

Supplementary material

A quantitative assessment of shoot flammability for 60 tree and shrub species supports rankings based on expert opinion

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Device specifications

We measured flammability on a custom-built device constructed following the specifications of Jaureguiberry *et al.* (2011), and adjusted to meet New Zealand safety standards. The device consisted of a 85 × 60 cm barrel cut in half and arranged horizontally on four 100 cm-long metal legs (Fig. S1). The barrel was open at the front and closed at the back for wind protection. Samples were arranged on a grill, and heated by a burner located beneath the grill. A blowtorch (16.7 kW) located beneath the grill was used to ignite the samples. Both the burner and blowtorch were fuelled by liquid petroleum gas. Temperature of the grill and burning sample were measured using an infrared laser thermometer (Fluke 572; Fluke Corp., Everett, WA, USA) capable of measuring temperatures up to 900 °C, with a precision of 0.1 °C and an accuracy of ± 0.75% of the reading. The emissivity value of the thermometer was set at 0.94, the emissivity of natural wood (Fluke Corp. 2005). The procedure we adopted was to ‘paint’ the flames with the thermometer and record the maximum temperature reached during flaming combustion.



Fig. S1. A sample of *Dracophyllum acerosum* burning on the device. A handheld infrared laser thermometer (left) is being used to measure the flame temperature.

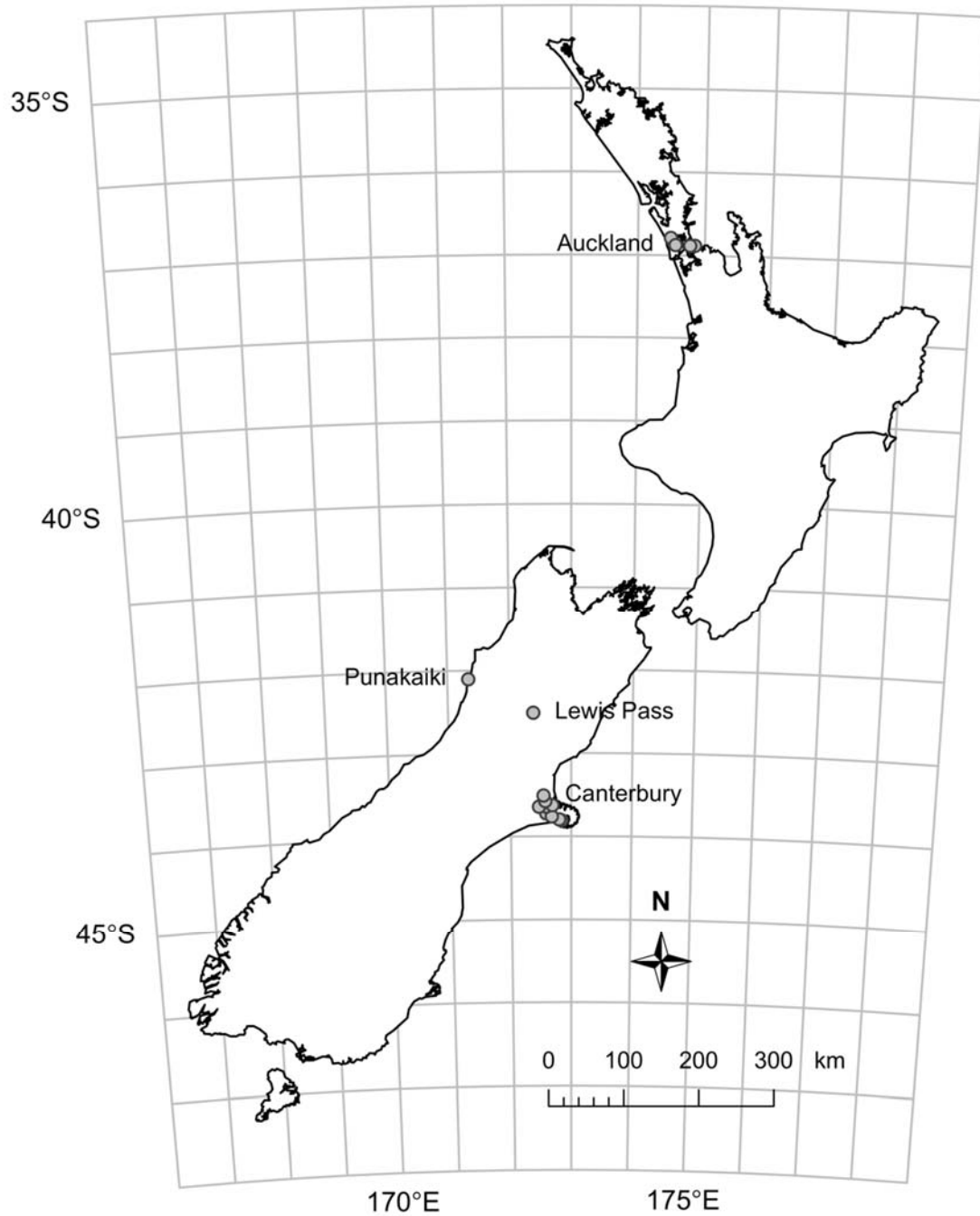


Fig. S2. Collection site locations in the North and South Islands of New Zealand for the samples burnt in this study; see Table S2 for details on species collected in each region.

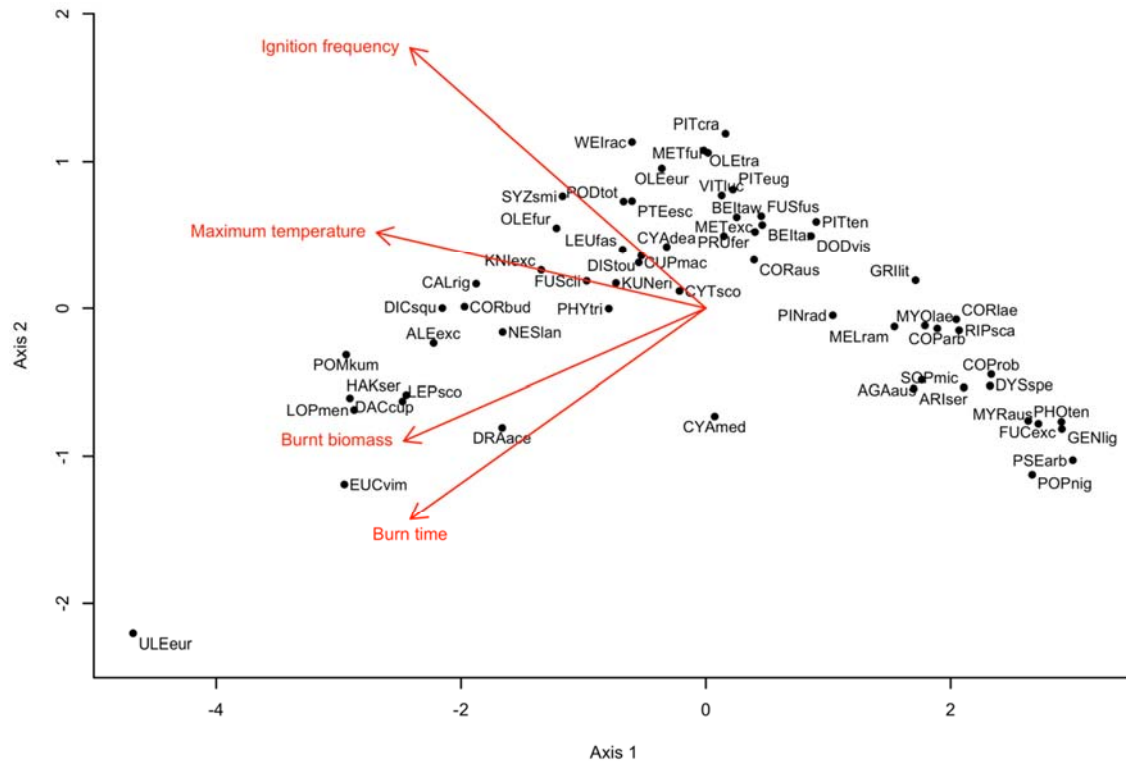


Fig. S3. Principal components analysis (PCA) of the mean values per species for the three measured flammability variables (maximum temperature, burn time, and burnt biomass), as well as ignition frequency per species (the percentage of each species samples that had achieved ignition and burnt once the blowtorch was turned off). The first ordination axis explained 80% of the variation in the data. The second ordination axis explained 11% of the variation in the data, however the interpretation of this second axis should be treated with caution given the possible horseshoe effect. See Table 1 for definitions of species codes.

Table S1. Summary flammability data for the 60 species (10 exotic species [*] and 50 New Zealand indigenous species) burnt in this study

Percent ignited indicates the percentage of samples of a species that maintained flaming ignition once the blowtorch was turned off. Burnt biomass, burn time and maximum temperature data represent means \pm the standard error of the mean. Flammability rank (1 = highest flammability) is based on the mean species scores on the first axis of a PCA computed from the burnt biomass, burn time, maximum temperature, and ignition frequency data. The first PCA axis was negatively correlated with all measured flammability variables and explained 80% of the variation in the data

Species	Code	n	Percent ignited	Burnt biomass (%)	Burn time (s)	Max. temp. (°C)	Rank
<i>Agathis australis</i>	AGAaus	8	42.9	8.2 \pm 5.3	6.0 \pm 3.0	206.3 \pm 99.6	46
<i>Alectryon excelsus</i>	ALEexc	8	100	63.8 \pm 7.0	21.9 \pm 4.7	551.9 \pm 67.3	8
<i>Aristotelia serrata</i>	ARIser	7	42.9	17.1 \pm 9.9	3.0 \pm 1.8	188.1 \pm 98.7	44
<i>Beilschmiedia tarairi</i>	BEItar	8	75	13.6 \pm 4.7	4.6 \pm 1.4	421.4 \pm 98.7	34
<i>Beilschmiedia tawa</i>	BEItaw	8	87.5	18.8 \pm 7.2	7.0 \pm 2.1	344 \pm 74.2	36
<i>Callistemon rigidus</i> *	CALrig	8	100	38.1 \pm 7.7	25.1 \pm 5.3	613 \pm 32.4	12
<i>Coprosma arborea</i>	COParb	8	50	8.8 \pm 3.4	1.0 \pm 0.5	173.4 \pm 70.3	48
<i>Coprosma robusta</i>	COProb	8	37.5	3.8 \pm 2.1	1.6 \pm 1.0	135.6 \pm 75.2	55
<i>Cordyline australis</i>	CORaus	8	87.5	10.0 \pm 2.7	15.9 \pm 5.0	266.1 \pm 50.2	39
<i>Corokia buddleioides</i>	CORbud	8	100	66.8 \pm 9.1	14.0 \pm 2.1	532.9 \pm 18	10
<i>Corynocarpus laevigatus</i>	CORlae	8	50	3.4 \pm 1.6	1.5 \pm 0.7	160.5 \pm 65.4	51
<i>Cupressus macrocarpa</i> *	CUPmac	11	90.9	18.6 \pm 4.3	19.7 \pm 7.6	446.5 \pm 55.9	21
<i>Cyathea dealbata</i>	CYAdea	8	87.5	28.1 \pm 5.0	10.0 \pm 2.3	423.5 \pm 71.4	27
<i>Cyathea medullaris</i>	CYAmcd	8	62.5	28.8 \pm 10.2	19.1 \pm 8.5	331.9 \pm 103.9	23
<i>Cytisus scoparius</i> *	CYTSCO	8	87.5	31.3 \pm 7.9	13.3 \pm 4.7	323.5 \pm 58.3	28
<i>Dacrydium cupressinum</i>	DACCup	8	100	58.1 \pm 9.8	36.5 \pm 7.4	660.4 \pm 35.9	4
<i>Dicksonia squarrosa</i>	DICsqu	8	100	55.0 \pm 7.7	21.5 \pm 3.1	606.3 \pm 24.2	9
<i>Discaria toumatou</i>	DISTou	9	100	45.0 \pm 6.0	8.4 \pm 2.6	292 \pm 35.8	24
<i>Dodonea viscosa</i>	DODvis	9	77.8	16.1 \pm 3.4	2.9 \pm 0.6	268.1 \pm 53.5	42
<i>Dracophyllum acerosum</i>	DRAace	8	87.5	35.6 \pm 8.2	38.4 \pm 9.0	483.8 \pm 86.3	11
<i>Dysoxylum spectabile</i>	DYSSpe	8	37.5	4.0 \pm 3.1	3.0 \pm 2.4	120.8 \pm 72.8	54

Species	Code	n	Percent ignited	Burnt biomass (%)	Burn time (s)	Max. temp. (°C)	Rank
<i>Eucalyptus viminalis</i> *	EUCvim	24	100	46.7 ± 6.5	53.4 ± 9.2	574.2 ± 39.5	3
<i>Fuchsia excorticata</i>	FUCexc	8	25	1.3 ± 0.8	0.3 ± 0.2	55.3 ± 36.2	59
<i>Fuscospora cliffortoides</i>	FUScli	8	87.5	35.6 ± 8.3	15.1 ± 5.4	521.8 ± 88.4	15
<i>Fuscospora fusca</i>	FUSfus	8	87.5	18.1 ± 4.9	5.8 ± 1.6	296 ± 56.8	40
<i>Geniostoma ligustrifolium</i>	GENlig	8	25	2.2 ± 1.5	0.6 ± 0.4	41.6 ± 30.9	60
<i>Griselinia littoralis</i>	GRIlit	16	62.5	3.8 ± 1.4	3.3 ± 1.1	172.3 ± 46.2	50
<i>Hakea sericea</i> *	HAKser	8	100	43.1 ± 7.2	40.5 ± 9.3	584.3 ± 39	7
<i>Knightia excelsa</i>	KNIexc	8	100	26.9 ± 8.3	25.4 ± 8.8	525.1 ± 35.2	14
<i>Kunzea ericoides</i>	KUNeri	21	90.5	37.8 ± 6.7	13.7 ± 1.9	421.3 ± 39.6	19
<i>Leptospermum scoparium</i>	LEPsco	8	100	54.4 ± 6.6	35.8 ± 7.7	555.1 ± 28.3	6
<i>Leucopogon fasciculatus</i>	LEUfas	9	100	42.8 ± 7.5	9.9 ± 2.6	345.9 ± 51.8	20
<i>Lophozonia menziesii</i>	LOPmen	8	100	40.0 ± 7.1	47.0 ± 9.8	679.4 ± 32.9	5
<i>Melicytus ramiflorus</i>	MELram	9	55.6	13.3 ± 8.0	2.9 ± 1.2	197.1 ± 81	45
<i>Metrosideros excelsa</i>	METexc	14	85.7	12.9 ± 3.1	12.5 ± 3.9	376.1 ± 54.4	30
<i>Metrosideros fulgens</i>	METful	8	100	16.3 ± 4.6	6.4 ± 1.7	375.4 ± 61	35
<i>Myoporum laetum</i>	MYOlae	6	50	5.8 ± 3.3	2.8 ± 1.6	210.8 ± 100.8	47
<i>Myrsine australis</i>	MYRaus	7	28.6	2.9 ± 1.8	2.3 ± 1.8	59.7 ± 46.6	57
<i>Nestegis lanceolata</i>	NESlan	8	100	29.4 ± 8.0	34.1 ± 9.4	508.5 ± 48.6	13
<i>Olea europaeus</i> *	OLEeur	8	100	13.1 ± 5.2	12.6 ± 1.7	456.8 ± 54	29
<i>Olearia furfuraceae</i>	OLEfur	8	100	27.5 ± 6.5	18.9 ± 2.6	553.6 ± 24.6	16
<i>Olearia traversiorum</i>	OLEtra	6	100	19.2 ± 2.4	4.8 ± 0.9	380.5 ± 45.7	32
<i>Phormium tenax</i>	PHOten	8	25	0.9 ± 0.6	2.3 ± 1.7	127 ± 83.5	56
<i>Phyllocladus trichomanoides</i>	PHYtri	8	87.5	31.9 ± 6.3	19.3 ± 6.6	444 ± 78.7	18
<i>Pinus radiata</i> *	PINrad	24	66.7	10.6 ± 2.5	10.5 ± 2.7	234 ± 40.6	41
<i>Pittosporum crassifolium</i>	PITcra	8	100	8.4 ± 1.5	7.0 ± 3.0	386.3 ± 40	38
<i>Pittosporum eugenioides</i>	PITEug	9	88.9	19.4 ± 3.8	3.9 ± 0.6	376.6 ± 62.5	33

Species	Code	n	Percent ignited	Burnt biomass (%)	Burn time (s)	Max. temp. (°C)	Rank
<i>Pittosporum tenuifolium</i>	PITten	20	80	9.0 ± 2.6	5.3 ± 1.0	272.7 ± 39.1	43
<i>Podocarpus totara</i>	PODtot	8	100	24.1 ± 5.4	13.4 ± 3.1	461.1 ± 51.9	22
<i>Pomaderris kumeraho</i>	POMkum	8	100	77.5 ± 8.5	21.4 ± 2.0	683.4 ± 21.3	2
<i>Populus nigra</i> *	POPnig	27	18.5	10.0 ± 4.8	1.7 ± 1.0	84.4 ± 35.7	53
<i>Prumnopitys ferruginea</i>	PRUfer	8	87.5	13.4 ± 4.7	10.5 ± 6.3	297.4 ± 70.7	37
<i>Pseudopanax arboreus</i>	PSEarb	13	15.4	1.5 ± 1.0	0.8 ± 0.5	74.1 ± 50.2	58
<i>Pteridium esculentum</i>	PTEesc	8	100	13.8 ± 2.3	18.1 ± 3.1	469.6 ± 26.7	26
<i>Ripogonum scandens</i>	RIPsca	8	50	5.0 ± 2.5	1.9 ± 0.8	134.5 ± 56.3	52
<i>Sophora microphylla</i>	SOPmic	10	40	10.5 ± 4.9	2.3 ± 1.3	131.1 ± 66.1	49
<i>Syzygium smithii</i> *	SYZsmi	8	100	23.1 ± 2.1	16.8 ± 1.1	598.8 ± 30.6	17
<i>Ulex europaeus</i> *	ULEeur	8	100	84.3 ± 5.0	65.1 ± 7.3	704.8 ± 30.3	1
<i>Vitex lucens</i>	VITluc	8	87.5	12.2 ± 3.0	8.5 ± 4.4	423.9 ± 66.3	31
<i>Weinmania racemosa</i>	WEIrac	8	100	16.9 ± 4.0	9.1 ± 2.6	548.5 ± 33.1	25

Table S2. Collection location regions for the 60 species (10 exotic species [*] and 50 New Zealand indigenous species) burnt in this study

See Fig. S2 for location map

Species	Code	Collection location
<i>Agathis australis</i>	AGAaus	Auckland
<i>Alectryon excelsus</i>	ALExc	Auckland
<i>Aristotelia serrata</i>	ARIsr	Punakaiki
<i>Beilschmiedia tarairi</i>	BEItar	Auckland
<i>Beilschmiedia tawa</i>	BEItaw	Auckland
<i>Callistemon rigidus</i> *	CALrig	Auckland
<i>Coprosma arborea</i>	COParb	Auckland
<i>Coprosma robusta</i>	COProb	Auckland
<i>Cordyline australis</i>	CORaus	Auckland
<i>Corokia buddleioides</i>	CORbud	Auckland
<i>Corynocarpus laevigatus</i>	CORlae	Auckland
<i>Cupressus macrocarpa</i> *	CUPmac	Canterbury
<i>Cyathea dealbata</i>	CYAdes	Auckland
<i>Cyathea medullaris</i>	CYAmes	Auckland
<i>Cytisus scoparius</i> *	CYTSCO	Canterbury
<i>Dacrydium cupressinum</i>	DACCup	Auckland
<i>Dicksonia squarrosa</i>	DICsqu	Auckland
<i>Discaria toumatou</i>	DISTou	Lewis Pass
<i>Dodonea viscosa</i>	DODvis	Canterbury
<i>Dracophyllum acerosum</i>	DRAace	Canterbury
<i>Dysoxylum spectabile</i>	DYSSpe	Auckland
<i>Eucalyptus viminalis</i> *	EUCvim	Canterbury
<i>Fuchsia excorticata</i>	FUCexc	Canterbury
<i>Fuscopora cliffortoides</i>	FUScli	Canterbury
<i>Fuscopora fusca</i>	FUSfus	Canterbury
<i>Geniostoma ligustrifolium</i>	GENlig	Auckland
<i>Griselinia littoralis</i>	GRilit	Canterbury
<i>Hakea sericea</i> *	HAKser	Auckland
<i>Knightia excelsa</i>	KNExc	Auckland
<i>Kunzea ericoides</i>	KUNeri	Canterbury, Lewis Pass
<i>Leptospermum scoparium</i>	LEPSco	Canterbury
<i>Leucopogon fasciculatus</i>	LEUfas	Auckland
<i>Lophozonia menziesii</i>	LOPmen	Canterbury
<i>Melicytus ramiflorus</i>	MELram	Auckland, Canterbury
<i>Metrosideros excelsa</i>	METexc	Auckland, Punakaiki
<i>Metrosideros fulgens</i>	METful	Auckland
<i>Myoporum laetum</i>	MYOlae	Canterbury
<i>Myrsine australis</i>	MYRaus	Auckland
<i>Nestegis lanceolata</i>	NESlan	Auckland
<i>Olea europaeus</i> *	OLEeur	Auckland
<i>Olearia furfuraceae</i>	OLEfur	Auckland
<i>Olearia traversii</i>	OLEtra	Punakaiki

Species	Code	Collection location
<i>Phormium tenax</i>	PHOten	Canterbury
<i>Phyllocladus trichomanoides</i>	PHYtri	Auckland
<i>Pinus radiata</i> *	PINrad	Canterbury
<i>Pittosporum crassifolium</i>	PITcra	Canterbury
<i>Pittosporum eugenioides</i>	PITeug	Canterbury
<i>Pittosporum tenuifolium</i>	PITten	Canterbury
<i>Podocarpus totara</i>	PODtot	Canterbury
<i>Pomaderris kumeraho</i>	POMkum	Auckland
<i>Populus nigra</i> *	POPnig	Canterbury
<i>Prumnopitys ferruginea</i>	PRUfer	Auckland
<i>Pseudopanax arboreus</i>	PSEarb	Canterbury
<i>Pteridium esculentum</i>	PTEesc	Canterbury
<i>Ripogonum scandens</i>	RIPsca	Auckland
<i>Sophora microphylla</i>	SOPmic	Canterbury
<i>Syzygium smithii</i> *	SYZsmi	Auckland
<i>Ulex europaeus</i> *	ULEeur	Canterbury
<i>Vitex lucens</i>	VITluc	Auckland
<i>Weinmania racemosa</i>	WEIrac	Auckland