Supplement of

Fuel types and fire severity effects on atmospheric pollutant emissions in an extreme wind-driven wildfire

Albert Alvarez et al.

Correspondence to: Albert Alvarez Nebot (a.alvarez@creaf.uab.cat)

S1. Method used to assess atmospheric emissions based on Seiler and Crutzen (1980).

To assess wildfire atmospheric emissions (French et al., 2011) at global (Thonicke et al., 2010; Wiedinmyer et al., 2011; Turquety et al., 2014) and biome level (Urbanski, 2014; van Leeuwen et al., 2014), previous studies have employed “the fire emissions model”. This model was originally defined by Seiler and Crutzen (1980), and was later adapted and applied to regional and local studies, including some of the largest wildfires in the world (Campbell et al., 2007; De Santis et al., 2010; Lavoué et al., 2007; Surawski et al., 2016; Won et al., 2012). Using this method, the amount of greenhouse gases released by fires is assessed by calculating the burnt area, the mass of available fuel load, the combustion factor and the emission factor. The mass of available fuel load represents the existing total biomass before the wildfire (French et al., 2011; Ottmar, 2014; Urbanski, 2014). This includes all the different biomass layers consumed in high-intensity wildfires that release greenhouse gases into the atmosphere (e.g. young trees, shrubs, grasses, litter), which are often not quantified using field data (Garcia-Hurtado et al., 2013; Domingo et al., 2017). The combustion factor is defined as the fraction of pre-fire fuel consumed during the fire event (French et al., 2011; Chiriacó et al., 2013). Previous studies on fuel consumption are usually based on look-up tables of biome average values from literature, or they are calculated from global vegetation or biogeochemical models (Chiriacó et al., 2013; van Leeuwen et al., 2014). Finally, the emission factor provides the mass of a compound emitted per mass of dry fuel consumed (Urbanski, 2014). There are compiled emission factor data from a wide range of regions and vegetation types, determined under natural conditions, in the laboratory and at biome-specific level (Andreae and Merlet, 2001; Akagi et al., 2011), especially in the USA and Canada (Prichard et al., 2020; Urbanski et al., 2022).

Supplementary Tables and Figures

Table S1. Main characteristics of the four fuel types in *Pinus* and *Quercus* forests

Fuel type	Structural characteristics	Fire behavior	Dominant fire type
1	Open forest structures with variable proportion of large trees. Very low tree density (<500 trees ha^{-1}), which means very low tree horizontal continuity	Fire cannot spread as an active crown fire but, depending on vertical continuity and surface fuel load, they can burn either as a surface fire or a passive crown fire	Passive crown fire
2	High proportion (>85%) of one layer of large trees and low vertical continuity. Low tree density (<1300 trees^{-1}) with intermediate horizontal continuity	Fire has difficulties climbing up the canopies and usually burns as a surface fire. If it reaches the canopies, it can generate passive or, in very few cases, an active crown fire	Surface fire
3	Three groups of forest structures with high vertical or horizontal continuity	Fire has a lot of points for jumping to canopies, which means that a passive crown	Both passive and active crown fire

	(a) Structures with low vertical continuity (>85% of large trees) but high horizontal continuity (density > 1300 trees ha^{-1}) (b) Structures with two layers with moderate vertical continuity (60–85% of large trees) and a second layer below. Moderate or high horizontal continuity (density > 1300 trees ha^{-1}). (c) Structures with high vertical continuity (<60% of large trees) but low horizontal continuity (density < 1300 trees ha^{-1})	fire is a common occurrence. Under extreme meteorological conditions with moderate horizontal continuity this fuel type can burn as an active crown fire	
4	Proportion of large trees lower than 60% with high vertical continuity. High tree density (d > 1300 trees ha^{-1}) with high horizontal continuity	With vertical and horizontal continuity, a crown fire can be sustained under extreme meteorological conditions	Active crown fire

Table S2. Results of the multiple linear regression models (MLR) using plots from the IFN3 from the Alt Empordà region for explaining shrub total biomass (Mg/ha) A) in *Q. suber* plots using shrub cover (%) and presence or absence of *Erica arborea* in the plot (n=83); B) in *P. halepensis* plots of IFN3 in the Alt Empordà region (Mg/ha) using shrub cover (%) (n=51).

A) Total biomass in *Quercus suber* understory (Mg/ha)

Parameter	**Coefficient**	**SE**	**t value**	**P**
Intercept	3.680	1.220	3.0	**0.003**
Shrub cover	0.098	0.013	7.2	**<0.001**
Presence of *Erica Arborea*	-3.340	0.639	-5.2	**<0.001**

B) Total biomass in *Pinus halepensis* understory (Mg/ha)

Parameter	**Coefficient**	**SE**	**t value**	**P**
Intercept	1.990	0.970	2.0	**0.045**
Shrub cover	0.120	0.010	11.8	**<0.001**

Table S3. Results of the multiple linear regression models (MLR) using plots from the IFN3 from the Alt Empordà region for explaining fine shrub total biomass (Mg/ha) using total shrub biomass A) in *Quercus suber* plots (n=80), B) in *Pinus halepensis* plots (n=50).

A) Fine biomass in *Quercus suber* understory (Mg/ha)

Parameter	**Coefficient**	**SE**	**t value**	**P**
Intercept	1.770	0.370	4.7	**<0.001**
Total shrub biomass	0.400	0.030	11.9	**<0.001**

B) Fine biomass in *Pinus halepensis* understory (Mg/ha)

Parameter	**Coefficient**	**SE**	**t value**	**P**
Intercept	0.350	0.330	1.1	**0.287**
Total shrub biomass	0.600	0.025	24.3	**<0.001**

Table S4. Results of the multiple linear regression models (MLR) using plots from the Ecological Forestry Inventory of Catalonia for explaining litter biomass (Mg/ha): A) in *Quercus suber* plots from the Girona province (n=86); B) in *Pinus halepensis* plots from the Girona and Barcelona provinces (n=190). In the two cases litter biomass was with log-transformed.

A) Litter biomass in *Quercus suber* plots (Mg/ha)

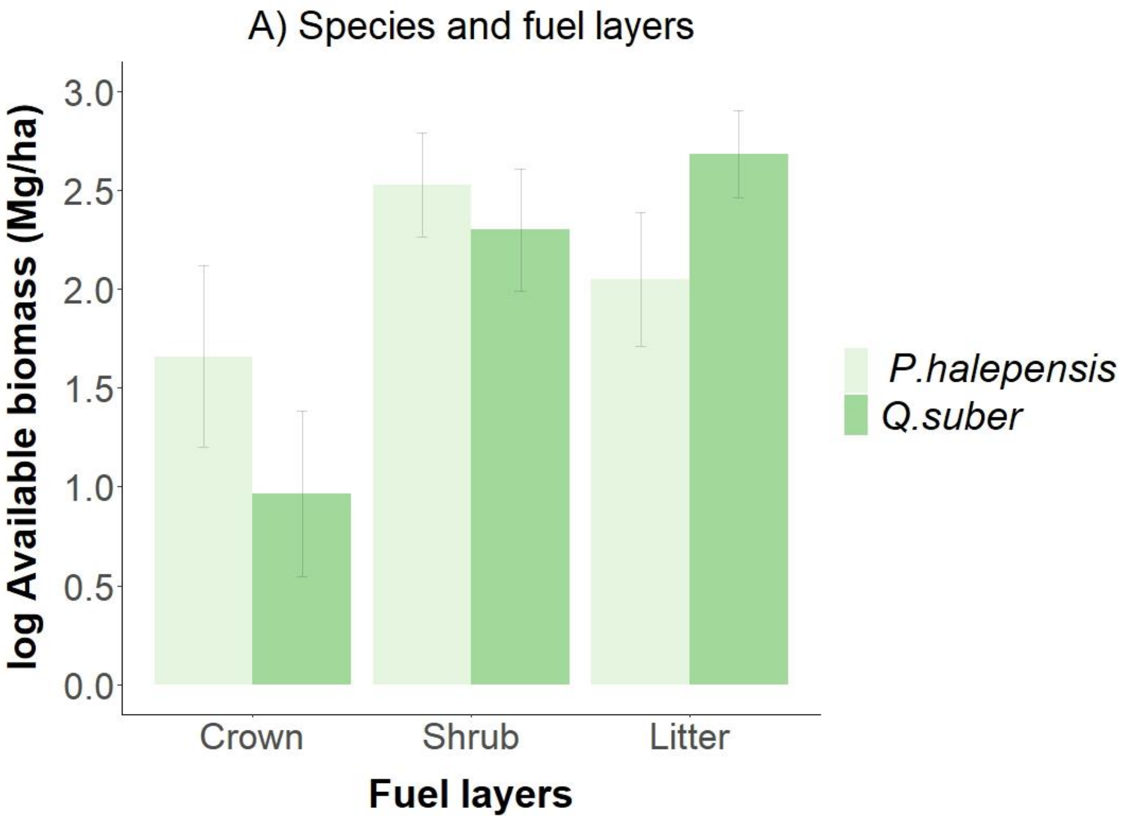
Parameter	**Coefficient**	**SE**	**t value**	**P**
Intercept	22.740	2.700	8.4	**<0.001**
Slope	-0.150	0.070	-2.2	**0.031**
Tree density	0.002	0.001	2.5	**0.013**
Shrub cover	-0.102	0.026	-3.8	**<0.001**
Recent fire	-5.840	1.610	-3.6	**<0.001**

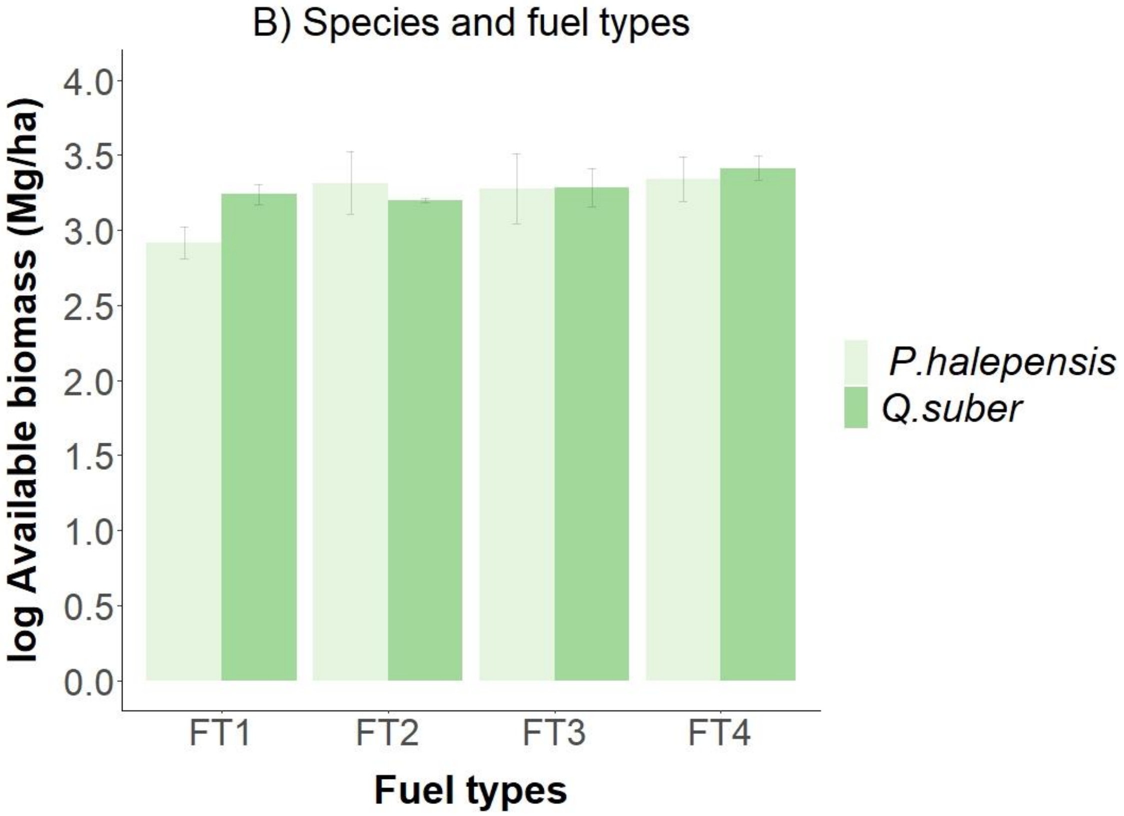
B) Litter biomass in *Pinus halepensis* plots (Mg/ha)

Parameter	**Coefficient**	**SE**	**t value**	**P**
Intercept	2.580	0.400	6.4	**<0.001**
% Dominant tree basal area	-0.016	0.004	-4.3	**<0.001**
Total tree basal area	0.025	0.006	2.0	**<0.001**
Shrub cover	0.004	0.002	2.0	**0.043**
Recent fire	-0.463	0.176	-2.6	**0.009**

Table S5. Average emission factors (g kg $^{-1}$ fuel burned dry basis) and the main atmospheric pollutants per forest type (*Quercus* vs *Pinus*) and fraction type (crown, shrub, litter) obtained from the literature.

Strata	**Forest type**	**Source**	CO_2	CO	CH_4	$PM_{2.5}$
Crown	*P. halepensis*	Fernandes et al. (2022)	1497	100	6	9
	Q. suber	Fernandes et al. (2022)	1393	128	6	11
Shrubs	The two forest types	Miranda (2005)	1477	82	4	9
Litter	*P. halepensis*	Pallozi et al. (2018)	1228	167	0.3	9.7
	Q. suber	Pallozi et al. (2018)	984	124	0.1	9





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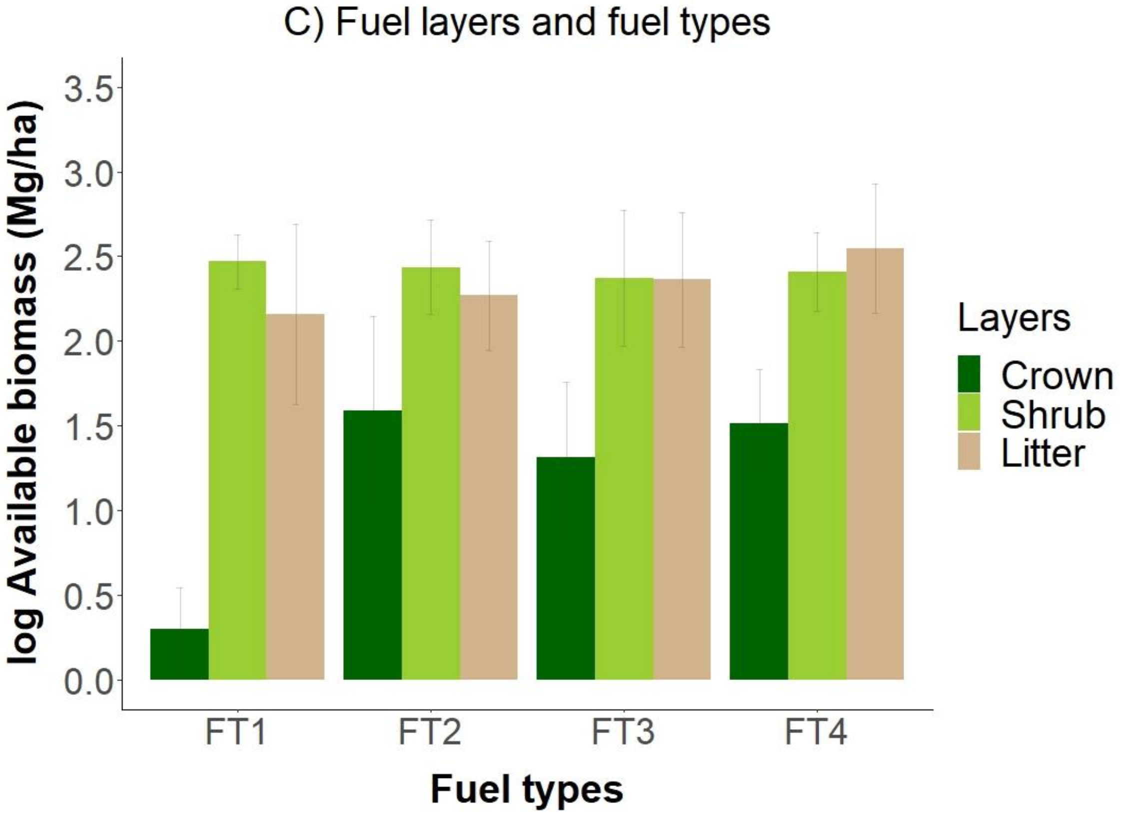

Figure S1. Mean (± standard deviation) values of log available biomass (Mg/ha) with significant bivariate interactions between A) Species and fuel layers, B) Species and fuel types, and C) Fuel layers and fuel types.

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