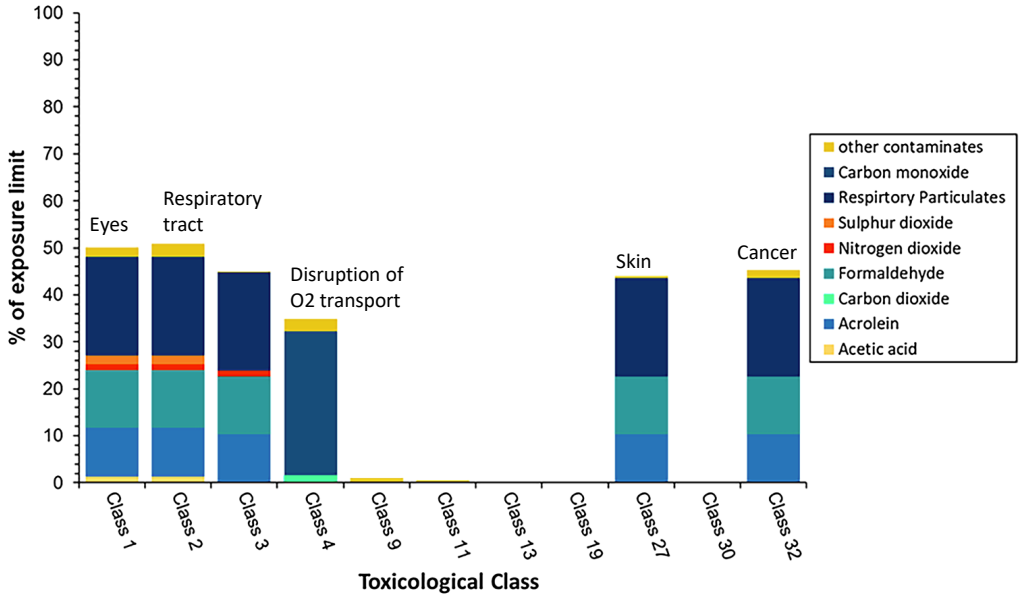
Major contributors are respirable particles, CO, formaldehyde and acrolein



MacSween et al (2019) Cumulative Firefighter Exposure to Multiple Toxins Emitted During Prescribed Burns in Australia.
Exposure and Health; https://doi.org/10.1007/s12403-019-00332-w

Other factors to consider

- Longer work shifts
- Heavy or strenuous work
- Additive/synergistic health effects
- Pre-existing health conditions



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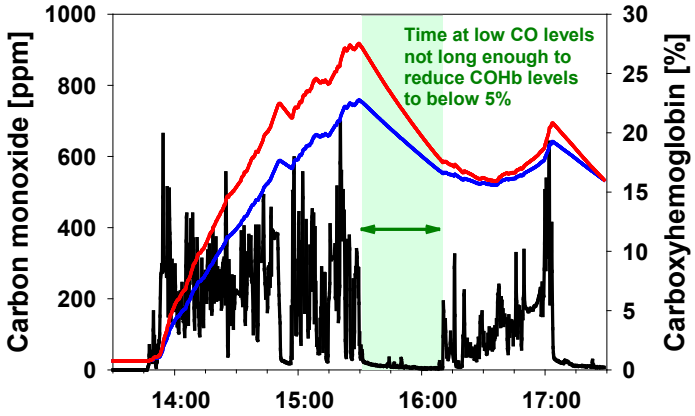
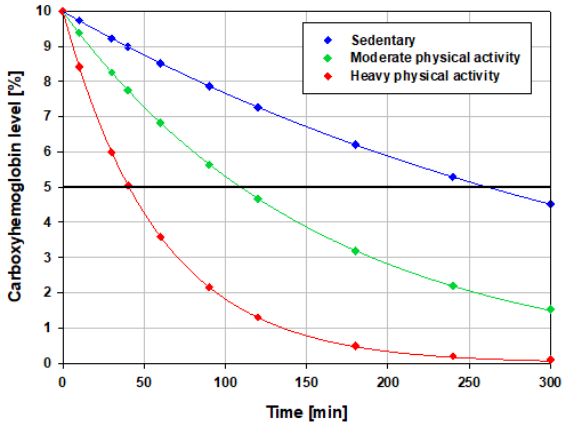
Monitor exposure time

Minimise time in dense smoke

Allow for sufficient recovery time



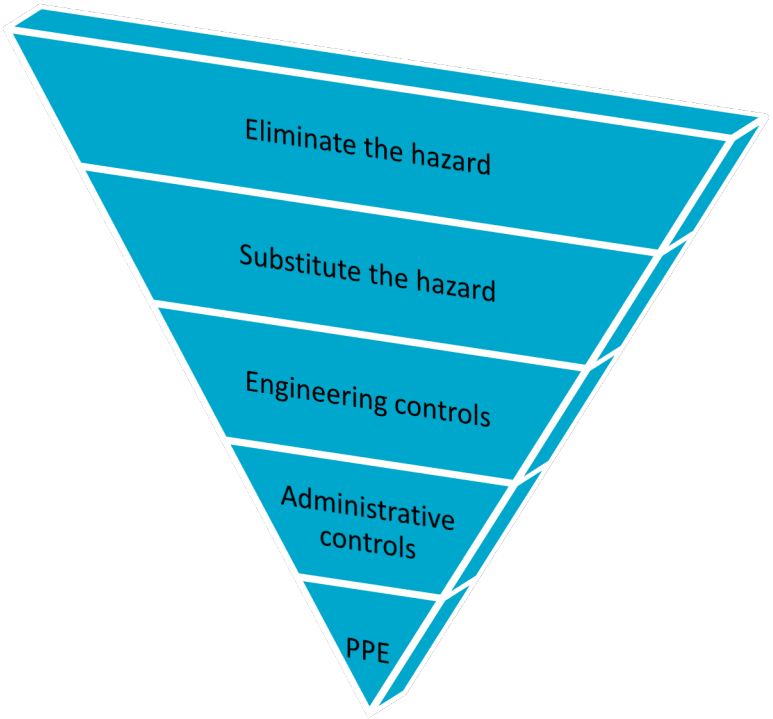
Monitor COHb levels



Insights and strategies

- Understanding the **harmful components** in bushfire smoke
- Recognizing specific **health risks/symptoms** from various smoke components
- Understanding the **conditions/factors** that have the potential to contribute to high levels of bushfire smoke exposure

- Minimising and monitoring exposure
  - Planning
  - Regular rotation of crews
  - Reducing time spent in heavy smoke
  - Recovery time
  - Health and environmental monitoring
  - Effective use of PPE



Thank you

Environment
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