Government of **Western Australia**
Department of **Fire & Emergency Services**

DFES
Department of Fire & Emergency Services

# Kimberley Burning Guidelines

Environmental Protection Branch
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# Kimberley Burning Guidelines

GOVERNMENT OF WESTERN AUSTRALIA

DFES Department of Fire & Emergency Services


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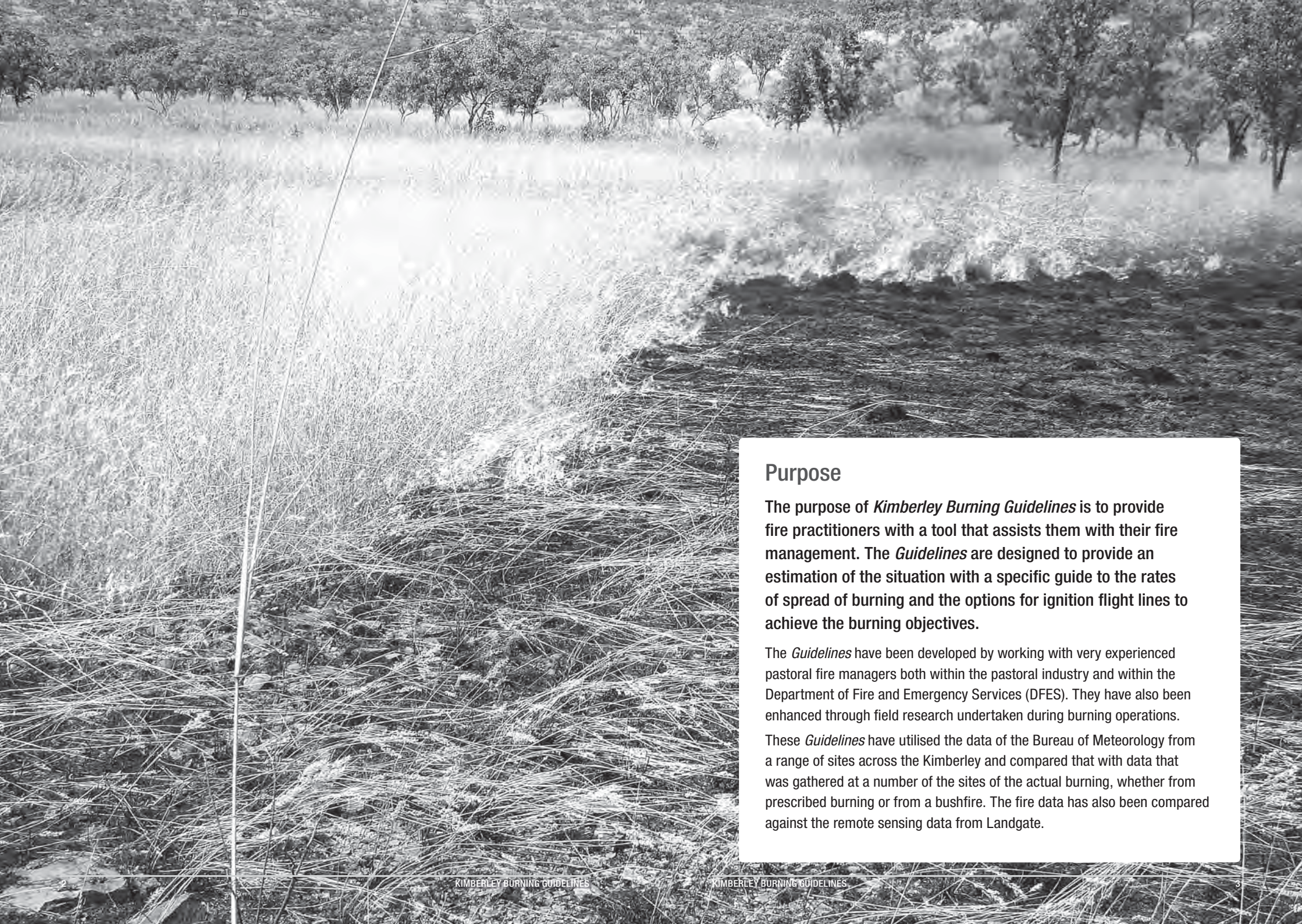
1. Emergency Management Australia (EMA).
2. Pastoralists and Graziers Association (PGA).
3. Pastoralists in the Kimberley, and in particular in the Fitzroy Crossing area.
4. Bureau of Meteorology (BoM).
5. Department of Fire and Emergency Services (DFES) staff.

These *Guidelines* are modified from the *Kimberley Bush Fire Burning Guidelines and Firebreak Location, Construction and Maintenance Guidelines* published in 2007 by Fire and Emergency Services Authority (FESA), Australian Government Local Grant Scheme and the Pastoralists and Graziers Association (PGA).

## Disclaimer



## Contents



## Purpose

**The purpose of *Kimberley Burning Guidelines* is to provide fire practitioners with a tool that assists them with their fire management. The *Guidelines* are designed to provide an estimation of the situation with a specific guide to the rates of spread of burning and the options for ignition flight lines to achieve the burning objectives.**

The *Guidelines* have been developed by working with very experienced pastoral fire managers both within the pastoral industry and within the Department of Fire and Emergency Services (DFES). They have also been enhanced through field research undertaken during burning operations.

These *Guidelines* have utilised the data of the Bureau of Meteorology from a range of sites across the Kimberley and compared that with data that was gathered at a number of the sites of the actual burning, whether from prescribed burning or from a bushfire. The fire data has also been compared against the remote sensing data from Landgate.

# Burning Guidelines for the Kimberley

| Prescribed Burning | | | Unplanned Bushfires |
|---|---|---|---|
| **Hard Spinifex (Hummock grasses)[1]** | **Hard Spinifex (Hummock grasses)** | **Pasture (tussock) grasses[2]** | **All vegetation** |
| **0–3 years since last burnt** | **3 years and longer since last burnt** | **All fuel ages** | **All fuel ages and vegetation types** |
| Temperature: < 35°C | Temperature: < 35°C | Temperature: < 35°C | Temperature: > 35°C |
| Relative Humidity: > 20% | Relative Humidity: > 35% | Relative Humidity: > 35% | Relative Humidity: < 25% |
| Fuel Moisture Content: > 6% | Fuel Moisture Content: 7–10% | Fuel Moisture Content: > 6% | Fuel Moisture Content: < 6% |
| Rate of Spread: 2 km/hr | Rate of Spread: < 2 km/hr | Rate of Spread: < 2 km/hr | Rate of Spread: > 2 km/hr |
| Curing: > 40% (within pasture grasses) | Curing: > 20% (within pasture grasses) | Curing: 50–70% (within pasture grasses) | Curing: > 70% (within pasture grasses) |
| Wind speed: 10–20 km/hr | Wind speed: 10–20 km/hr | Wind speed: 10 –20 km/hr | |
| When to burn: Early to mid-dry season (March–June) | When to burn: Late wet season or early dry season—when soil moisture is present (February–March) | When to burn: Early to mid-dry season (March–June) | |

Notes:

1. The Rate of Spread is based on the open grassland on the CSIRO Fire Spread Meter for Northern Australia. If the vegetation type changes then the open forest or woodland section of the meter should be used.
2. The Fuel Moisture Content determination is undertaken without considering the impact/effect of recent rainfall.
3. Curing is a visual estimation undertaken in the field.
4. The CSIRO Fire Spread Meter for Northern Australia is known to lack some accuracy when curing is below 95%. Whilst this deficiency is acknowledged, the CSIRO meter is still the best tool available at this time.
5. Wind speed is based on the standard 10 metre above ground level. If measuring the wind speed at 2 metres above the ground multiply the reading by 1.25 to obtain the equivalent 10 metre wind speed.
6. Provide some caution when burning Spinifex during dry soil conditions as it is possible to kill the plant if they are large mature plants.

[1] Hard spinifex includes *Triodia pungens* which is locally described as soft spinifex.

[2] Pasture grasses is a generic term covering the full range of grasses such as Ribbon grass (*Chrysopogan* spp.), Flinders grass (*Iseilema spp.*), Buffel grass (*Cenchrus* spp.), Cane grass (*Ophiuros* spp.), Sorghum (*Sarga* spp. and *Sorghum* spp.), Rice grass (*Xerochloa* spp.), Birdwood grass (*Cenchrus* spp.).

## Burning Guidelines process

1. Take the temperature, relative humidity and wind readings at the burn site or from the weather forecast.
2. Observe the level of curing in the tussock grasses.
3. Calculate the theoretical fire behaviour utilising the CSIRO Fire Spread Meter for Northern Australia.
4. Does the theoretical fire behaviour match the burn prescription? If yes, then plan to undertake the burn.

As an example:

- Fuel type: Spear and cane grass
- Temperature: 30°C
- Relative humidity: 40%
- Wind readings: 18 km/hr

From the physical inspection of the level of curing: 60%

From the CSIRO Fire Spread Meter for Northern Australia the calculations will be:

- Fuel Moisture Content: 9%
- Open grassland rate of spread: 200 metres per hour
- Woodland rate of spread: 100 metres per hour
- Open forest rate of spread: 60 metres per hour

Another example with a different fuel type and weather conditions:

- Fuel type: Hard spinifex
- Temperature: 35°C
- Relative humidity: 35%
- Wind readings: 15 km/hr

From the physical inspection of the tussock grasses in the adjacent area the level of curing: 70%

From the CSIRO Fire Spread Meter for Northern Australia the calculations will be:

- Fuel Moisture Content: 7%
- Open grassland rate of spread: 620 metres per hour
- Woodland rate of spread: 310 metres per hour
- Open forest rate of spread: 210 metres per hour



## Dew point

These *Guidelines* have been further developed in recent years (from the 2007 *Guidelines* publication) following extensive field testing and applying remote sensing data and have concluded that when the dew point drops below 10°C, open edged burns are unlikely to self-extinguish, particularly if accompanied by strong or consistent winds over 20 km/hr.

## Wind

### Wind speed interception and vegetation

| Type of Vegetation | Ratio between wind speed at 10 m in the open and wind speed at 2 m | Rate of forward spread relative to spread in the open |
|---|---|---|
| Open grasslands | 10 : 8 | 1.0 |
| Woodlands (5–7 m) | 10 : 6 | 0.5 |
| Open forests (10–15 m) | 10 : 4.2 | 0.3 |

Source: *Grassfires fuel, weather and fire behaviour* by Cheney & Sullivan.

For example:

If the wind speed is measured as 16 km/hr with a hand-held wind meter held at 2 metres above the ground in open grassland, the wind speed at 10 metres will be 20 km/hr (as per the middle column).

If the rate of forward spread of the fire in the open grassland is 100 m/hr it will drop to 50 m/hr in woodlands and 30 m/hr in open forests (as per third column).

### Wind speed

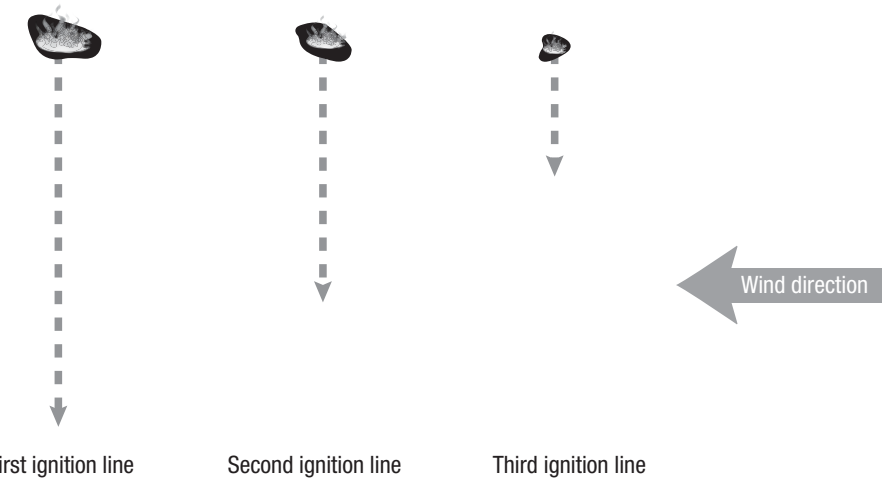
Wind speed has not been described in the above burning guidelines table but it is apparent that a wind speed in excess of 8 km/hr at 2 metres above ground, or greater than 10 km/hr at the standard height of 10 metres (also the forecast height), is required to achieve a reasonable burn. Wind speed will be a significant driver in the discontinuous grass fuels, where the flame length will need to be such that it can contact neighbouring vegetation to continue the fire run.

Insufficient wind speeds will not result in a significant fire run and the burning will be quite patchy, particularly when curing is in the 50% to 60% level. These conditions may be suitable for the mosaic burning associated with pasture management.

Wind speeds less than 10 km/hr will provide a fine-grained mosaic burn, but will not provide sufficient rate of spread to achieve a suitable buffer burn.

## Wind direction

To assist in achieving the optimum burning outcome it is considered preferable to undertake the ignition, both aerial and hand, with the wind blowing across the ignition line(s).




In some instances, after viewing the fire behaviour, it may be necessary to apply a second and/or third parallel ignition line. The actual level of ignition will be a combination of the level of curing, the fire behaviour and the objectives of the burning. The second or third flight line may need to be undertaken on a subsequent day when more of the grasses have cured.

Flying lines with or into the wind can achieve improved results in fuels that are discontinuous as each spot can better preheat and ignite the adjoining clumps such as occurs with hummock grasses such as spinifex.



# Curing

## Curing physiological changes for grasses

| % Cured | Colour | Physiological changes |
|---|---|---|
| 10 | Green | Seed heads formed and flowering. |
| 20 | Greenish–yellow | Seed heads maturing and opening from the top. |
| 40 | Yellow–green | Most seed heads maturing and seed dropping. |
| 60 | Straw–odd patch of Yellow–green | Seed dropped. Lower portions of stems green. Some paddocks may be almost fully cured, others fairly green. |
| 80 | Straw–very little green evident | Some stalks still showing some greenness but at least half fully cured. |
| 90 | Straw–odd green gully | Odd stalks may show some greenness. |
| 100 | Bleached | Seed heads and stalks break easily. |

Source: Bushfire Board, 1985, *Fire Weather Officers Course*, Perth.

## Curing and fire behaviour

Curing is important for the success of the burning and the subsequent fire behaviour. When the vegetation is green (that is, less than 50% cured) ignition will be difficult and (other than in spinifex) the fire is unlikely to sustain itself and will self-extinguish.

As the curing level increases to 50% to 70% the fire behaviour will increase correspondingly. In essence this increasing level of curing will permit a fire burning under the same temperature, humidity and wind conditions to be at a greater intensity and rate of spread than the fire burning under curing of less than 50%.

In aerial ignitions it may be possible to increase the spacing of the incendiary drops when the grasses are more cured and still achieve the desired outcome. To achieve a greater than 70% ignition on a flight line will generally require a level of grass curing of at least 60% cured.

# Aerial burning (fixed wing or rotary) incendiary spacing

## Distance between ignition lines

To determine the distance between ignition lines it is proposed that it should be double the head fire rate of spread. During the planning phase of the operation, the theoretical rate of spread from the forecast for burn area or actual readings for the site should be determined from the CSIRO Fire Spread Meter for North Australia. This will provide an indication of the expected rate of spread and fire behaviour and also some indication of the spotting distance and strip width required to achieve the burn objectives.

Once the aircraft has completed one flight line, the actual fire behaviour observed during the first ignition flight line, after 15–20 minutes, will assist in determining the required strip and spot width.

For example if the theoretical rate of spread from the forecast and calculations utilising the CSIRO Fire Spread Meter for North Australia is 200 metres per hour, it is proposed that this is confirmed during the first ignition flight line, and then the incendiary distance modified to achieve the desired objective.

| | Period between incendiary drops (seconds) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Aircraft speed** | **0.5** | **1** | **2** | **3** | **4** | **5** | **10** | **15** | **20** | **25** | **30** |
| | Distance apart (metres) | | | | | | | | | | |
| 180 km/hr | 25 | 50 | 100 | 150 | 200 | 250 | 500 | 750 | 1000 | 1250 | 1500 |
| 200 km/hr | 27 | 55 | 110 | 165 | 220 | 275 | 550 | 825 | 1100 | 1375 | 1650 |
| 220 km/hr | 30 | 61 | 122 | 183 | 244 | 305 | 610 | 915 | 1220 | 1525 | 1830 |

**Note:** Unlike fuels that are continuous, such as in a closed forest environment where leaf litter and scrub will constitute the surface fuels the backing fire will not burn back to the same degree. In discontinuous fuels such as hummock grasses (spinifex) the backing fire will be negligible as the bulk of the fire will be driven by the wind.



An example of the spot and strip width determination:

Utilising the previous example:

- Fuel type: Pasture grass
- Temperature: 30°C
- Relative humidity: 40%
- Wind readings: 18 km/hr

From the physical inspection of the level of curing: 60%

From the CSIRO Fire Spread Meter for Northern Australia the calculations will be:

- Fuel Moisture Content: 9%
- Open grassland rate of spread: 200 metres per hour
- Woodland rate of spread: 100 metres per hour
- Open forest rate of spread: 60 metres per hour

Rate of spread (for open grassland) = 200 m/hr.

**Spot distance** will be 220 metres (**head fire rate of spread**)—an incendiary every 4 seconds at 200 km/hr plane speed.

**Strip width** will be 100 metres or **half the head fire rate of spread** (200 m/hr).

| | Period between incendiary drops (seconds) | | | | |
|---|---|---|---|---|---|
| **Aircraft speed** | **0.5** | **1** | **2** | **3** | **4** |
| | Distance apart (metres) | | | | |
| 180 km/hr | 25 | 50 | 100 | 150 | 200 |
| 200 km/hr | 27 | 55 | 110 | 165 | **220** |
| 220 km/hr | 30 | 61 | 122 | 183 | 244 |

## Hand burning

When conducting hand burning it is important to ensure that the spot and strip widths are applied in such a manner that the burn objectives are achieved. To achieve this may require continuous lines of fire, or spots relatively close together or spots spread quite widely.

The guidelines on pages 4–5 are designed to provide anticipated fire rate of spread and fire behaviour. The actual burning conditions and lighting pattern will determine the success or otherwise of the burn.

Prior to lighting large areas it is recommended that a small discreet area is burnt to determine the actual fire behaviour and then modify the spot and strip widths to ensure the burn objectives are met. Both the spot and strip widths may vary during the day as the vegetation and weather conditions change (e.g. reduced humidity and a corresponding reduction in fuel moisture and increased fire behaviour).

## Pasture burning guidelines

### Recommended burning conditions for prescribed burning on pastoral lands with a variety of objectives

| Management objective | Fire intensity | Fuel load (kg DM/ha) | Season of burn |
|---|---|---|---|
| Maintaining woody vegetation structure | Moderate–High | 2000–3000 (2–3 t/ha) | April–October |
| Change woody vegetation structure, control exotic weeds | High–Very High | 2500–4500 (2.5–4.5 t/ha) | August–October |
| Hazard reduction—reducing risk of wildfire | Low–Moderate | >1500–2000 (>1.5–2 t/ha) | April–June |
| Hazard reduction and provide early, dry green pick for grazing* | Low–Moderate | >1500 (>1.5–2 t/ha) | March–April |
| Remove old, rank pasture, modify grazing distribution | Low–Moderate | >1500 (>1.5 t/ha) | November –December |

**Note:** (kg DM/ha) = kg of dried matter per ha (bracketed fuel loads are t/ha).

*Burning during the late wet season to extend the period of green pick into the early dry is generally not recommended except in lightly stocked, extensive paddocks in high rainfall areas.

Source: *Savanna Burning*. Tropical Savanna CRC.



## Controlling woody plants

### Burning conditions necessary to achieve an 80% kill of woody plants

| Maximum tree/ shrub height (cm) | Relative humidity (%) | Wind speed (km/h) | Fuel load (kg/ha) | Fire intensity (kW/m) |
|---|---|---|---|---|
| 50 | 30 | 5 | 2200 | 1000 |
| 100 | 30 | 8 | 2500 | 1400 |
| 150 | 30 | 10 | 3000 | 2200 |
| 200 | 30 | 12 | 3500 | 3000 |
| 300 | 30 | 15 | 4900 | 4600 |
| 50 | 50 | 8 | 2400 | 1100 |
| 100 | 50 | 10 | 2900 | 1800 |
| 150 | 50 | 12 | 3400 | 2600 |
| 200 | 50 | 13 | 4300 | 3500 |
| 300 | 50 | 15 | 5900 | 5300 |

Source: *Savanna Burning*. Tropical Savanna CRC.
Burning conditions (relative humidity, wind speed, fuel load and fire intensity) necessary to achieve an 80% to kill of woody plants with increasing height classes in the Victoria River District and pasture cover of 60%.

## Calculating fire line intensity

**I = HWR**

where:

I = fire intensity in kilowatts per metre (kW/m)

H = fuel heat yield (kJ/kg)

W = fuel weight in kilograms per square meter (kg/$m^2$)

R = linear rate of advance in metres per second (m/s) also expressed as head fire rate of spread

**Note:** This equation is applicable for bushfires in a quasi-steady state.

## Fire frequency and paddock size

### Recommended fire frequency and size for paddocks

| Rainfall Zone | | Fire frequency (interval between fires) | Proportion of paddock burnt each year |
|---|---|---|---|
| **High** | > 700 mm | 2–5 years | 25–50% |
| **Medium** | 400–700 mm | 4–7 years | 20–30% |
| **Low** | < 400 mm | 6–15 years | 15–25% |

Source: *Savanna Burning*. Tropical Savanna CRC.

**Note:** In some high rainfall areas the fire frequency may be shortened so that the maximum period between burning particularly in Buffel pasture may be reduced to 3 to 4 years.

## Recommended rainfall, season, vegetation and soil types

| Rainfall Zone | Fire frequency (interval between fires) and season | Soil type | Stocking rate |
|---|---|---|---|
| **High**<br>> 700 mm | 2–3 years<br>Early dry season<br>Patchy mosaic burn | Gently undulating with red volcanic soils | Relatively low |
| | Lower frequency (3+ years) where recovery from fire is slower | Gravelly rises or rugged sandstone country (primarily seed regeneration areas) | |
| | Annual fires should be avoided.<br>Springs and rain forest should be protected from hot fires | These fires favour annual native sorghum over desirable perennial grasses | |
| **Intermediate**<br>400–700 mm | Cautious approach required<br>Burning small patches along tracks in the dry season can lead to a concentration of grazing<br>Scrub control can be a problem | Red soil country | Less resilient to heavy grazing and soils prone to erode |
| | Traditionally protected from fire<br>Minimum of 4 years between fires<br>Burn late in the year after first rains | Black soil country | Relatively high carrying capacities |
| | Short-lived perennial *Enneapogan* grasses<br>No obvious benefits from burning | Limestone grass country | |
| | Vegetation over deep red and yellow sands in West Kimberley<br>Mainly curly spinifex and ribbon grass<br>Burn October–December no more often than every 4 years | Pindan Pastures | Rest over the subsequent wet season following burning |
| **Low**<br>< 400 mm | Spinifex pastures<br>Most value as feed in early stages of regeneration (1–2 years post-fire)<br>Intervals for burning 4–6 years<br>Soft spinifex—cool fires resprouts from root stock—hot fires will kill most adult plants and regeneration dependent on seed store<br>Seedlings are vulnerable to being pulled out in the early stages | | Grazing should be deferred until well established (1 year) |

**Note:** Soft spinifex = *Trodia pungens*.

Source: *Fire Management Guidelines for Kimberley Pastoral Rangelands. Best Management Practice*. March 2005, Department for Planning and Infrastructure, PLB.

From the discussions held with pastoralists in the low rainfall zone of the Kimberley there was a train of thought that the spinifex—other than soft spinifex (*Trodia pungens*)—was of primary value as a food source during the period when the seed was available as a food crop. The benefits of burning spinifex was mainly in the natural introduction of the herbaceous plants that developed in the now open areas vacated by the burnt spinifex which had declined back to its root stock.

## Aerial Burning Checklist

1. Burn prescription (including burn objectives and strategies) completed—which includes an ignition flight map and written prescription.
2. Permits to burn obtained from the local government.
3. Visual inspection of the fuels and level of grass curing (pasture grasses, not spinifex).
4. Forecast for the area of burning is obtained.
5. Determine a theoretical rate of spread and fire behaviour from the CSIRO meter and ensure that it matches the prescription.
6. Incendiary spot widths determined from theoretical model.
7. When over the job, the initial incendiary drops are observed to ensure suitable ignition and fire behaviour (15–20 minutes after ignition).
8. If required, modify the incendiary drop rate to match the percentage ignition development and fire behaviour.
9. After last incendiary drop on the first ignition line, review fire behaviour and determine if a second ignition line is required.
10. If curing conditions or fire behaviour warrant, then a second or subsequent burning day should be chosen to achieve the burn objectives.

### Safety considerations

**Safety is a key consideration when undertaking any burning operations.** Aerial ignition provides the opportunity to ignite large areas of land relatively quickly and it is therefore important to ensure that the activity is undertaken in a safe manner.

1. Incendiary operator must be trained and competent.
2. All participants must be aware of the potential and actual hazards in the area to be burnt.
3. Neighbours must be notified of the burn.
4. There must be no threat to any unexpected people in the burn area.
5. Prior to burning commences there must be a communication to the people in the area. This could be achieved by a radio announcement by a broadcaster such as the ABC.