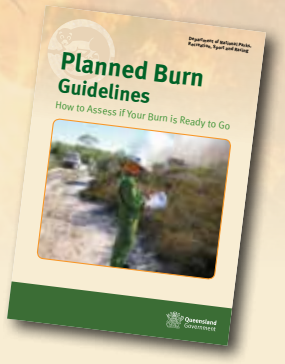
QPWS planned burn
fire behaviour tables

(Refer to "How to" guidelines for full instructions)



Queensland Government

Step 1 Estimate time before you can burn

Rainfall event Amount of rain (mm)	Open forests and woodlands		Wallum and heath	Open grassland
	A site with leaf litter	A grassy site with some leaf litter		
	Minimum drying time (days) *(approximate)			
2	1–2	1	1	1
5	2–3	2	1	1
10	4–6	3	2	1
20	6–10	4	2	2
30	7–12	4	3	2
40	8–14	5	3	2
50	10–18	6	3	2
75+	14–22	9	5	3

*Drying time may vary dependant on seasonal conditions (adapted from Qld Forestry, c. 1970)

Step 2 Estimate fuel moisture

Figures inside the thick lines indicate optimum conditions for planned burns.

Relative humidity (%)	Temperature (° C)									
	14	16	18	20	22	24	26	28	30	32
	Fuel moisture factor									
15				5.6	5.1					
20				6.0	5.8	5.5	5.1			
25		7.4	7.1	6.8	6.5	6.1	5.7	5.4	5.0	
30	8.5	8.0	7.7	7.5	7.1	6.8	6.4	6.0	5.6	5.3
35	9.2	8.7	8.4	8.0	7.8	7.4	7.0	6.7	6.3	6.0
40	9.8	9.3	9.0	8.6	8.4	8.1	7.7	7.3	7.0	6.7
45	10.5	10.0	9.7	9.3	9.0	8.8	8.4	8.0	7.7	7.3
50	11.1	10.7	10.3	10.0	9.7	9.4	9.0	8.7	8.3	8.0
55	11.8	11.3	11.0	10.6	10.3	10.0	9.7	9.3	9.0	8.7
60	12.4	12.0	11.6	11.3	11.0	10.7	10.3	10.0	9.7	9.3
65	13.1	12.7	12.3	12.0	11.6	11.3	11.0	10.7	10.4	10.0
70	13.7	13.3	13.0	12.6	12.3	12.0	11.7	11.3	11.0	10.7
75	14.4	14.0	13.6	13.3	13.0	12.6	12.3	12.0	11.7	11.4

Add one per cent for heavily shaded fuels; subtract 0.5 per cent for very open forest. (Adapted from QDPIF, 2005)

Step 3 Estimate wind force using the Beaufort scale

Wind force (Bf. No.)	Title	Characteristics	Km/h	Knots
0	Calm	Smoke rises vertically, no perceptible wind.	‹ 1	0
1	Light air	Smoke drifts, leaves barely move.	1–5	1–3
2	Light breeze	Wind felt on face, leaves rustle, small twigs move.	6–11	4–6
3	Gentle breeze	Leaves and small twigs in constant motion, light flags extended.	12–19	7–10
4	Moderate breeze	Raises dust, small branches are moved.	20–29	11–16
5	Fresh breeze	Small trees sway, large branches sway.	30–39	17–21
6	Strong breeze	Large branches in constant motion, wires whistle, umbrellas held with difficulty.	40–49	22–27
7	Near gale	Whole trees in motion, inconvenience felt when walking against wind.	50–61	28–33
8	Gale	Branches break off trees.	62–74	34–40
9	Strong gale	Slight structure damage, branches litter the ground.	75–88	41–47

Note: Wind force used in the fire behaviour tables are based on estimates at 10 m on open, flat ground.
If using a Kestrel at two metres, choose an open, flat site and multiply by 1.25 to approximate 10 m conditions.

Step 4 Estimate fuel load

Stage 1—Choose representative locations (three sites ideally)				
Stage 2—Surface fine fuels (‹ 6 mm): % cover / 100 x Depth (cm) x 5(t/ha) = Fuel Load (t/ha)				
Stage 3—Elevated fuels: (% cover of knee layer + % cover of waist layer + % cover of shoulder layer) / 100 x 5(t/ha) = Fuel Load (t/ha)				
Stage 4—Total fuel load = surface fuels + elevated fuels + bark (as required) (if bark fuel is present add 1 or 2 tonnes/hectare)				
Stage 1—Site	**Stage 2**— Surface Fuels	**Stage 3**— Elevated Fuels	**Stage 4a**—Bark (add as required)	**Stage 4b**— Total fuel load
Site 1				t/ha
Site 2				t/ha
Site 3				t/ha
Stage 4c: Average total fuel load (sites: 1 + 2 + 3 / 3)			Av	t/ha

Step 5 Select a comparative vegetation type and use results from steps 3 & 4 to predict fire behaviour.

QPWS adapted Queensland Forestry Fire Behaviour Tables

Slope: The rate of spread doubles for every 10˚ upslope and conversely halves for every 10˚ down slope (e.g. 10˚ ↑ slope increases R, H x 2; 30˚ ↑ x 8).

Table A. Light fuels = 8 t/ha
Figures inside the thick lines indicate optimum conditions for planned burns.

Wind force (Bf no.)	Fuel moisture factor							Details
	12	11	10	9	8	7	6	Percentage (%)
0	7	9	10	14	18	27	28	Rate of spread (m/hr)
	0.1	0.2	0.2	0.3	0.3	0.4	0.6	Flame height (m)
	1.0	1.0	1.0	2.0	2.0	2.0	3.0	Scorch height (m)
1	10	11	15	18	25	35	48	Rate of spread (m/hr)
	0.2	0.2	0.3	0.3	0.4	0.5	0.7	Flame height (m)
	1.0	1.0	2.0	2.0	2.0	3.0	3.5	Scorch height (m)
2	12	15	18	23	31	42	59	Rate of spread (m/hr)
	0.2	0.3	0.3	0.4	0.5	0.6	0.8	Flame height (m)
	1.0	2.0	2.0	2.0	3.0	3.0	4.0	Scorch height (m)
3	16	20	25	33	43	59	81	Rate of spread (m/hr)
	0.3	0.3	0.4	0.5	0.6	0.8	1.1	Flame height (m)
	2.0	2.0	2.0	3.0	3.0	4.0	5.5	Scorch height (m)
4	20	25	33	42	55	75	109	Rate of spread (m/hr)
	0.3	0.4	0.5	0.6	0.8	1.0	1.3	Flame height (m)
	2.0	2.0	3.0	3.0	4.0	5.0	6.5	Scorch height (m)
5	28	34	43	56	74	99	136	Rate of spread (m/hr)
	0.4	0.5	0.6	0.8	1.0	1.3	1.7	Flame height (m)
	2.0	3.0	3.0	4.0	5.0	6.5	8.0	Scorch height (m)

Subtract one from wind force when burning in stands with greater than 60 per cent canopy cover, to allow for reduction in wind.

Example calculation* from the table above:

If slope = 0˚; the wind force = 2 bf; and the fuel moisture factor = 8, then:
- Rate of spread = 31 m/hr
- Flame height = 0.5 m
- Scorch height = 3 m.

*Calculation assumes flat country (use slope calculation as required).

Table B. Moderate–heavy fuels = 12 t/ha
Figures inside the thick lines indicate optimum conditions for planned burns.

Wind force (Bf no.)	Fuel moisture factor							Details
	12	11	10	9	8	7	6	Percentage (%)
0	12	15	17	23	30	45	61	Rate of spread (m/hr)
	0.3	0.3	0.4	0.5	0.7	1.0	1.3	Flame height (m)
	1.5	2.0	2.0	2.5	3.5	5.0	6.5	Scorch height (m)
1	16	18	25	30	42	57	80	Rate of spread (m/hr)
	0.4	0.4	0.6	0.7	0.9	1.2	1.7	Flame height (m)
	2.0	2.0	3.0	3.5	4.5	6.0	8.0	Scorch height (m)
2	20	25	30	39	52	70	98	Rate of spread (m/hr)
	0.5	0.6	0.7	0.9	1.1	1.5	2.1	Flame height (m)
	2.5	3.0	3.5	4.5	5.5	7.0	9.5	Scorch height (m)
3	27	33	42	55	72	98	135	Rate of spread (m/hr)
	0.6	0.8	0.9	1.2	1.5	2.1	2.7	Flame height (m)
	3.0	4.0	4.5	6.0	7.0	9.5	11.5	Scorch height (m)
4	34	42	55	70	93	125	172	Rate of spread (m/hr)
	0.8	0.9	1.2	1.5	2.0	2.8	3.8	Flame height (m)
	4.0	4.5	6.0	7.0	9.0	12.0	15.0	Scorch height (m)
5	47	57	72	93	124	165	227	Rate of spread (m/hr)
	1.0	1.2	1.5	2.0	2.8	3.8	4.8	Flame height (m)
	5.0	6.0	7.0	9.0	12.0	15.0	18.0	Scorch height (m)

Table C. Grassy forest
Figures inside the thick lines indicate optimum conditions for planned burns.

Wind force (Bf no.)	Fuel moisture factor							Details
	12	11	10	9	8	7	6	Percentage (%)
0	10	18	25	30	40	60	80	Rate of spread (m/hr)
	0.2	0.3	0.3	0.4	0.6	0.8	1.1	Flame height (m)
	1.5	2.0	2.0	2.0	3.0	4.0	5.5	Scorch height (m)
1	16	23	32	40	50	72	96	Rate of spread (m/hr)
	0.2	0.3	0.4	0.6	0.7	1.0	1.2	Flame height (m)
	1.5	2.0	2.0	3.0	4.0	5.0	6.0	Scorch height (m)
2	23	30	40	50	63	88	111	Rate of spread (m/hr)
	0.3	0.4	0.6	0.7	0.8	1.2	1.5	Flame height (m)
	2.0	2.0	3.0	4.0	4.0	6.0	7.5	Scorch height (m)
3	36	47	58	71	90	120	148	Rate of spread (m/hr)
	0.5	0.7	0.8	1.0	1.2	1.6	1.9	Flame height (m)
	3.0	4.0	4.0	5.0	6.0	8.0	9.0	Scorch height (m)
4	52	64	77	96	122	160	194	Rate of spread (m/hr)
	0.7	0.8	1.0	1.2	1.6	2.0	2.4	Flame height (m)
	4.0	4.0	5.0	6.0	8.0	9.0	10.5	Scorch height (m)
5	74	89	108	136	171	218	265	Rate of spread (m/hr)
	1.0	1.2	1.4	1.7	2.1	2.6	3.0	Flame height (m)
	5.0	6.0	7.0	8.0	9.5	11.0	12.0	Scorch height (m)

This table is based on average fuel condition of 4–8 t/ha, grasses 90 per cent cured and average canopy cover.

Heavy grass fuels will produce greater flame height than these average figures.
For open stands (20–40 per cent cover), add 1 to the wind force.

Table D. Open grassland

Wind force (Bf no.)	Fuel moisture factor							Details
	12	11	10	9	8	7	6	Percentage (%)
0	10	18	25	30	40	60	80	Rate of spread (m/hr)
	0.2	0.3	0.4	0.4	0.6	0.8	0.8	Flame height (m)
1	30	39	49	61	77	105	133	Rate of spread (m/hr)
	0.4	0.6	0.7	0.8	0.8	0.8	0.9	Flame height (m)
2	75	90	110	137	173	220	265	Rate of spread (m/hr)
	0.8	0.8	0.9	0.9	1.0	1.1	1.1	Flame height (m)
3	120	150	185	235	294	390	450	Rate of spread (m/hr)
	0.9	0.9	1.0	1.1	1.2	1.3	1.4	Flame height (m)
4	350	450	550	650	760	880	1000	Rate of spread (m/hr)
	1.3	1.4	1.6	1.8	1.8	2.0	2.5	Flame height (m)
5	800	940	1000	› 1000	› 1000	› 1000	› 1000	Rate of spread (m/hr)
	2.1	2.3	2.5	2.5	2.5	2.5	2.5	Flame height (m)

This table is based on average native pasture which is 90 per cent cured.

Step 6 Select relevant table, then use flame and/or scorch height from step 5 to determine fire severity class.

Table 1. Open grassland/sedgeland (excludes tropical savanna)

Fire severity class	Fire intensity (during the fire)		Fire severity (post fire)	
	Fire Intensity (kWm-1)	Average flame height (m)	Average scorch height (m)	Description (loss of biomass)
Patchy (P)	‹ 50	‹ 0.3	≤ 1.5	High percentage of patchiness. Does not remove all the surface fuels (litter) and near surface fuels.
Low (L)	50–100	0.3–0.5	≤ 2.5	Some patchiness. Most of the surface and near surface fuels have burnt. Stubble still evident.
Moderate (M)	100–1500	0.5–1.5	Complete standing biomass removed.	All surface and near surface fuels burnt. Stubble burnt to blackened remnants.
High (H)	1500–5300	1.5–4.0	Complete biomass removed.	Ground burnt completely. Stubble burnt to ash.
Very high (VH)	› 5300	› 4.0	Complete biomass removed.	Usually for high biomass grasses. Ground burnt completely. Stubble burnt to ash.

Note: based on fuel load at 6 t/ha, grasses cured at 90 per cent, Byram fireline intensity at 18 000 kilojoules per kilogram (kJ/kg).

Table 2. Tropical savanna woodlands and grasslands

Fire severity class	Fire intensity (during the fire)		Fire severity (post fire)	
	Fire intensity (kWm-1)	Average flame height (m)	Average scorch height (m)	Description (loss of biomass)
Patchy (P)	‹‹ 100	‹‹ 0.5	‹‹ 2.0	High percentage of patchiness. Does not remove all the surface fuels (litter) and near surface fuels. Some scorching of elevated fuels (no higher than 2 m). No canopy scorch.
Low (L)	‹ 100	‹ 0.5	‹ 2.0	Some patchiness, most of the surface and near surface fuels have burnt. Some scorching of elevated fuels. Little or no canopy scorch.
Moderate (M)	100–500	0.5–1.5	2.0–5.0	All surface and near surface fuels burnt. All or most of mid-storey canopy leaves scorched. Upper canopy leaves may be partly scorched.
High (H)	500–10 000	1.5–4.0	Complete canopy scorch.	All ground material affected by fire. All mid storey canopy leaves scorched or charred. All upper storey canopy leaves scorched.
Very high (H) to Extreme (E)	› 10 000	› 4.0	Completely charred.	Ground, mid-storey, and upper-canopy are completely affected by fire. Most leaf material is removed or charred.

Note: based on fuel load at 6 t/ha, Byram fireline intensity at 20 000 kJ/kg. Higher fire intensities at high to extreme fire severity classes due to tropical savanna conditions—but flames heights are still compatible with the fire behaviour tables.

(Adapted from Edwards, A. 2009 - Bushfire CRC).

Table 3. Open forests/woodlands

Fire severity class	Fire intensity (during the fire)		Fire Severity (post fire)	
	Fire intensity (kWm-1)	Average flame height (m)	Average scorch height (m)	Description (loss of biomass)
Low (L)	‹ 150	‹ 0.5	‹ 2.5	Significant patchiness. Litter retained but charred. Humus layer retained. Nearly all habitat trees, fallen logs, and grass stubble retained. Some scorching of elevated fuels. Little or no canopy scorch.
Moderate (M)	150–500	0.5–1.5	2.5–7.5	Moderate patchiness. Some scorched litter remains. About half the humus layer and grass stubble remain. Most habitat trees and fallen logs retained. Some scorch of elevated fuels. Little or no canopy scorch.
High (H)	500–1000	1.5–3.0	7.5–15.0	Some patchiness. Some humus remains. Some habitat trees and fallen logs affected. At least some canopy scorch in moderate ‹ 20 m height canopy, mid stratum burnt completely (or nearly so).
Very high (VH)	1000–3000	3.0–10.0	Extensive scorching.	All understorey burnt to ash (or nearly so). Most habitat trees and fallen logs affected. Extensive crown scorch.
Extreme (E)	› 3000	› 10.0	Partial or total defoliation.	All understorey burnt to ash (or nearly so). Loss of nearly all habitat trees and fallen logs. Partial or total defoliation.

Note: based on fuel load at 8 t/ha, grasses cured at 90 per cent, Byram fireline intensity at 18 000 kJ/kg.

Table 4. Low open forest/woodland with heath dominate understorey ‹ 10 m

Fire severity class	Fire intensity (during the fire)	Fire severity (post fire)	
	Average flame height (m)	Average scorch height (m)	Description (loss of biomass)
Patchy (P) to Low (L)	‹ 1.0	‹ 5.0	40–60 per cent vegetation burnt. Unburnt vegetation (green patches) in the ground and shrub layer. Does not remove all the surface fuels (litter) and near surface fuels. Can create distinct 'holes' in closed heath. Overall little canopy scorch. Some scorching of shrubs and small trees.
Moderate (M) to Extreme (E)	› 1.0	› 5.0	Understorey burnt to mineral earth. Greater than 60 per cent vegetation burnt. Extensive to total foliage burnt. Minimal evidence of green vegetation remaining. Largely only skeletal frames of shrubs and small trees remain.

Note: based on fuel load at 12 t/ha, Byram fireline intensity at 18 000 kJ/kg.

Table 5. Heathland ‹ 2 m (coastal, sandstone, montane)

Fire severity class	Fire intensity (during the fire)	Fire severity (post fire)
	Average flame height (m)	Description (loss of biomass)
Patchy (P) to Low (L)	‹ 1.0	40–60 per cent vegetation burnt. Unburnt vegetation (green patches) in the ground and shrub layer. Does not remove all the surface fuels (litter) and near surface fuels. Can create distinct 'holes' in closed heath. Overall little canopy scorch. Some scorching of shrubs and small trees.
Moderate (M) to Extreme (E)	› 1.0	Greater than 60 per cent vegetation burnt. Understorey burnt to mineral earth. Extensive to total foliage burnt. Minimal evidence of green vegetation remaining. Skeletal frames of shrubs.

Note: based on fuel load at 12 t/ha, Byram fireline intensity at 18 000 kJ/kg.

Table 6. Cypress dominated communities

Fire severity class	Fire intensity (during the fire)		Fire severity (post fire)	
	Fire intensity (kWm-1)	Average flame height (m)	Average scorch height (m)	Description (loss of biomass)
Low (L)	‹ 50	‹ 0.3	‹ 1.5	High percentage of patchiness with minimal encroachment into cypress dominated communities. Undamaged cypress crowns. No signs of stem or bark damage.
Moderate (M)	50–200	0.3–1.0	1.5–5.0	Some patchiness, most of the surface fuels have burnt. Moderate scorch with up to 50 per cent of crown affected. Up to 25 per cent of stem circumference charred or weeping.
High (H)	200–500	1.0–2.0	5.0–10	Ground and mid-stratum burnt. Some habitat trees and fallen trees affected. Severe scorch with 50–100 per cent of crown affected. Up to 50 per cent of stem circumference charred or weeping.
Very high (VH)	500–2000	2.0–4.0	Complete canopy scorch.	All understory burnt. Most habitat trees and fallen logs affected. Full crown scorch with high probability of death expected. All butt stem (0.5 to 1 m height) circumference charred or weeping. Occasional flaring to tree tops.
Extreme (E)	› 2000	› 4.0	Completely charred.	All understory burnt. Most habitat trees and fallen logs affected. Full crown removal with no recovery expectation. All stem circumference charred or weeping. Frequent flaring and/or crown fires.

Note: Based on fuel load at 6–12 t/ha, Byram fireline intensity at 18 000 kJ/kg.

Step 7 Do your fire behaviour predictions suit the objectives of your planned burn?

Important points to consider:

- Assess weather patterns before, during and after the burn. It is important to be aware of weather conditions in the month following a burn, particularly with seasonal changes and the possibility of severe fire weather. Re-ignition can occur in more severe fire weather weeks after a burn, and the risk is higher for mild burns with unburnt mosaics, retained duff layer, or unburnt boundary sections.

  Note: Ensure a 'go to burn' is obtained from your regional manager (or delegate) for planned burns during fire risk periods (as defined by local fire preparedness procedures).

- Prior to commencement of a planned burn, test burns should be conducted. Before igniting a test burn, ensure you have adequate resources to easily extinguish the burn.

Bp1952