International Journal of Wildland Fire
doi:10.1071/WF11065_AC

Supplementary material

Fire behaviour in south-western Australian shrublands: evaluating the influence of fuel age and fire weather

Joseph B. Fontaine[A,D], *Vanessa C. Westcott*[B], *Neal J. Enright*[A], *Janneke C. Lade*[B] *and Ben P. Miller*[C]

[A]School of Environmental Science, Murdoch University, Perth, WA 6150, Australia.

[B]School of Geography, University of Melbourne, Melbourne, VIC 3010, Australia.

[C]Botanic Gardens and Parks Authority, West Perth, WA 6005, Australia.

[D]Corresponding author. Email: j.fontaine@murdoch.edu.au

doi:10.1071/WF11065_AC

Table S1. Weather, fuel moisture, and ignition characteristics of 35 experimental fires lit in three shrubland vegetation types of Western Australia 2006–09

Fire Ran refers to whether each ignition successfully propagated, burning the entire plot. Litter moisture and Live fine fuel moisture measured as a percentage of dry mass at 50–60°C. Predictive modelling should utilise values standardised to 100°C

Shrubland vegetation type	Time since fire (years)	Fire Ran?	Date of fire	Time of ignition	Forest Fire Danger Index	Relative humidity (%)	Temperature (°C)	Mean wind velocity (km h^{-1})	Litter moisture (%)	Live fine fuel moisture (%)
Calcareous	3	Yes	12-Apr-07	1154	25.7	17	31.4	8.6	4.2	28.9
Calcareous	3	No	31-Mar-09	1335	13.9	56	25.7	14.0	5.3	85.5
Calcareous	4	Yes	14-Apr-08	1339	13.7	12	33.1	8.3	6.8	93.4
Calcareous	5	No	17-Apr-07	1137	11.0	25	26.8	5.5	7.1	46.6
Calcareous	5	Yes	21-Apr-09	1349	17.3	45	30.5	14.0	5.5	118
Calcareous	6	Yes	26-Apr-07	1456	8.5	34	23.3	6.2	9.9	68.9
Calcareous	6	Yes	17-Apr-07	1410	11.0	42	24.3	13.0	6.4	47.5
Calcareous	6	No	05-May-08	1341	9.2	27	33.5	4.5	5.3	83.8
Calcareous	7	No	15-May-07	1230	9.0	33	19.9	8.3	5.5	83.8
Calcareous	7	Yes	09-May-08	1427	9.8	36	27.8	8.2	4.2	81.2
Calcareous	7	Yes	16-Apr-08	1502	20.2	67	25.4	10.7	5.6	66.7
Calcareous	8	Yes	29-Apr-09	1330	23.3	36	28.8	6.0	1.4	118
Calcareous	8	Yes	28-Apr-09	1330	21.0	27	30.0	7.0	5.0	95.7
Calcareous	9	Yes	09-May-07	1720	16.1	28	25.7	3.0	5.9	78.6
Calcareous	9	Yes	24-Apr-09	1350	13.3	60	25.0	6.0	1.4	83.5
Calcareous	14	Yes	16-May-07	1240	10.4	35	21.4	6.4	5.0	63.4
Calcareous	15	Yes	07-May-08	1319	11.5	26	30.3	7.0	8.7	113
Calcareous	24	Yes	08-May-09	1146	19.8	37	27.0	9.0	3.3	114
Shallow sand	4	No	06-Apr-06	1415	23.0	30	26.0	17.0	1.1	19.2
Shallow sand	4	No	07-Apr-06	1305	24.8	26	29.4	8.9	2.9	29.7
Shallow sand	5	Yes	11-Apr-07	1250	24.3	23	27.6	8.6	1.1	14.8

doi:10.1071/WF11065_AC

Shrubland vegetation type	Time since fire (years)	Fire Ran?	Date of fire	Time of ignition	Forest Fire Danger Index	Relative humidity (%)	Temperature (°C)	Mean wind velocity (km h^{-1})	Litter moisture (%)	Live fine fuel moisture (%)
Shallow sand	6	Yes	15-Apr-08	1334	22.4	31	31.2	11.1	0.8	29.4
Shallow sand	14	Yes	22-Apr-08	1312	10.9	40	28.0	16.6	9.4	46.0
Deep sand	4	No	06-Apr-06	1530	25.5	27	27.3	15.1	1.8	25.8
Deep sand	4	No	07-Apr-06	1455	27.3	24	30.3	9.6	5.3	46.2
Deep sand	5	No	23-Apr-07	1217	11.5	42	24.5	6.5	2.1	59.0
Deep sand	6	No	08-May-08	1314	10.8	44	28.4	8.1	1.5	81.2
Deep sand	7	Yes	24-Apr-07	1226	12.1	46	25.1	13.7	1.8	23.5
Deep sand	8	Yes	20-Apr-06	1515	21.6	32	32.2	8.9	1.2	80.8
Deep sand	9	Yes	19-Apr-07	1213	12.7	39	24.4	7.2	1.2	9.4
Deep sand	11	Yes	27-Apr-07	1305	23.5	29	26.3	14.4	1.9	23.2
Deep sand	12	Yes	06-May-08	1206	19.9	23	29.0	3.3	0.8	63.9
Deep sand	14	Yes	08-May-07	1600	19.5	35	25.0	4.1		
Deep sand	14	Yes	02-May-08	1442	18.0	23	28.3	6.4	2.2	79.2
Deep sand	16	Yes	08-May-07	1335	25.6	17	28.4	3.0	1.6	66.1

doi:10.1071/WF11065_AC

Table S2. Fuel characteristics of 35 experimental fires ignited across three shrubland vegetation types in Western Australia

Shrubland vegetation type	Time (years)	Fire Ran?	Litter biomass (t ha^{-1})	Live biomass (t ha^{-1})	Total biomass (t ha^{-1})	Fuel bed depth (cm)
Calcareous	3	Yes	1.9	4.9	6.8	54.8
Calcareous	3	No	1.7	5.4	7.1	31.5
Calcareous	4	Yes	1.6	4.5	6.1	47.7
Calcareous	5	No	2.0	14.3	16.2	77.4
Calcareous	5	Yes	2.5	5.9	8.4	45.0
Calcareous	6	Yes	2.5	12.0	14.5	61.8
Calcareous	6	Yes	2.0	7.2	9.2	35.3
Calcareous	6	No	1.9	5.6	7.4	61.3
Calcareous	7	No	2.9	13.1	16.0	85.5
Calcareous	7	Yes	2.2	16.0	18.2	56.9
Calcareous	7	Yes	2.6	8.8	11.4	41.2
Calcareous	8	Yes	4.0	14.9	18.9	63.0
Calcareous	8	Yes	3.7	12.3	16.0	45.4
Calcareous	9	Yes	2.8	14.7	17.5	107.6
Calcareous	9	Yes	2.3	8.6	10.9	40.5
Calcareous	14	Yes	3.3	23.0	26.3	94.8
Calcareous	15	Yes	3.4	15.7	19.2	113.1
Calcareous	24	Yes	4.8	13.4	18.2	46.6
Shallow sand	4	No	0.7	1.9	2.5	43.8
Shallow sand	4	No	0.7	2.7	3.4	45.0
Shallow sand	5	Yes	0.5	2.4	2.9	45.6
Shallow sand	6	Yes	0.6	2.6	3.3	42.0
Shallow sand	14	Yes	1.1	2.0	3.1	46.0
Deep sand	4	No	0.8	5.6	6.4	59.8
Deep sand	4	No	1.4	5.2	6.6	64.9
Deep sand	5	No	1.0	3.9	4.9	57.3
Deep sand	6	No	1.1	5.3	6.4	56.8
Deep sand	7	Yes	1.1	4.0	5.0	54.4
Deep sand	8	Yes	2.5	10.8	13.4	63.5
Deep sand	9	Yes	1.6	5.3	7.0	72.2
Deep sand	11	Yes	3.3	7.7	11.0	58.5
Deep sand	12	Yes	2.8	10.3	13.1	64.1
Deep sand	14	Yes	4.1	14.8	18.8	71.6
Deep sand	14	Yes	2.0	5.1	7.1	59.5
Deep sand	16	Yes	2.2	8.9	11.0	68.8

Table S3. Observed and predicted measures of fire behaviour in 35 experimental fires conducted across three shrubland vegetation types in Western Australia, 2006–09

Notes: blank cells represent instances in which ignition did not result in a forward-spreading fire through plots

Shrubland vegetation type	Time since fire (years)	Fire Ran?	Time >120°C	Mean maximum temperature (°C)	Observed ROS (m s^{-1})	Observed FI (kW m^{-1})	Predicted ROS (m s^{-1})	Predicted FI (kW m^{-1})
Calcareous	3	Yes	168	133	0.85	3960	0.32	2855
Calcareous	3	No					0.23	2099
Calcareous	4	Yes	297	77	0.92	3603	0.20	1290
Calcareous	5	No					0.03	78
Calcareous	5	Yes	341	205	0.59	3533	0.33	3647
Calcareous	6	Yes	124	88	0.60	4410	0.03	99
Calcareous	6	Yes	218	130	0.65	3500	0.34	4052
Calcareous	6	No					0.12	1036
Calcareous	7	No					0.07	299
Calcareous	7	Yes	453	92	0.61	4711	0.03	116
Calcareous	7	Yes	172	118	0.74	5037	0.23	3426
Calcareous	8	Yes	267	273	0.83	8857	0.14	3460
Calcareous	8	Yes	209	171	0.21	2035	0.12	2172
Calcareous	9	Yes	264	118	0.45	3895	0.02	85
Calcareous	9	Yes	136	150	0.69	4268	0.11	1813
Calcareous	14	Yes	263	71	0.36	4012	0.04	194
Calcareous	15	Yes	609	193	0.08	776	0.06	252
Calcareous	24	Yes	905	370	0.68	8223	0.22	5771
Shallow sand	4	No					0.76	2333
Shallow sand	4	No					0.31	1115
Shallow sand	5	Yes	36	103	0.38	525	0.30	868
Shallow sand	6	Yes	111	126	0.48	840	0.35	1290
Shallow sand	14	Yes	97	114	0.35	900	0.78	2351
Deep sand	4	No					0.05	69
Deep sand	4	No					0.37	2783
Deep sand	5	No					0.22	1206
Deep sand	6	No					0.15	700
Deep sand	7	Yes	121	125	0.82	2384	0.58	3664
Deep sand	8	Yes	[A]	183	[A]	[A]	0.25	4340
Deep sand	9	Yes	138	103	1.57	6679	0.37	3269
Deep sand	11	Yes	165	157	1.40	11073	0.88	15105
Deep sand	12	Yes	204	128	0.23	1717	0.10	1946
Deep sand	14	Yes	[A]	190	[A]	[A]	0.14	3977
Deep sand	14	Yes	139	106	0.66	3249	0.23	2067
Deep sand	16	Yes	138	166	0.10	602	0.10	1383

[A]Instruments failed at two fires, thus heating duration, ROS and FI were not able to be estimated.

doi:10.1071/WF11065_AC

Table S4. Univariate correlations (Pearson) between measures of fire behaviour and individual components of fuels and weather from experimental fires in shrublands of Western Australia

Pearson correlations are *, $P < 0.05$; **, $P < 0.01$; ***, $P < 0.001$. Data from $n = 23$ experimental fires that successfully propagated. ROS, rate of spread; FI, fireline intensity. The heating duration was the time above 120°C

		ROS ($m\ s^{-1}$)	FI ($kW\ m^{-1}$)	Mean maximum temperature (°C)	Heating duration (s)
Fuels	Fuel age (years)	–0.25	0.12	0.50**	0.55**
	Litter mass ($t\ ha^{-1}$)	–0.06	0.55**	0.66***	0.67***
	Live mass ($t\ ha^{-1}$)	–0.29	0.26	0.21	0.51**
	Total mass ($t\ ha^{-1}$)	–0.26	0.32	0.29	0.55**
	Litter moisture (%)	–0.26	–0.17	–0.18	0.21
	Live moisture (%)	–0.44*	0.04	0.45*	0.58**
Weather	FFDI	–0.01	0.09	0.37	–0.14
	Wind ($km\ h^{-1}$)	0.31	0.10	0.02	–0.07
	Relative humidity (%)	0.20	0.23	0.09	–0.02
	Temperature (°C)	–0.19	–0.28	0.22	0.14

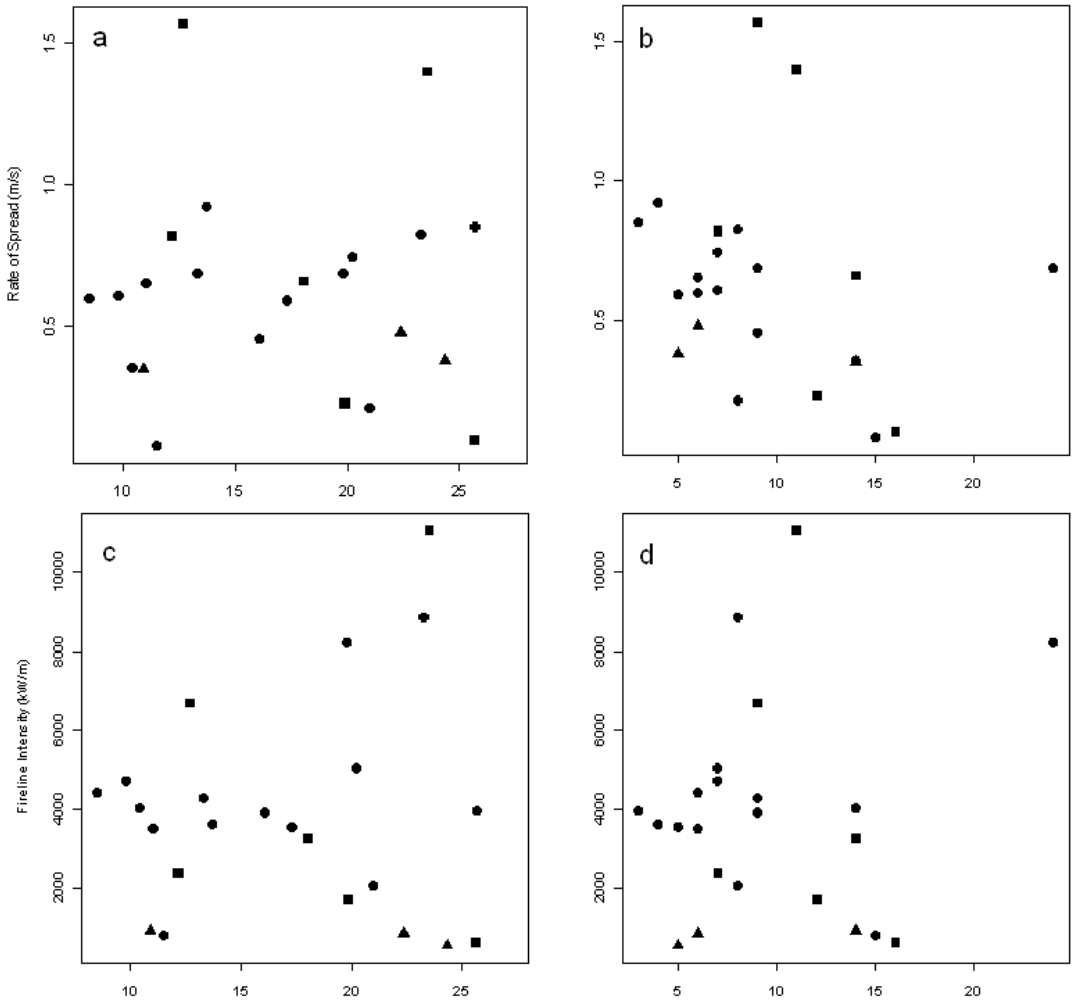

Fig. S1. Observed fire behaviour (rate of spread (a–b); fireline intensity (c–d); mean surface temperature (e–f); heating duration (s > 120°C) (g–h)) relative to fire danger (a, c, e, g) and fuel age (b, d, f, h) from 23 experimental fires in shrublands of Western Australia. No correlations were statistically significant with the exception of f and h at $P < 0.01$, see Table S4 for details.

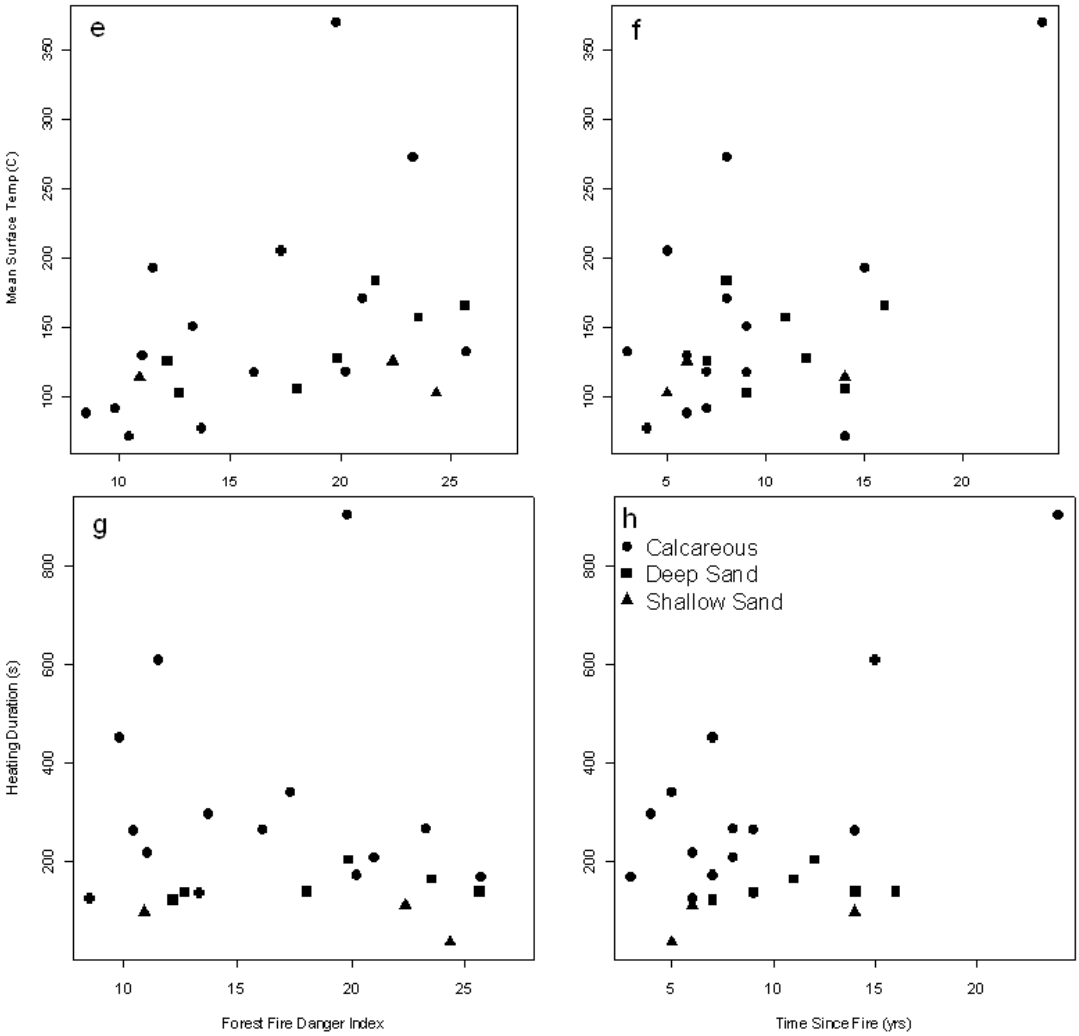
e
f
g
h
Mean Surface Temp (C)
Heating Duration (s)
Forest Fire Danger Index
Time Since Fire (yrs)
Calcareous
Deep Sand
Shallow Sand

Fig. S1. (*Cont.*)