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Supplementary Material

Improved laboratory method to test flammability metrics of live plants under dynamic conditions and future implications

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Calculation method of bulk volume

Bulk volume of each sample V_{bulk} was obtained by calculating a sector of volume of a solid of revolution. A solid of revolution is a solid 3D figure obtained by rotating a plane curve around the axis of revolution (*x* axis in our particular case). To do so we required to characterize the geometry of our samples. Figure S1 shows side and front views for *Acacia, Cassinia* and *Pinus* samples. Volume of Bark samples was calculated as the volume of parallelepiped.

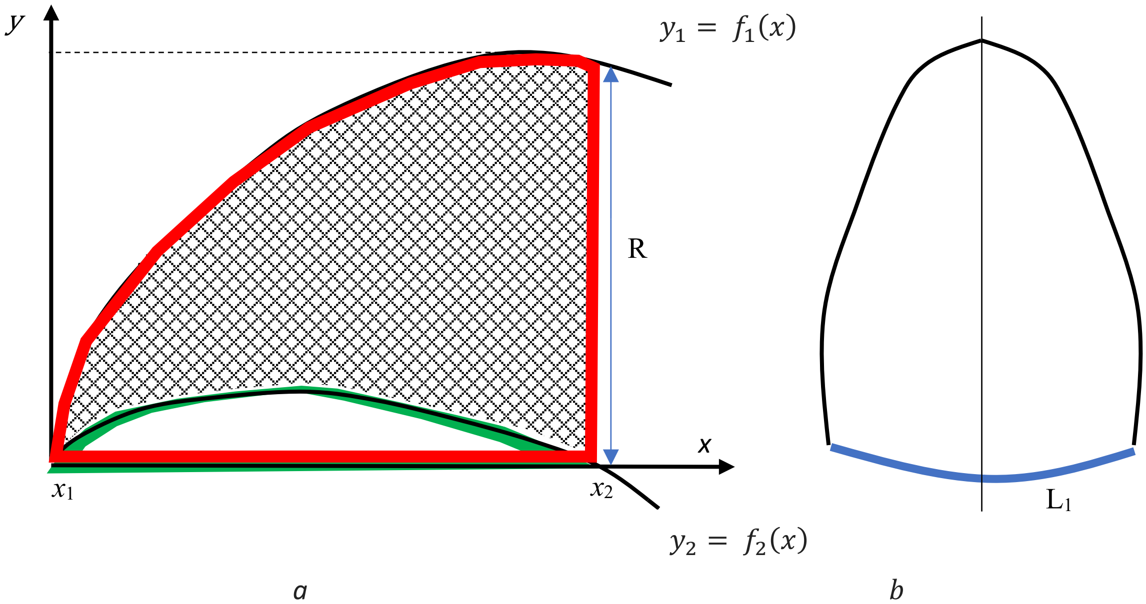

Figure S1. Geometry of sample: (*a*) side view and (*b*) front view. Where $y_1 = f_1(x)$ and $y_2 = f_2(x)$ are the rotation curves; x_1 and x_2 are the sample dimensions; R is radius of the sample base; L_1 is length of the base sector (blue line).

The volume of the solid *V* (hatched area) formed by rotating the area between the curves $y_1 = f_1(x)$ and $y_2 = f_2(x)$ and the lines $x=x_1$ and $x=x_2$ about the *x*-axis can be calculated using the following equations:

$$V = V_1 - V_2, \tag{S1}$$

$$V_1 = \pi \int_{x_1}^{x_2} f_1^2(x)dx, \; V_2 = \pi \int_{x_1}^{x_2} f_2^2(x)dx, \tag{S2}$$

$$V = \pi \int_{x_1}^{x_2} f_1^2\,(x)dx - \pi \int_{x_1}^{x_2} f_2^2\,(x)dx \qquad \text{(S3)}$$

where V_1 and V_2 are the volumes of 3D shapes obtained by rotating y_1 (red outline) and y_2 (green outline) around the axis x.

To calculate volumes firstly we need to define the two functions $y_1 = f_1(x)$ and $y_2 = f_2(x)$ (Figure S1) that best describe the approximate sample shape for each species (except Bark). To do this, the software GetData Graph Digitizer version 2.26.0.20 (Federov 2002-2013) was used. Twenty points along each curve of the sample shape were selected, using an image of the approximated sample shape and the mean sample dimensions for each species as inputs.

Using obtained points from GetData Graph Digitizer and R version 3.6.0 (R Core Team 2019) the following function describing the sample shapes was defined:

$$f(x) = A_0 + A_1x + A_2x^2 + A_3x^3 + A_4x^4, \qquad \text{(S4)}$$

where A_0, A_1, A_2, A_3 and A_4 are constants.

Table S1A shows constants and input parameters to calculate volume using equation (S4).

Table S1. Input parameters.

	Acacia		***Cassinia***		***Pinus*[1]**
	y_1	y_2	y_1	y_2	y_1
x_1, mm	0	0	0	0	0
x_2, mm	371 (33)	371 (33)	391 (17)	391 (17)	192 (20)
A0	7.17493	0.66667	7.99923	0.28603	-1.27196
A1	2.1538	0.51173	1.82949	0.26486	1.31424
A2	0.01295	0.00331	0.01101	0.00162	-0.0149
A3	3.98E-05	1.06E-05	3.32E-05	5.00E-06	9.86E-05
A4	-4.88E-08	-1.54E-08	-3.94E-08	-7.08E-09	-2.43E-07

[1]*Pinus* has data only for y_1 due to y_2=0 for all samples. Values in round brackets are standard deviation.

Using functions $y_1 = f_1(x)$ and $y_2 = f_2(x)$ defined for the sample shape for each species, the dimensions of the samples and the equation (S3), the volume of 3D shape *V* for each species (except Bark) can be calculated.

To calculate volume of the sector V_{bulk} we used the following approach. We calculated circumference *C* of the 3D base first and then proportion of it occupied by the sample:

$$L = 2\pi R, \qquad \text{(S5)}$$

$$S = \frac{L_1}{C}, \qquad \text{(S6)}$$

$$V_{bulk} = VS, \qquad \text{(S7)}$$

where S is the proportion of 3D figure representing sample.

V_{bulk} for Bark was calculated using the equation (S8) below. Length (L), width (W) and depth (D) measurements were taken from the mean dimension calculations.

$$V_{bulk} = LWD \qquad \text{(S8)}$$

Calculated values are presented in Table S2.

Table S2. Calculated parameters.

Species	Mean R (SD), mm	Mean C (SD), mm	Mean L_1 (SD), mm	Mean V (SD), m^3	Mean S (SD)	Mean V_{bulk} (SD), m^3
Acacia	165 (70)	1039 (441)	249 (56)	0.0222 (0.0022)	0.29 (0.14)	6.49E-03 (3.45E-03)
Cassinia	139 (57)	874 (361)	132 (31)	0.0179 (0.0007)	0.18 (0.08)	3.12E-03 (1.37E-03)
Pinus	-	-	-	0.0023 (0.0001)	1	2.31E-03 (1.17E-04)
Bark	-	-	-	-	-	9.81E-05 (1.75E-05)

R is the radius of the sample base; SD is the standard deviation; C is the circumference of the 3D base; L_1 is length of the base sector; V is the volume of a solid of revolution; S is the proportion of 3D figure representing sample; V_{bulk} is the bulk volume of a sample; length (L), width (W) and depth (D) for bark were 192 (20) mm, 53 (6) mm, 10 (2) mm respectively.

Supplementary Appendix S2

Table S3. Mean time to false ignition in piloted experiments. Sample size (*n*) is also shown.

Species	**Mean Time to False Ignition (sec)**	
	Static	**Dynamic**
Acacia	12.4 ± 9.7 (*n*=10)	111 ± 103 (*n*=9)
Cassinia	2.8 ± 3.8 (*n*=10)	5.9 ± 13.9 (*n*=9)
Pinus	1.9 ± 2.9 (*n*=10)	3.4 ± 5.2 (*n*=10)
Bark	1 (*n*=2)	9.6 ± 8.7 (*n*=5)

Supplementary Appendix S3

Table S4. Comparison of models for the ignition success, time to flammability measure and radiant exposure to flammability measure

Response variable/ Model	Model 1 Spp+Exp+Pilot	Model 2 Spp*Exp+Spp*Pilot+Exp*Pilot	Model 3 Spp*Exp*Pilot
Ignition success, AIC	111	119	123
Time to reach pyrolysis, AIC	527	372	304
Radiant exposure to reach pyrolysis, AIC	547	391	312
Time to reach smouldering, AIC	302	246	234
Radiant exposure to reach smouldering, AIC	317	288	275
Time to ignition, AIC	228	178	182
Radiant exposure to ignition, AIC	246	218	222
Time to reach complete consumption, AIC	85	92	96
Radiant exposure to reach complete consumption, AIC	126	131	135

Spp is the species under the study (*Acacia, Cassinia, Pinus* and *Bark*), Exp is the type of the heating regime (static or dynamic), Pilot is the ignition method (piloted or unpiloted)

Table S5. Summary of results showing median time (sec) required for each species and bark to reach pyrolysis, smouldering, flaming ignition, complete consumption and the median consumption time (sec).

Flammability measure	***Acacia*, Median (MAD)**				***Cassinia*, Median (MAD)**				***Pinus*, Median (MAD)**				**Bark, Median (MAD)**			
	Unpiloted		***Piloted***		***Unpiloted***		***Piloted***		***Unpiloted***		***Piloted***		***Unpiloted***		***Piloted***	
	Static	**Dynamic**	**Static**	**Dynamic**	**Static**	**Dynamic**	**Static**	**Dynamic**	**Static**	**Dynamic**	**Static**	**Dynamic**	**Static**	**Dynamic**	**Static**	**Dynamic**
Pyrolysis	16 (2)	347 (12)	3 (2)	308 (69)	6 (2)	271 (20)	1 (NA)	1 (NA)	48 (6)	462 (40)	1 (NA)	1 (NA)	1 (NA)	128 (17)	1 (NA)	130 (31)
Smouldering	25 (3)	480 (22)	22 (6)	319 (81)	13 (3)	443 (32)	11 (4)	150 (94)	57 (6)	515 (9)	48 (10)	378 (83)	4 (2)	184 (12)	2 (1)	171 (27)
Flaming ignition	85 (NA)	589 (NA)	36 (8)	319 (81)	48 (7)	487 (41)	20 (7)	150 (93)	102 (7)	558 (31)	73 (34)	422 (146)	7 (1)	275 (32)	3 (1)	198 (25)
Complete consumption	117 (NA)	600 (NA)	87 (19)	393 (135)	82 (24)	562 (36)	65 (28)	497 (65)	137 (23)	574 (27)	141 (20)	555 (47)	118 (12)	433 (23)	66 (6)	306 (20)
Consumption time	32 (NA)	11 (NA)	59 (55)	48 (23)	16 (7.4)	12 (4.5)	50 (34)	198 (173)	22 (13)	16 (6)	46 (37)	44 (50)	111 (22)	86 (59)	62 (8.2)	97 (21)

NA (not applicable) is for experiments with one successful ignition. MAD is the median standard deviation (sec).

Table S6. Summary of results showing median radiant exposure H_e (kJ/m^2) required for each species and bark to reach pyrolysis, smouldering, flaming ignition, complete consumption and the median consumption H_e (kJ/m^2).

Flammability measure	***Acacia*, Median (MAD)**				***Cassinia*, Median (MAD)**				***Pinus*, Median (MAD)**				**Bark, Median (MAD)**			
	Unpiloted		***Piloted***		***Unpiloted***		***Piloted***		***Unpiloted***		***Piloted***		***Unpiloted***		***Piloted***	
	Static	**Dynamic**	**Static**	**Dynamic**	**Static**	**Dynamic**	**Static**	**Dynamic**	**Static**	**Dynamic**	**Static**	**Dynamic**	**Static**	**Dynamic**	**Static**	**Dynamic**
Pyrolysis	1008 (126)	5119 (266)	189 (126)	4266 (1405)	378 (95)	3540 (369)	63 (NA)	9 (NA)	3024 (347)	8517 (1365)	63 (NA)	9 (NA)	63 (NA)	1351 (211)	63 (NA)	1376 (377)
Smouldering	1544 (158)	9187 (841)	1355 (347)	4498 (1725)	788 (158)	7843 (1033)	693 (252)	1648 (1118)	3560 (347)	10650 (397)	2993 (630)	5935 (2500)	221 (95)	2103 (177)	95 (32)	1924 (394)
Flaming ignition	5355 (NA)	14544 (NA)	2268 (504)	4498 (1725)	2993 (410)	9460 (1516)	1260 (410)	1648 (1113)	6426 (441)	12843 (1640)	4568 (2111)	7163 (4720)	410 (32)	3605 (572)	189 (63)	2318 (391)
Complete consumption	7371 (NA)	15232 (NA)	5481 (1197)	6403 (3098)	5166 (1512)	12982 (2122)	4095 (1764)	9870 (3113)	8631 (1449)	13710 (1522)	8883 (1260)	12605 (2755)	7403 (756)	7498 (728)	4127 (378)	4224 (427)
Consumption H_e	2016 (NA)	688 (NA)	3717 (3456)	1098 (684)	1008 (467)	419 (76)	3150 (2148)	5883 (4580)	1386 (841)	867 (175)	2898 (2335)	924 (657)	6962 (1354)	2087 (985)	3874 (514)	1867 (521)

NA (not applicable) is for experiments with one successful ignition. MAD is the median standard deviation (kJ/m^2).

Table S7. Median time and radiant exposure required to reach flammability measures and to consume samples for different heating regimes and ignition methods. Differences between medians are displayed through p-value (p). Symbols indicate level of significance: *n* is not significant (p>0.05), * is suggestive (0.05≥p>0.005), ** is significant (0.005≥ p> 0.0001), *** is highly significant (p ≤0.0001).

	Pyrolysis		**Smouldering**		**Flaming ignition**		**Complete consumption**		**Consumption time**	
	Static	**Dynamic**	**Static**	**Dynamic**	**Static**	**Dynamic**	**Static**	**Dynamic**	**Static**	**Dynamic**
Time, sec (MAD)	2 (1.5)	233 (200)	18 (19)	394 (172)	25 (28)	300 (151)	113 (52)	452 (163)	60 (51)	83 (101)
p-value	<0001 ***		<0001 ***		<0001 ***		<0001 ***		0.02316 *	
Radiant exposure, kJ/m² (MAD)	126 (93)	2873 (3470)	1134 (1214)	6339 (5285)	1575 (1775)	4102 (3275)	7088 (3269)	8151 (5534)	3748 (3222)	1682 (1409)
p-value	<0001 ***		<0001 ***		0.00024 **		0.03529 *		0.02587 *	
	Pyrolysis		**Smouldering**		**Flaming ignition**		**Complete consumption**		**Consumption time**	
	Piloted	**Unpiloted**	**Piloted**	**Unpiloted**	**Piloted**	**Unpiloted**	**Piloted**	**Unpiloted**	**Piloted**	**Unpiloted**
Time, sec (MAD)	1 (0)	72 (104)	55 (73)	75 (108)	68 (87)	103 (145)	231 (229)	166 (154)	73 (56)	56 (64)
p-value	<0001 ***		0.02047 *		0.1756 n		0.5772 n		0.03471 *	
Radiant exposure, kJ/m² (MAD)	63 (81)	2043 (2516)	1844 (1872)	2790 (3575)	2268 (2265)	3558 (4289)	5576 (3235)	7775 (2763)	3159 (2953)	1953 (1784)
p-value	<0001 ***		0.002072 **		0.1234 n		0.1278 n		0.166 n	

Table S8. Comparison of median time required to reach flammability measures and to consume samples for different heating regimes and ignition methods. Differences between medians are displayed through p-value (p). Symbols indicate level of significance: *n* is not significant (p>0.05), * is suggestive (0.05≥p>0.005), ** is significant (0.005≥ p> 0.0001), *** is highly significant (p ≤0.0001). NA is not applicable.

	Acacia				***Cassinia***				***Pinus***				**Bark**			
	Static vs Dynamic		*Unpiloted vs Piloted*		*Static vs Dynamic*		*Unpiloted vs Piloted*		*Static vs Dynamic*		*Unpiloted vs Piloted*		*Static vs Dynamic*		*Unpiloted vs Piloted*	
	Unpiloted	Piloted	Static	Dynamic	Unpiloted	Piloted	Static	Dynamic	Unpiloted	Piloted	Static	Dynamic	Unpiloted	Piloted	Static	Dynamic
Pyrolysis	p<0001 ***	p<0001 ***	p=0.00017 **	p=0.18 n	p<0001 ***	p=0.26 n	p=0.00029 **	p<0001 ***	p<0001 ***	p=0.26 n	p<0001 ***	p<0001 ***	p<0001 ***	p=0.0031 **	p=0.051 n	p=0.88 n
Smouldering	p<0001 ***	p<0001 ***	p=0.64 n	p=0.0056 *	p<0001 ***	p=0.005 **	p=0.9 n	p=0.0013 **	p<0001 ***	p=0.00014 **	p=0.2 n	p=0.0034 **	p<0001 ***	p=0.00021 **	p=0.0035 **	p=0.25 n
Flaming ignition	p=N/A	p=0.00019 **	p=N/A	p=N/A	p=0.0054 *	p=0.00014 **	p=0.26 n	p=0.11 n	p=0.0019 **	p=0.014 *	p=0.29 n	p=0.035 *	p<0001 ***	p=0.00037 **	p=0.00034 **	p=0.00097 **
Complete consumption	p=N/A	p=0.0026 **	p=N/A	p=N/A	p<0001 ***	p=0.00036 **	p=0.54 n	p=0.1 n	p=0.0016 **	p=0.00046 **	p=0.42 n	p=0.22 n	p<0001 ***	p<0001 ***	p=0.0015 **	p<0001 ***
Consumption time	p=N/A	p=0.38 n	p=N/A	p=N/A	p=0.28 n	p=0.036 *	p=0.46 n	p=0.99 n	p=0.3 n	p=0.28 n	p=0.81 n	p=0.13 n	p=0.89 n	p=0.092 n	p=0.0037 **	p=0.99 n

Table S9. Comparison of median radiant exposure (H_e) required to reach flammability measures and to consume samples for different heating regimes and ignition methods. Differences between medians are displayed through p-value (p). Symbols indicate level of significance: *n* is not significant (p>0.05), * is suggestive (0.05≥p>0.005), ** is significant (0.005≥ p> 0.0001), *** is highly significant (p ≤0.0001). NA is not applicable.

	Acacia				***Cassinia***				***Pinus***				**Bark**			
	Static vs Dynamic		*Unpiloted vs Piloted*		*Static vs Dynamic*		*Unpiloted vs Piloted*		*Static vs Dynamic*		*Unpiloted vs Piloted*		*Static vs Dynamic*		*Unpiloted vs Piloted*	
	Unpiloted	Piloted	Static	Dynamic	Unpiloted	Piloted	Static	Dynamic	Unpiloted	Piloted	Static	Dynamic	Unpiloted	Piloted	Static	Dynamic
Pyrolysis	p<0001 ***	p<0001 ***	p=0.00017 **	p=0.27 n	p<0001 ***	p=0.74 n	p=0.0029 **	p<0001 ***	p<0001 ***	p=0.062 n	p<0001 ***	p<0001 ***	p<0001 ***	p=0.0066 *	p=0.051 n	p=0.84 n
Smouldering	p<0001 ***	p=0.0069 *	p=0.64 n	p=0.0075 *	p<0001 ***	p=0.08 n	p=0.9 n	p=0.0014 **	p<0001 ***	p=0.039 *	p=0.2 n	p=0.00026 **	p<0001 ***	p=0.00052 **	p=0.0035 **	p=0.25 n
Flaming ignition	p=N/A	p=0.033 *	p=N/A	p=N/A	p=0.042 *	p=0.16 n	p=0.0081 *	p=0.021 *	p=0.16 n	p=0.64 n	p=0.29 n	p=0.06 n	p<0001 ***	p=0.0011 **	p=0.00034 **	p=0.0011 **
Complete consumption	p=N/A	p=0.61 n	p=N/A	p=N/A	p=0.0054 *	p=0.67 n	p=0.54 n	p=0.11 n	p=0.2 n	p=0.32 n	p=0.42 n	p=0.27 n	p=0.77 n	p=0.38 n	p=0.0015 **	p=0.0003 **
Consumption H_e	p=N/A	p=0.79 n	p=N/A	p=N/A	p=0.63 n	p=0.78 n	p=0.46 n	p=0.86 n	p=0.28 n	p=0.89 n	p=0.81 n	p=0.16 n	p=0.00011 **	p=0.0011 **	p=0.0037 **	p=0.22 n