International Journal of Wildland Fire 2020, 29(7), 637-647
doi:10.1071/WF19196_AC

Supplementary material for

Soil moisture thresholds for combustion of organic soils in western Tasmania

Lynda D. Prior[A], *Ben J. French*[A], *Kathryn Storey*[B], *Grant J. Williamson*[A] *and David M.J.S. Bowman*[A]

[A]School of Natural Sciences, University of Tasmania Private Bag 55, Hobart, Tasmania 7001, Australia

[B]Natural and Cultural Heritage Division, Department of Primary Industries, Parks, Water and Environment, GPO Box 44, Hobart, Tasmania 7001

[C]Corresponding author. Email: lynda.prior@utas.edu.au

Rainforest/mixed forest on a south facing slope north of the sentinel Range. Note the charred root wads, and the lack of charring on the trunks indicating that ground fire destroyed the soil in an area which had not been exposed to surface fire.

Melaleuca swamp near Arthur River. Note the depth of soil loss. This swamp smouldered for several weeks despite extensive suppression efforts, including the application of approximately 400,000 litres of water (8 milk tanker loads).

Fig. S1. Examples of the impacts of ground fires in Western Tasmania from the 2016 fires. These fires occurred under unusually dry soil conditions, and there were numerous instances of smouldering ground fires becoming established. Photos: Ben French

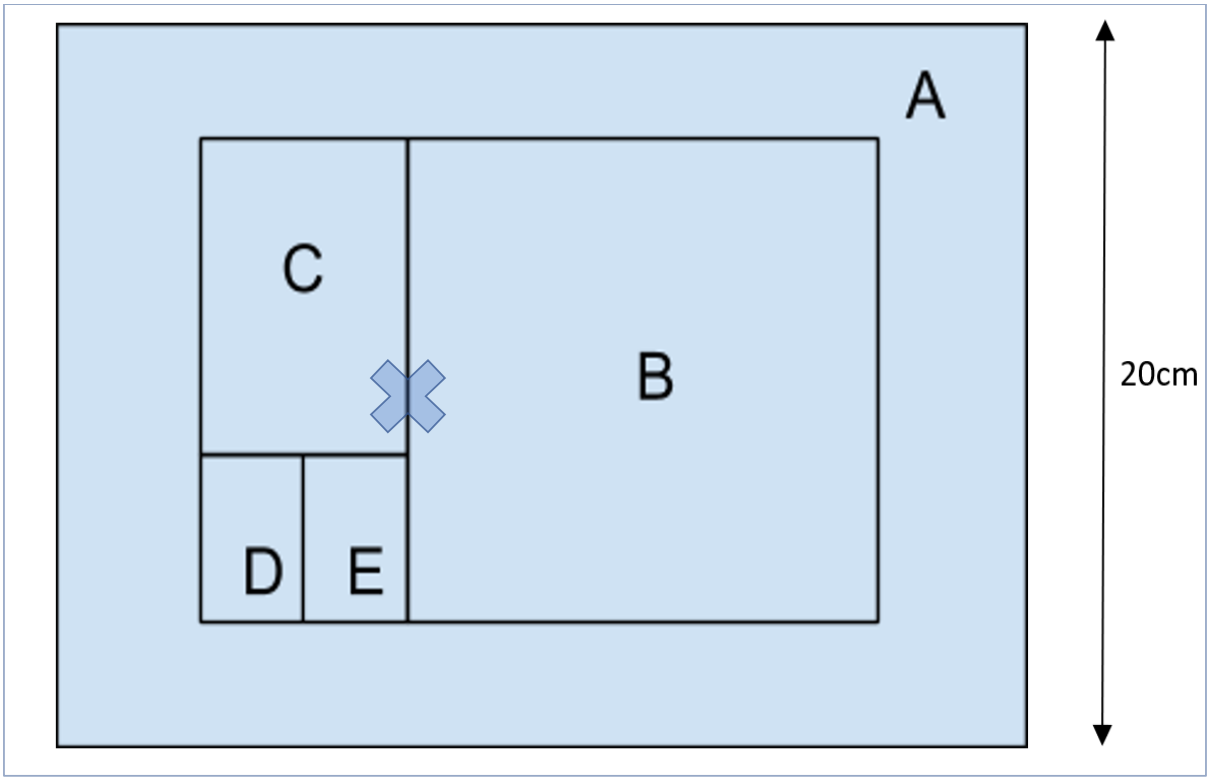

Fig. S2. Schematic diagram showing the division of each peat turf in plan view. First, VMC was measured by inserting the probe at the position marked by the cross. Part A was then discarded. Block B was used for burn testing, Block C to measure gravimetric moisture content and bulk density, Block D, organic content, and Block E, for elemental carbon and nitrogen analyses.

Fig. S3. Custom-built burn boxes (10 x 10 x 7 cm), with soil Block B inside and coil heater inserted, held in place with a G-clamp.

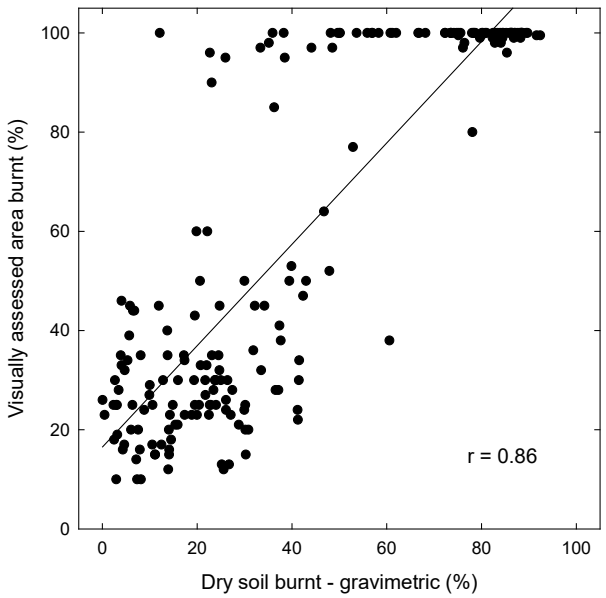

Fig. S4. The relationship between visually assessed area burnt (%) and gravimetrically determined mass of dry soil burnt (%).

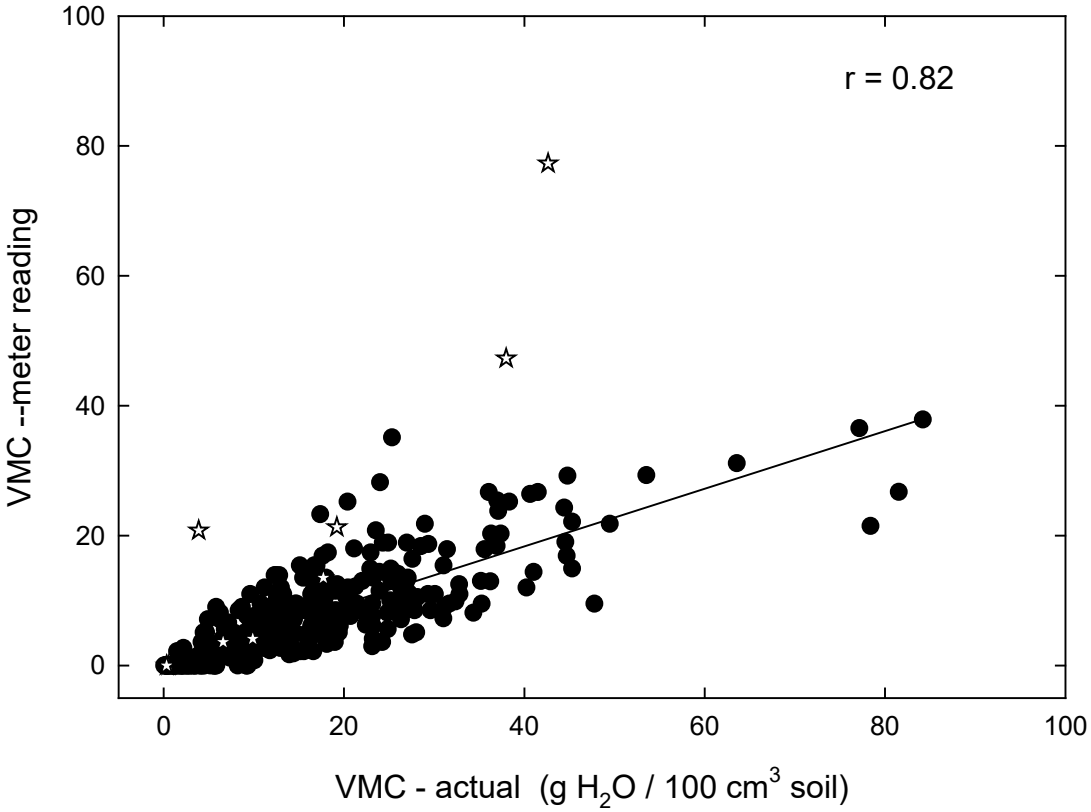

Fig. S5. Calibration of the VMC meter against VMC_{actual} . The open stars are samples from sites where soils were considered inorganic (average carbon content <12%); these were not used in the calibration. For our organic soils, the equation to convert from VMC_{meter} readings to VMC_{actual} is: $VMC_{actual} = 4.67 + 1.500 * VMC_{meter}$.

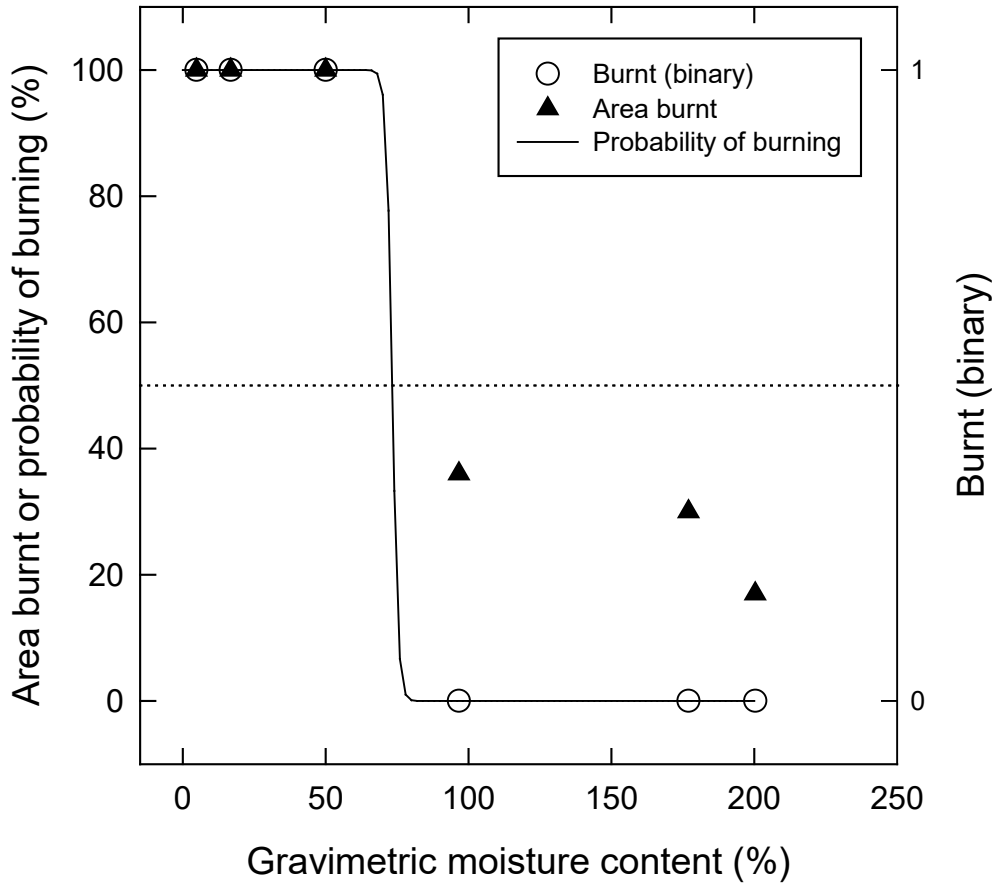

Fig. S6. Example of how area burnt varied as a function of gravimetric moisture content (GMC) for an individual site. Area burnt was converted to a binary variable 'Burnt' (0 if <50% burnt, 1 if ≥ 50% burnt) to model the probability of burning (solid line). In this example, a 50% probability of burning (dotted line) corresponded to GMC of 73.3%.

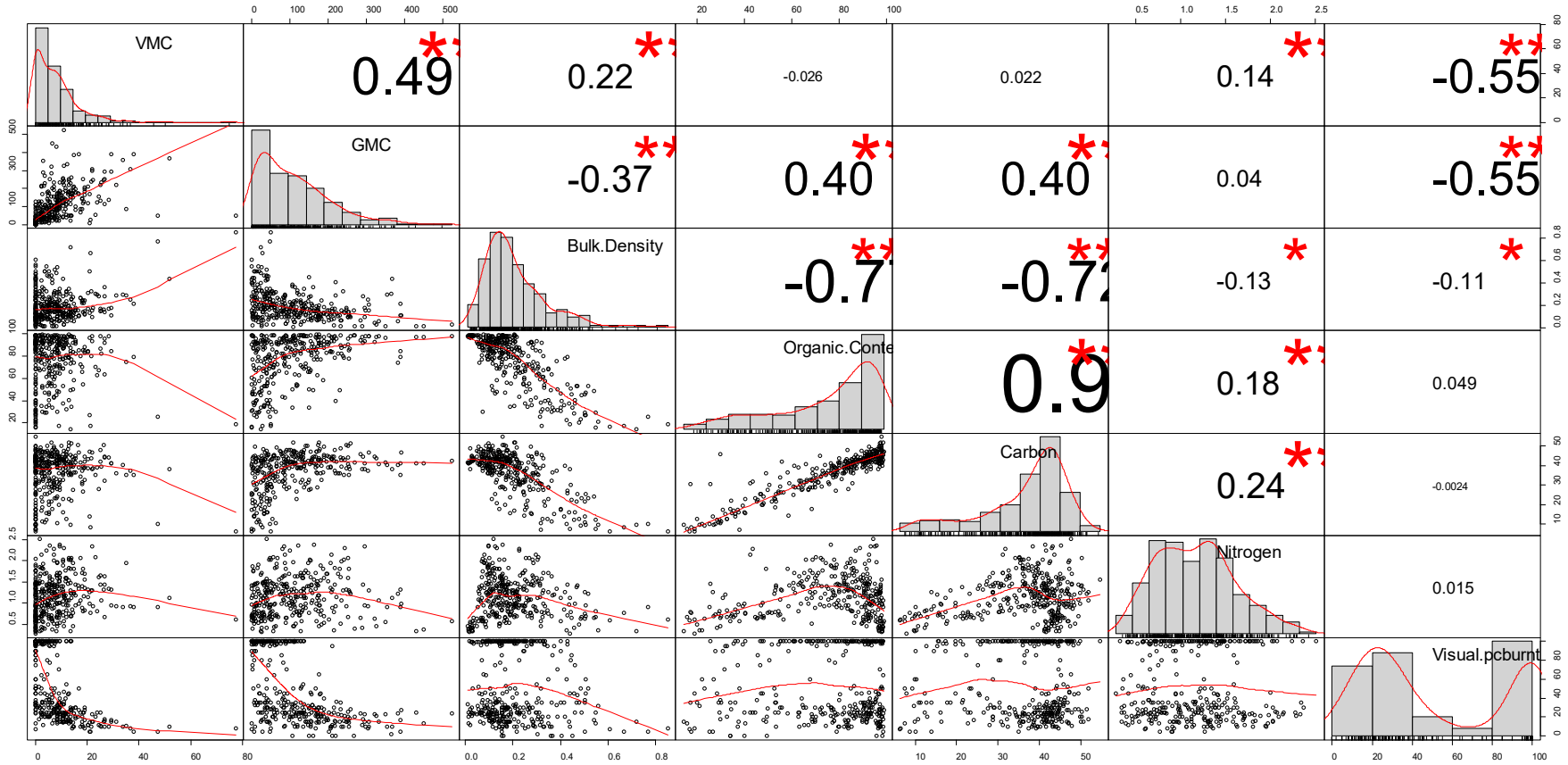

Fig. S7. Correlation coefficients and scatterplots describing the relationships among soil variables. Cells on the diagonal contain frequency histograms for the variables: VMC (volumetric moisture content) is the VMC meter reading; GMC is gravimetric moisture content (%); Bulk.Density is soil bulk density (g cm^{-3}); Soil Organic.Content, Carbon and Nitrogen are in %, and Visual.pcburnt is percentage burnt (visually assessed). Values above and to the right of the diagonal are correlation coefficients, with *, ** and *** denoting P <0.05, 0.01 and 0.0001, respectively. Absence of asterisks indicates non-significant correlations. Panels below and to the left of the diagonal contain scatterplots. Data are presented for all turves, including sites with mineral soils. This figure was produced using the R package 'PerformanceAnalytics' (Peterson and Carl 2014).

Table S1. Effect of adding other soil terms to the moisture models (GMC and VMC_{meter}), with 'burnt' as a binomial response variable and Site as a random effect. Terms with AICc more than two below the moisture only models were considered to have statistical support, and are shown in bold. Only samples with valid observations for all variables were used for this comparison (n = 282)

Moisture term	GMC			VMC_{meter}		
Additional term	AICc	ΔAICc	% deviance explained	AICc	ΔAICc	% deviance explained
Moisture only	260.8	23.7	46.6	265.3	0	47.2
+organic content	**242.6**	**5.5**	51.3	267.1	1.8	48.3
+BD	**237.1**	**0**	50.9	267.3	2.0	46.9
+C	**252.1**	**15.0**	48.3	267.2	1.9	46.8
+N	262.6	25.4	46.8	265.4	0.1	46.4

Table S2. Parameter estimates for the best supported binomial GLMMs describing the probability of burning, with a logit link and Site as a random effect.

Adding organic content or BD to the improved the GMC model, but not the VMC_{meter} one. All valid observations for organic soils were used in fitting these models.

Term	Estimate	Standard error	Deviance explained by the model (%)	n
Burnt ~ GMC + organic content				
Intercept	-0.9175	0.889	52.5	307
GMC	-0.0425	0.0070		
organic content	0.0513	0.0136		
Burnt ~ GMC + BD				
Intercept	5.0254	0.9328	51.7	307
GMC	-0.0419	0.0067		
BD	-10.143	2.419		
Burnt ~ VMC_{meter}				
Intercept	2.1266	0.4136	52.2	335
VMC_{meter}	-0.4194	0.0660		

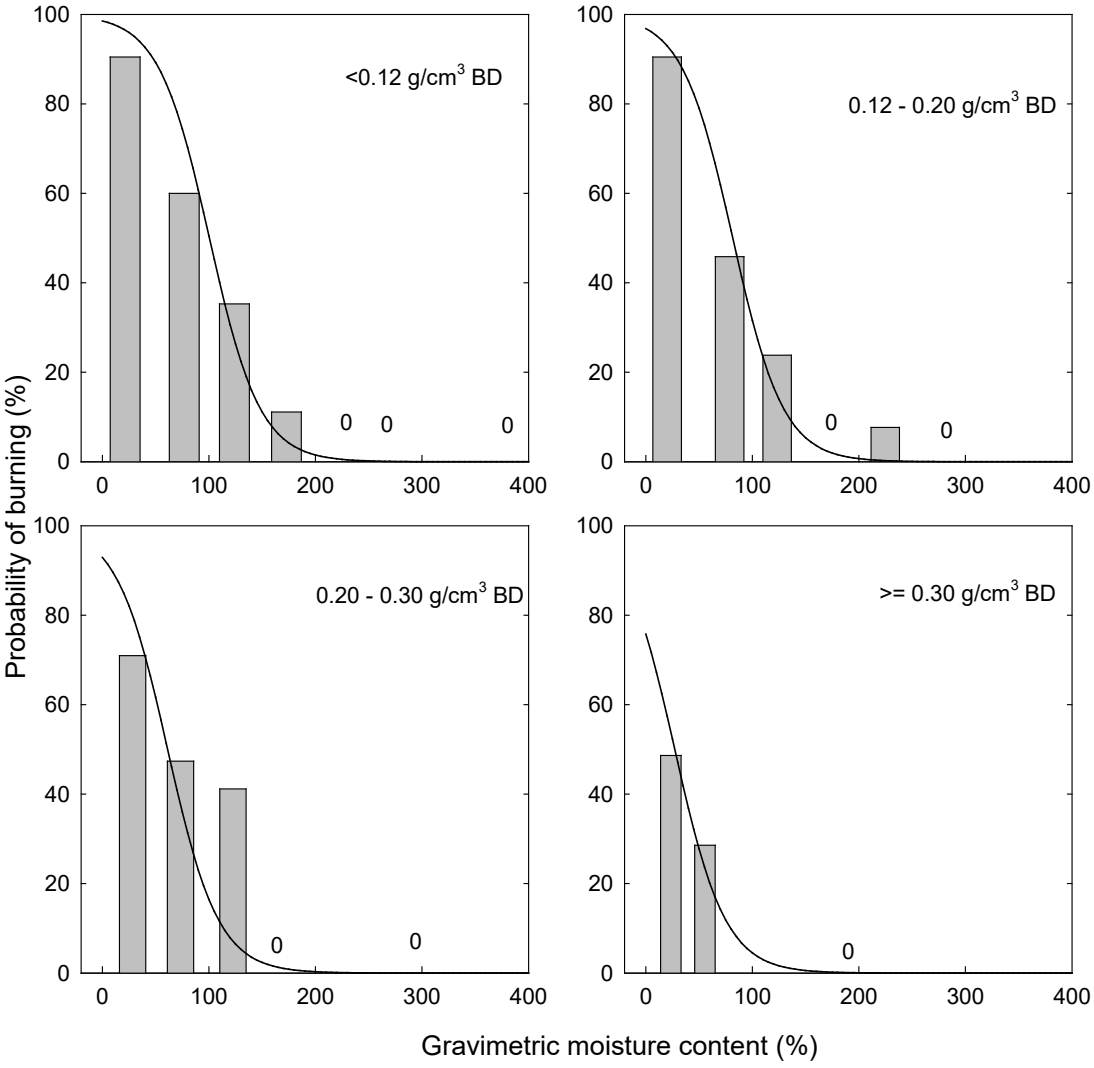

Fig. S8. Probability of burning in relation to soil gravimetric moisture content (GMC) and bulk density (BD). Lines show model predictions, and bars show actual data. For presentation, data are binned into 50%-GMC classes; classes with <5 observations were combined. The GMC corresponding to a 50% probability of burning is 100, 82, 61 and 27%, respectively, for the four BD classes.

Table S3. Average soil characteristics for each broad vegetation type.
Change in AICc is the change when the term 'vegetation type' was added to the null (intercept only) model; a decrease >2 (in bold) was regarded as indicating support for differences among vegetation types. Only the nine vegetation types represented by four or more sites were included in the analyses, which used generalised linear mixed effects models with Site as a random effect.

Vegetation type	Number of sites	Organic content (%)	Soil carbon (%)	Soil nitrogen (%)	Bulk density (g cm^{-3})
Vegetation types compared in our analyses					
Alpine low vegetation	8	79.9	37.5	1.47	0.142
Eastern moorland	4	85.8	40.0	1.20	0.211
Leptospermum rainforest	4	85.9	42.6	0.91	0.153
Melaleuca swamp	5	68.3	33.1	1.34	0.220
Mixed forest	4	87.6	39.8	1.08	0.186
Moorland	7	69.7	35.8	1.05	0.296
Rainforest	6	76.9	36.9	1.19	0.189
Scrub	9	64.2	32.4	1.06	0.263
Sphagnum	4	94.0	41.9	0.84	0.052
Change in AICc		**-47**	**-29**	+16	+29
Not compared- insufficient sites					
Coastal lagoon	1	20.3	8.8	0.81	0.656
Coastal lawn	1	90.0	35.3	2.04	0.284
Cushion	3	87.9	44.0	0.62	0.120
Pencil pine	1	91.7	42.9	1.57	0.134
Poa	2	59.1	26.1	1.02	0.273
Wet forest	3	75.3	37.0	1.40	0.240
Wetland	1	66.7	30.3	1.44	0.175
Overall	63	75.8	36.5	1.16	0.208

Table S4. Contingency table showing accuracy of combustibility classifications, in relation to the specified probabilities of combustion.

The probability of combustion was predicted according to the equation: logit(probability)= 2.127-0.41944*VMC_{meter}. The number of correct predictions of combustion (from a total of 334 samples) is shown in the highlighted columns. With a very conservative classification, namely that samples with >1% probability of combustion are 'combustible', most samples were classed as 'combustible', but only one of these actually burned. With the 50% probability used as the moisture threshold, there was a greater overall accuracy, but more 'non-combustible' samples burned.

Threshold probability of burning to be classed as 'combustible'	VMC_{meter}	'Non-combustible'		'Combustible'		Correctly classified (%)
		Number that did not burn	Number that burned	Number that did not burn	Number that burned	
1%	16.0	40	1	154	139	54
5%	12.1	68	4	126	136	61
10%	10.3	92	7	102	133	67
20%	8.4	124	11	70	129	76
50%	5.1	155	37	39	103	77