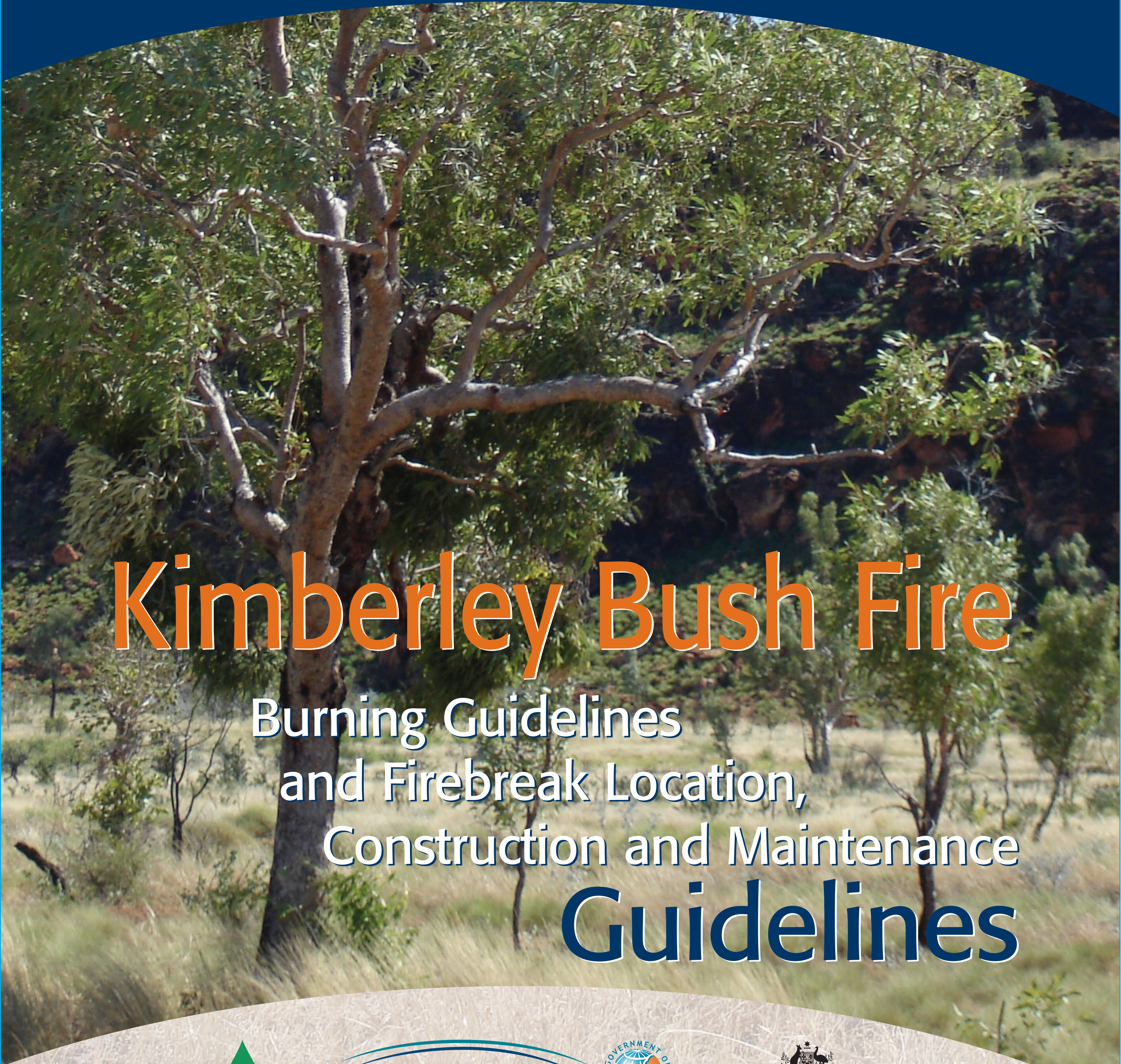

Kimberley Bush Fire

Burning Guidelines and Firebreak Location, Construction and Maintenance

Guidelines

PGA

FESA

Fire & Emergency Services Authority of Western Australia

Government of Western Australia

An Australian Government Initiative

Working Together to Manage Emergencies

This project funded through the Local Grants Scheme

Bush Fire & Environmental Protection Branch

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Acknowledgements

These *Guidelines* have been successfully developed because of the cooperation, assistance and advice FESA has received from the many people and organisations that provided support. In particular the support and assistance from the following is sincerely appreciated.

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

Note
FESA has developed these Guidelines as a reference tool to assist pastoral fire managers in determining solutions for firebreak location, construction and maintenance when a management issue is likely to eventuate. FESA is aware that many pastoralists have very extensive firebreaks on stations that suffer no erosion and therefore do not require any additional erosion mitigation works.

ISBN: 978-0-9751711-8-9

Contents

Kimberley Burning Guidelines

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 Fire and Emergency Services Authority (FESA).

These *Guidelines* have utilized the data of the Bureau of Meteorology from the Fitzroy Crossing site 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 bush fire.

Burning Guidelines for the Kimberley

Prescribed Burning			Unplanned Bush Fires
Hard Spinifex (Hummock grasses)[1]	Hard Spinifex (Hummock grasses)	Pasture 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 2km/hr	Rate of Spread < 2km/hr	Rate of Spread < 2km/hr	Rate of Spread > 2km/hr
Curing – > 40% (within pasture grasses)	Curing – > 2 0% (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 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. Exercise some caution when burning Spinifex during dry soil conditions as it is possible to kill the plant if they are large mature plants.

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[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°
- 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°
- 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

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 (5-7m)	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 20km/hr (as per the middle column).

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

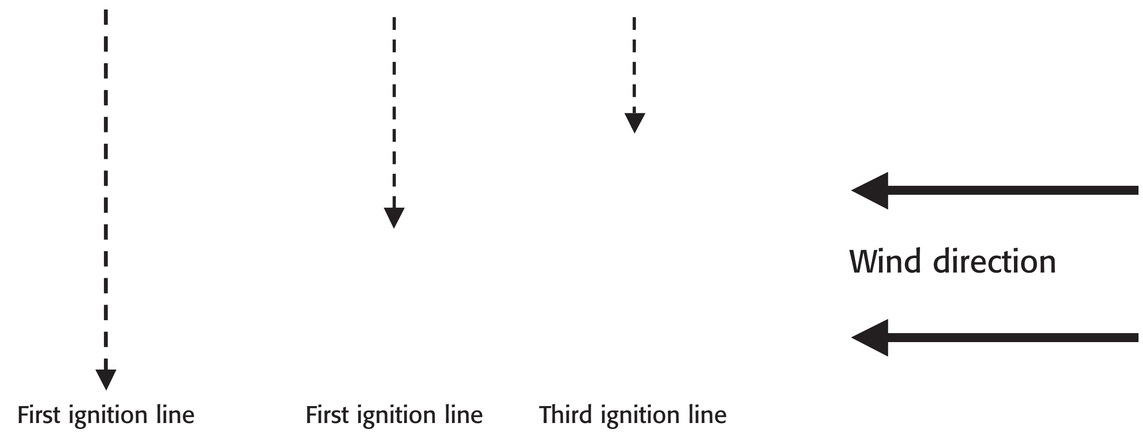
Speed

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) are required to achieve a reasonable burn. Wind speed will be a significant factor 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 speed 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 type of 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.

Direction

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



In some instances after obscuring 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 pre-heat and ignite the adjoining clumps such occurs with hummock grasses such as Spinifex.

Curing

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.

Curing Physiological Changes for Grasses

% Cured	Colour	Physiological changes
10	Green	Seed heads formed and flowering
20	Greenish-yellow	Seed heads maturing & 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: Bush Fire Board, 1985, "Fire Weather Officers Course", Perth

Aerial Burning Incendiary Spacing (metres)

Distance between ignition lines

To determine the distance between ignition lines it is suggested 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 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, 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	0.5 seconds	1 sec	2 sec	3 sec	4 sec	5 sec	10 sec	15 sec	20 sec	25 sec	30 sec
Plane speed 180 km/hr	25 metres	50	100	150	200	250	500	750	1000	1250	1500
Plane speed 200 km/hr	27 metres	55	110	165	220	275	550	825	1100	1375	1650
Plane speed 220 km/hr	30 metres	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 majority of the fire will be driven by the wind.

Strip and Spot Widths

An example of the spot and strip width determination

Utilising the previous example:

- Fuel type – pasture grass
- Temperature – 30°
- 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 – 100metres per hour
- Open forest rate of spread – 60 metres per hour

Rate of spread (for open grassland) = 200m/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 400 metres or **twice the head fire rate of spread** (200m/hr)

Period between incendiary drops	0.5 seconds	1 sec	2 sec	3 sec	4 sec
Plane speed 180 km/hr	25 metres	50	100	150	200
Plane speed 200 km/hr	27 metres	55	110	165	220
Plane speed 220 km/hr	30 metres	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. This may require continuous lines of fire, or spots relatively close together or spread quite wide to achieve the desired outcome.

The guidelines on page 3 are designed to provide predicted 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, eg. 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% to 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%

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) & Season	Soil Type	Stocking rate
High >700 mm	2-3 years Early dry season Patchy mosaic burn Lower frequency (3+ years) where recovery from fire is slower Annual fires should be avoided. Springs and rain forest should be protected from hot fires	Gently undulating with red volcanic soils Gravelly rises or rugged sandstone country (primarily seed regeneration areas) These fires favour annual native sorghum over desirable perennial grasses	Relatively low
Intermediate 400-700 mm	Cautious approach required Burning small patches along tracks in the dry season can lead to a concentration of grazing Scrub control can be a problem	Red soil country	Less resilient to heavy grazing and soils prone to erode
	Traditionally protected from fire Minimum of 4 years between fires Burn late in the year after first rains	Black soil country	Relatively high carrying capacities
	Short lived perennial *Enneapogan* grasses No obvious benefits from burning	Limestone grass country	
	Vegetation over deep red and yellow sands in West Kimberley Mainly curly spinifex and ribbon grass Burn October-December no more often than every 4 years	Pindan Pastures	Rest over the subsequent wet season following burning

Rainfall Zone	Fire frequency (Interval between fires) & Season	Soil Type	Stocking rate
Low <400 mm	Spinifex pastures Most value as feed in early stages of regeneration (1-2 years post fire) Intervals for burning 4-6 years Soft spinifex – cool fires resprouts from root stock – hot fires will kill most adult plants and regeneration dependant on seed store 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*

Discussions held with pastoralists in the low rainfall zone of the Kimberley indicated that spinifex (other than soft spinifex (*Trodia pungens*) was of primary value as a fodder 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 strategy) is complete and which includes an ignition flight map, written prescription and signed Deed of Release
2. Permits to burn obtained from local government
3. Visual inspection of the fuels and level of grass curing (pasture grasses not spinafex)
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 enables ignition of 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. When burning commences there must be a communication to the people generally living in the area. This could be achieved by a short radio announcement by a broadcaster such as the ABC.

Kimberley Firebreak Location, Construction and Maintenance Guidelines

Contents

Purpose

The purpose of *Kimberley Firebreak Location, Construction and Maintenance Guidelines* is to provide fire practitioners with a tool that assists them with the location, construction and maintenance of the fire breaks on a pastoral station. The *Guidelines* are designed to provide an estimation of the situation with specific guidance to the soil types, slope and estimations of water concentrations and volumes and the impact of these factors on soil erosion associated with firebreak location, construction and maintenance.

The *Guidelines* have been developed by working with very experienced pastoral fire managers both within the pastoral industry and within the Fire and Emergency Services Authority (FESA) and publications on soil management and erosion.

FESA has designed these *Guidelines* as a reference tool to assist pastoral fire managers in determining solutions for firebreak location, construction and maintenance when a management issue is likely to eventuate. FESA is aware that many pastoralists have very extensive firebreaks on stations that suffer no erosion and therefore do not require any additional erosion mitigation works.

The *Guidelines* are in two parts. The first part is the key considerations component that act as an awareness raiser or memory jogger. The second part contains the more in-depth guidance and options that could be considered to avoid a problem developing or to rectify a problem that has occurred.

Abstract

Firebreaks used in the natural environment are developed for a range of purposes. Each purpose will be determined by the bush fire protection needs of the individual pastoralist owner or manager. The bush fire protection needs will be determined to a large extent by the soil type, slope, vegetation type and density, the risk of ignition, the fire suppression response capability and options and the values at risk.

Unless the land is actively eroding, run off from undisturbed grazing land is relatively free of suspended solids. There are several methods to assist in reducing sediment movement. The first is to keep the area of land disturbed, for firebreaks, tracks and roads to a minimum and the second is to limit the amount of clean runoff passing though disturbed areas.

In many instances the application of a theoretical tool in the practical world requires that where erosion is not an issue then the practical application is achieving the desired result and the creation of additional erosion control measures is not warranted.

Introduction

Firebreaks serve a number of functions. Generally they are considered to be relatively narrow man-made barriers of bare ground intended to stop bush fires.[3] Under Kimberley conditions man-made mineral earth firebreaks can be more assistance in slowing down a bush fire rather than stopping the bush fire because of the effects of spotting and the absence of a direct fire suppression attack. Some firebreaks are designed to prevent the escape from fires associated with high risk activities, and others are designed to restrict entry of a fire from outside the property or area. In the Kimberley there are also very large areas protected by the placement of strategically placed aerial burning firebreaks where they are designed to provide a firebreak of between 300 metres and 1000 metres.

Where firebreaks are not required as a fire prevention tool, they can fill a very important fire suppression role by providing access routes for fire vehicles and also access to water supplies. They can also provide a prepared, ready to operate back burning boundary so that valuable time is not lost establishing the boundary during the fire suppression activities.

The vegetation type and density are important determinants of the firebreak width. The soil type, slope and peak and long duration periods and rainfall concentrations are also significant determinants in determining soil propensity to erode.

Firebreaks associated with grassland areas with an average 4-5 t/ha[4] are effective when they are wider than where radiation and/or flame contact can be expected to be less than 4 times the flame length in the horizontal plane. When the Fire Danger Index (FDI) on the Grassland Fire Danger Meter is less than 2.5 it is recognized that the fire danger rating is low and the head fire is expected to be stopped by roads and tracks. An FDI of 7.5 recognises that the fire danger rating is moderate and the head fire is easily attacked by water. When the FDI rises to 32 the fire danger rating is high and the head fire attack is generally successful with water. When the FDI exceeds 32 the ability to successfully attack the bush fire diminishes to the point where if attack is required, it should only be undertaken under favourable conditions. This is based on assumption that the fuels are continuous and reasonably heavy.

The impact of firebrands (burning embers) of bush fire management and the effectiveness of firebreaks must also be considered when analysing whether firebreaks will be successful in stoping the fire, providing fire fighter access or a secure boundary to undertake back burning operations. Low intensity fires will generally have shorter spotting distances than very intense fires. Grasslands will generally have a shorter spotting distance than forest fuels.

In many areas there are natural firebreaks of bare ground or areas that have been developed for other purposes, eg. roads, transmission line clearings or land under fallow, that provide the same function. They create a discontinuous fuel area that will under many circumstances stop the bush fire or provide an area to undertake back burning operations.

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[3] Luke & McArthur, 1986, "Bushfire in Australia"

[4] Luke & McArthur, 1986, "Bushfire in Australia"

Pasture Land Firebreaks

Firebreaks in grassland areas have a three fold purpose.[5] To provide protection to valuable pasture assets either by preventing fires entering, or to provide protection to neighbours by preventing fires from leaving the individual pastoral station estate. Firebreaks also provide access into the station and also to water resources. Access into the station can be very difficult and this difficulty in travelling can add valuable time between detection and suppression action being commenced. This increased time allows the fire to develop more fully and become more difficult to suppress.

There appears to be a need for two different types of station firebreaks. Stations can have high value pasture that can be adversely affected by bush fire, both current season and next. It is therefore considered important that boundary firebreaks be constructed quite wide, possibly 10 to15 metres. The internal paddock breaks need to recognise the importance of the area being protected and it is recommended a narrower width of break of 6 to 10 metres.

Pastoral fires that have not developed a significant head fire may be readily suppressed on a low grassland fire danger index, by simply running into the firebreak. Even in a more intense pastoral fire the backing fire and tail end of the flank fires may be suppressed with no additional suppression effort when they run into a suitable width firebreak.

[5] Luke & McArthur, 1986, "Bushfire in Australia"

Location

Firebreaks should be located to achieve four objectives:

1. Provide a mineral earth break or reduced fuel zone so that unplanned fires do not enter the property – strategic external threat protection break
2. Provide a mineral earth firebreak or reduced fuel zone so that unplanned fires do not leave the station – strategic internal threat protection
3. Prescribed burns do not escape the prescribed burn area – strategic burn boundary
4. Provide access to the critical areas of the station so that fire suppression activities can be undertaken – pre-determined back burning boundary.

Each type of firebreak has important components that must be met.

• Provide a mineral earth break so that unplanned fires do not enter the property – strategic external threat protection break

These firebreaks must be located close to the boundary of the property and of sufficient width to minimise the chance of the radiant heat or direct flame contact with vegetation.

It is estimated that these firebreaks need to be a minimum of 12 metres wide (3 grader blade width breaks) but will frequently be 16 metres wide (4 grader blade width breaks).

It may also be appropriate to have both sides of the boundary fence graded depending on the ownership or management of the neighbouring land.

These breaks may be enhanced by conducting burning operations immediately adjacent to the graded break so that embers from the fire do not jump the break.

An alternative system may be to have a series of graded firebreaks 300 metres apart and to burn out one parallel area each subsequent year. A fire would therefore run into a graded firebreak and a burnt buffer within 300 metres of the boundary.

• Provide a mineral earth firebreak so that unplanned fires do not leave the station – strategic internal threat protection

These firebreaks must be located close to the boundary of the property and of sufficient width to minimise the chance of the radiant heat or direct flame contact with vegetation.

It is estimated that these firebreaks need to be a minimum of 12 metres wide (3 grader blade width breaks) but will frequently be 16 metres wide (4 grader blade width breaks).

It may also be appropriate to have both sides of the boundary fence graded depending on the ownership or management of the neighbouring land.

These breaks may be enhanced by conducting burning operations immediately adjacent to the graded break so that embers from the fire do not jump the break.

An alternative system may be to have a series of graded firebreaks 300 metres apart and to burn out one parallel area each subsequent year. A fire would therefore run into a graded firebreak and a burnt buffer within 300 metres of the boundary.

• Prescribed burns do not escape the prescribed burn area – strategic burn boundary

These firebreaks must be located close to the boundary of the burn and of sufficient width to minimise the chance of the radiant heat or direct flame contact with vegetation on the area not planned to be burnt.

These breaks need to be a minimum of 1 metre wide, but for burn security it is recommended that the breaks be 3 metres wide, particularly when the grasses are greater than 60% cured.

• Provide access to the critical areas of the station so that fire suppression activities can be undertaken – pre-determined back burning boundary

The provision of access is critical both for pastoral station management and bush fire management. If a firebreak is to be used primarily as an access track they need to be formed and maintained so that a constant vehicle speed can be maintained and also they do not become gullies for erosion to occur. For these factors to be met the firebreak needs to have erosion control measures implemented and maintained. One method of achieving this is to grade the firebreaks in the beginning of the dry season and then return immediately before the onset of the wet and return the windrow back across the firebreak.[6]

Whilst this soil return process is an option the preferred option is the establishment and maintenance of appropriate water turn outs and firebreak banks. The establishment maintenance of appropriate water turn outs and firebreak banks is recommended because mid dry season unseasonal rainfall will not cause the firebreak to erode or degrade. The erosion control measures are built into the firebreak and will work regardless of the ability of the pastoralist to implement additional erosion control measures that are time and access dependent.

[6] McGuffog, undated, *The 'how-to' of firebreaks and aerial burns*, Bushfires Council, Northern Territory

Firebreak Construction

Mineral earth firebreaks need to be constructed and maintained so that they do not cause erosion. In a range of slopes and soil types erosion may not be an issue and no additional erosion prevention works need to be undertaken.

It is recommended that where erosion is likely to be an issue the following be considered and applied when appropriate.

Banks on Firebreaks

Where the water will run down the firebreak it is essential to create water restraining bank, similar in structure to a speed hump, across the road. These need to be a minimum height of 400mm and a minimum of 500mm wide or if used in a high traffic area up to double the width of the firebreak. These banks should be placed in the firebreak when the firebreak exceeds one degree. At one degree slope it is prudent to consider a bank every 150 metres and as the slope increases the distance between banks should reduce by 20 metres for every degree increase.

Slope (Degrees)	Bank Distance Apart (metres)
1	150
2	130
3	110
4	90
5	70

Table 1: Bank distances as slope increases to reduce erosion[7]

[7] McGuffog, undated, *The 'how-to' of firebreaks and aerial burns*, Bushfires Council, Northern Territory

Water Turn Outs

Water turn outs are essential on a firebreak that is in a soil type, structure or slope where there is a propensity to erode.

Gradient in the Kimberley is generally flat with some short slopes associated with ranges and isolated hills. The Region is also subject to very heavy rainfall for only a relatively short duration wet season. As a consequence of the rainfall season and type soil that is exposed, that is with no vegetative cover, it can erode very quickly. It is critical for soils that have a propensity to erode for the water flow to be managed on the bare surface. The steeper the slopes the more water management is required.

Grade (degrees)	Grade (%)	Gradient
0.6	1	1 in 100
1.2	2	1 in 50
1.7	3	1 in 33.3
2.2	4	1 in 25
2.9	5	1 in 20
3.4	6	1 in 16.7
4	7	1 in 14.3
4.6	8	1 in 12.5

Table 2: Grade in degrees and percentage and gradient comparisons[8]

[8] Australian Centre for Minesite Rehabilitation Research, 1997, Short Course on Mine Rehabilitation: principles and practice, Kenmore, Queensland

Spacing (metres) = **factor**/road gradient (%)

The **factors** are:

Clay – Silt – fine sands	1000
Sand – very fine gravel – pumice	1500
Gravel with some sand	2000
Clean gravel	2500

Table 4: The factors to use in the spacing formulae

For example the spacing of a water turn out on a slope of 3° is calculated for clay as 1000/3 = 333 metres.

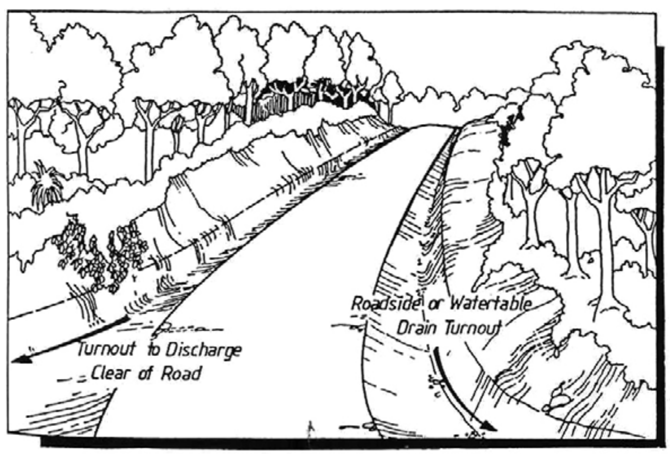

Figure 2: Diagram of the water table turnout[9]

[9] PNG, 1995, Papua New Guinea Logging Code of Practice, Department of Environment and Conservation, Boroko, Papua New Guinea

Road Crossfall or Camber

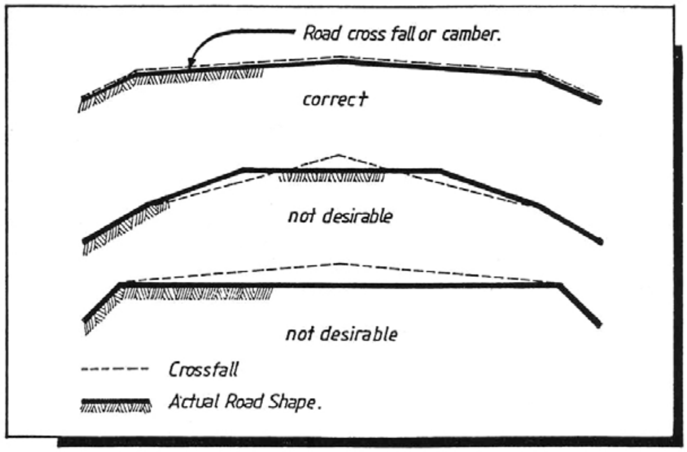

Figure 3: Road cross fall or camber required to minimise erosion[10]

When water erosion is likely to become an issue as a consequence of the frequency, duration or intensity of the rainfall. It is very important to consider the effects the rainfall will have on the firebreak (road) surface, and where the road will become a catchment that contains the water and encourages it to flow down the graded surface. It is very important to minimise the water movement down or across surfaces that have an increased propensity to erode such as a graded firebreak. The shape of the firebreak surface can lead to erosion and where appropriate road cross fall or camber should be built into the exposed surface to minimise erosion potential.

[10] PNG, 1995, Papua New Guinea Logging Code of Practice, Department of Environment and Conservation, Boroko, Papua New Guinea

Kimberley Firebreak Location, Construction and Maintenance Guidelines Supporting Papers

Contents

Purpose

The purpose of *Kimberley Firebreak Location, Construction and Maintenance Guidelines Supporting Papers* is to provide fire practitioners with a tool that assists them with the location, construction and maintenance of the fire breaks on a pastoral station. The *Guidelines* are designed to provide an estimation of the situation with specific guidance to the soil types, slope and estimations of water concentrations and volumes and the impact of these factors on soil erosion associated with firebreak location, construction and maintenance.

The *Guidelines* have been developed by working with very experienced pastoral fire managers both within the pastoral industry and within the Fire and Emergency Services Authority (FESA) and considering publications on soil management and erosion.

FESA has designed these *Guidelines* as a reference tool to assist pastoral fire managers in determining solutions for firebreak location, construction and maintenance when a management issue is likely to eventuate. FESA is aware that many pastoralists have very extensive firebreaks on stations that suffer no erosion and therefore do not require any additional erosion mitigation works.

Firebreaks

Firebreaks associated with grassland areas with an average 4-5 tonnes per hectare (t/ha)[11] are effective when they are wider than where radiation and/or flame contact can be expected to be less than 4 times the flame length in the horizontal plane. When the Fire Danger Index (FDI) on the Grassland Fire Danger Meter is less than 2.5 it is recognized that the fire danger rating is low and the head fire is expected to be stopped by roads and tracks. An FDI of 7.5 recognises that the fire danger rating is moderate and the head fire is easily attacked with water. When the FDI rises to 32 the fire danger rating is high and the head fire attack is generally successful with water. When the FDI exceeds 32 the ability to successfully attack the head fire diminishes to the point where it is required to be undertaken under favourable conditions. This is based on assumption that the fuels are continuous and reasonably heavy.

The impact of firebrands (burning embers) on bush fire management and the effectiveness of firebreaks must also be considered when analysing whether firebreaks will be successful in stopping the fire, providing fire fighter access or a secure boundary to undertake back burning operations. Low intensity fires will generally have shorter spotting distances than very intense fires. Grasslands will generally have a shorter spotting distance than forest fuels.

In many areas there are natural firebreaks of bare ground or areas that have been developed for other purposes, eg. roads, transmission line clearings or land under fallow, that provide the same function. They create a discontinuous fuel area that will under many circumstances stop the bush fire or provide an area to undertake back burning operations.

In the diagram below the probability of holding a bush fire on a range of firebreak widths adjacent to a range of vegetation type is described.

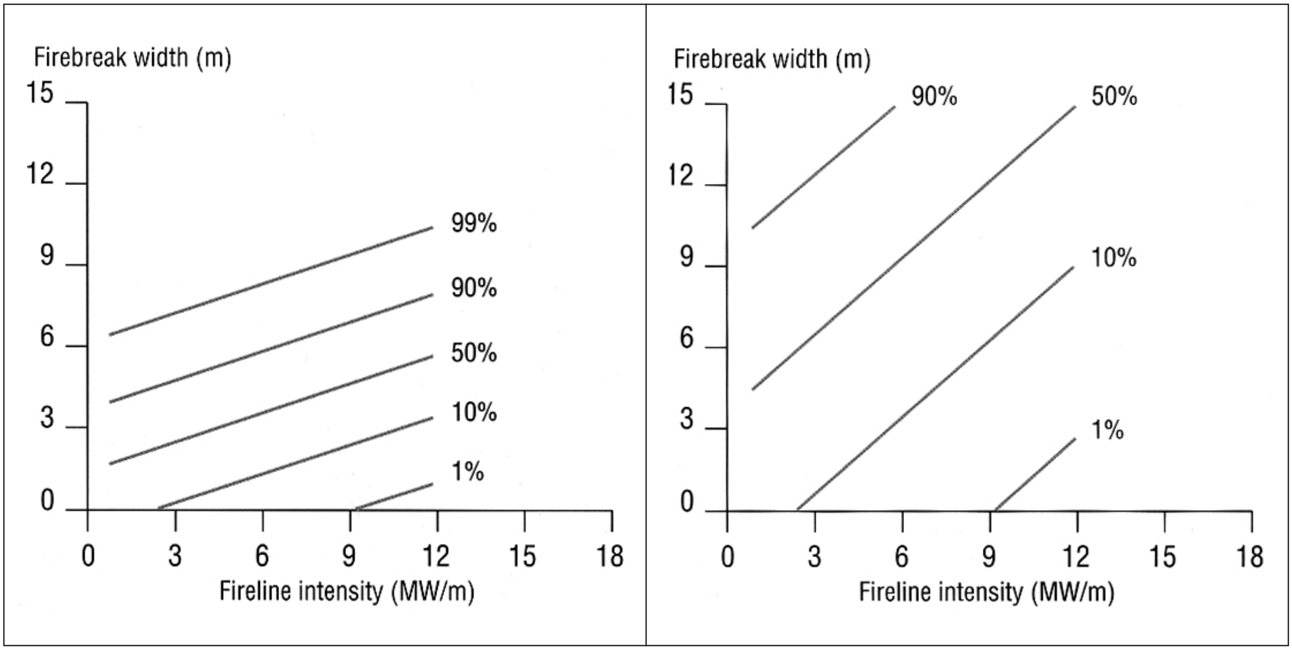

Figure 1: Probability of a firebreak holding a fire

Probability of a firebreak holding a headfire in relation to intensity. No trees within 20 metres of the break

Probability of a firebreak holding a headfire in relation to intensity. Trees within 20 metres of the break[12]

In the examples above a firebreak 10 metres wide has a 99% chance of holding a 10 megaWatt (MW/m) fire ie a fire in 4t/ha traveling at 5 km/hr where there in no spotting fuels (there is 1 megaWatt to a 1,000 kiloWatts).

Firebreaks can be very effective in grassy fuels provided the fire is not spotting.

[11] Luke & McArthur, 1986, "Bushfire in Australia"
[12] Cheney & Sullivan, 1997, *Grassfires fuel, weather and fire behaviour,* CSIRO Publishing, Canberra

Urban/Rural Interface

(includes towns, settlements and remote indigenous communities)

The urban/rural interface is one of the potentially most difficult areas to undertake bush fire suppression activities. The area is generally built up with homes being established within the vegetation. Another factor is that many of these homes have been built to the low bush fire threat as prescribed in "Australian Standard 3959 – Construction of buildings in bushfire-prone area" when the construction should have been for medium or high hazard. Effectively these homes will not have been built to the suitable standard for the threat, and firebreaks, building protection zones and hazard separation zones are needed to ensure increased protection.

Firebreaks will be critical in ensuring that these towns, settlements and communities as well as homes are protected from fires. These firebreaks assist in preventing bush fires entering the pastoral properties, or leaving the property whilst also providing a level of protection from a fire threat to the individual community or home.

Soil Structure

The soils structure is very important in determining the type and location of the fire break that should be created.[13] An inappropriate firebreak can result in increased water erosion and wind erosion and the loss of the productive top soil which is top 10-15 cm of soil. The physical, chemical and biological changes in the soil resulting from changes in agricultural practices also alter the soil as a habitat for micro-organisms.

The size and stability of the soil structure directly affect the susceptibility of the soils to erode. These components are the texture, structure, stability, organic matter content, soil micro-organisms, salts and colboids. For most soils their wind erosion susceptibility is increased by the reduction of soil clod or aggregate size, organic matter content and water content, eg. ploughing, cultivating and grazing. The texture of the soil is the major factor in wind erosion susceptibility. It also affects the soils ability to hold moisture. The more coarse textured material are generally more susceptible to erosion than fine textured soils. Coarse soils also hold less water and drain more rapidly than finer soils, which make them more susceptible to wind erosion.

Only root material will hold soil and this root growth and development only occurs where soils contain plants and can sustain the growth. Non wetting soils are usually coarser and the grains of sand appear to form a skin that sheds the water. These areas are generally leached of nutrients and consequently grow few plants. A deteriorating soil structure will result in an increase in the potential for soil erosion.

[13] G A Robertson, 1987, Soil Management fore Sustainable Agriculture, Resource Management Technical Report No. 95, WA Department of Agriculture

Many soils in the world are renewed naturally. The Western Australian soils have probably formed more than 50 million years ago, and little deposition now occurs.

Wind erosion occurs when vegetation ground cover is insufficient to protect the soils and soils are exposed to wind. Soil particles commence moving when wind speeds exceed 8 km/hr, and it is the very important fine particles that become airborne.

Water erosion occurs when the soil is unable to cope with the rainfall falls faster than the ground can soak up the water. This inability to cope with the rainfall may occur because the soil is at storage capacity, surface infiltration is impeded or the hard setting nature of duplex soils restrict infiltration. All of these result in increased overland flow of the water. The various types of water erosion all manifest themselves by transferring soil from one location and depositing it elsewhere. The site that suffers the soil loss may expose the less durable soils to further erosion problems.

Soil Types

Clay: Particles less than 0.002 mm in diameter.	Clays have very large surface areas compared with the other inorganic fractions. As a result clays are chemically very active and are able to hold nutrients on their surfaces. These nutrients can be released into soil water from where they can be used by plants. Like nutrients, water also attaches to the surfaces of clays but this water can be hard for plants to use.
Silt: Particles between 0.02 mm and 0.002 mm in diameter	Silt has a relatively limited surface area and little chemical activity. Soils high in silt may compact under heavy traffic and this affects the movement of air and water in the soil.
Sand: **Fine Sands:** Particles between 0.2 mm and 0.02 mm in diameter **Coarse sand:** Particles less than 2 mm and greater than 0.2 mm in diameter	Quartz is the predominant mineral in the sand fraction of most soils. Sand particles have a relatively small surface area per unit weight, low water retention and little chemical activity compared with silt and clay.
Gravel: Particles greater than 2 mm in diameter and up to 7.5 cm in diameter	An unconsolidated, natural accumulation of rounded rock fragments resulting from erosion, consisting predominantly of particles larger than sand, such as rocks, cobbles, granules or any combination of these fragments

Table 1: Soil types and texture[14]

[14] Source: *http://www.dpi.vic.gov.au/dpi*

Soil categories	Infiltration rates in cm/hr
Soils with high rates (sandy soils, friable loams)	
Bare soil	1.3-2.5
Forest and grass	3.8-19.1
Close-growing crops	3.2-7.6
Row crops	1.7-3.8
Soils with intermediate rates	
Bare soil	0.3-1.3
Forest and grass	0.8-9.5
Close-growing crops	0.6-3.8
Row crops	0.3-1.9
Soils with low rates (dense clays, clay loams	
Bare soil	0.03-0.3
Forest and grass	0.08-1.9
Close-growing crops	0.06-0.6
Row crops	0.02-0.4

Table 2: Infiltration rates for selected combinations of soil and ground cover[15]

[15] Anderson, Beiswenger, Purdom, 1987, *Environmental Science third edition*, Merrill Publishing Company, Columbus, Ohio

Causes of Soil Erosion

Soil erosion – happens when the energy of moving water or air is enough to overcome the cohesive forces that bind soil particles together:

- Particles detach from the surface and are carried in the moving fluid (i.e. particles are suspended in the moving fluid).

Sedimentation – results when fluid flow decreases to the point where its kinetic energy is no longer sufficient to maintain the particles in suspension (i.e. where the movement of the fluid stops enough to keep the particles suspended).

Wind erosion – is mostly initiated by coarser particles moving in saltation (bouncing) across the surface as carried by wind. With each bounce, finer material comes off the surface and is carried along in the air stream.

Water erosion – can happen in 2 ways

- Rain drop splash: a raindrop striking an unprotected soil surface will form a small crater with particles thrown in a roughly circular pattern around the hole. A vertically falling raindrop hitting a sloping surface will through more material to the downhill side – therefore large amount of surface soil may move downslope during rainfall. Also the energy from the raindrop impact pulverizes and compacts the soil which causes the surface to seal which reduces infiltration. Consequently this will increase the amount of rainfall that flows over the surface – contributing to a second form of erosion.
- Gully & sheet erosion are functions of the velocity of surface water flow and the cohesiveness or detachability of the soil particles.
    - Flow velocity is determined by the depth of flow, the angle and length of the slope and the retardance or surface roughness of the soil.
    - The cohesiveness of soil particles is affected by soil type (grain size & degree of aggregation) and by the binding effect which organic matter and plant roots have upon the soil).
- Control over velocity and depth of flow can be exerted by constructing contour furrows or contour banks at intervals down the slope:
    - Catchment area commencing at each bank or furrow
    - This stops the runoff from reaching a depth of flow or velocity that would cause erosion
    - As the slope angle increases, the furrows must be spaced closer together until a point is reached where they're not longer effective.

- Contour cultivation is only useful to slopes below about 5°.
- At steeper slopes, the water holding capacity of the individual plough furrows becomes limited.
- For slopes up to 10° contour deep-ripping or contour furrowing in conjunction with contour cultivation can provide a reasonable degree of erosion protection for a limited time.
    - Contour ripping
      Ripping to a depth of 60-90cm with conventional single or multi-tyne ripper (by bulldozer) for best results – use 2 tynes spaced 1m apart with individual rip lines spaced 2-6m apart depending on slope angle.
    - Contour furrowing
      Single tyne fitted with a "mould board" attachment that lifts soil from the furrow and forms a small bank on the downhill side – which increases water holding capacity.

      Both rips and furrows should be constructed precisely on the contour.
    - Contour banks are bigger versions of contour furrows with a proportionately greater capacity to store runoff and or drain it to some chosen discharge point.
        - There are 3 types of banks although 2 or more can be used in one continuous line.
    - **True contour or level banks**:
      Are constructed exactly on the contour and can discharge at either or both ends.
    - **Absorption banks**:
      Constructed along the contour but have both ends turned uphill to a pre-determined height so they pond a desired depth of water along their length.
    - **Graded banks**:
      Constructed away from the true contour at a designed gradient so that they drain water from one part of a slope to another (eg. to a watercourse or dam).

  As slope angle increases, the erosion control of these larger banks is reduced until at about 12-14° of slope, the need to be so close together that the benefit is doubtful. Plus on a steep slope there is a gully risk of gully erosion.[16]

[16] Hannan J C, 1984, *Mine Rehabilitation A Handbook for the coal mining industry*, New South Wales Coal Association, Sydney

Methods of Creating Firebreaks

There are a number of methods that can be used to establish a firebreak. These are:

- **Mineral earth** – created by ploughing, grading or other earth movement. The process involves mechanically removing the vegetation. This process is very effective, but can lead to erosion if poorly managed on steep slopes or lose sands. In most instances a plough or utilizing a rake will do less damage to the soils structure that a grader that removes the top soil.

When a mineral earth firebreak is created it is essential to manage the water that will run along the firebreak. Where possible it is preferable to ensure that the water is moved off the graded firebreak as soon as practical. Where the water will run down the firebreak it is essential to get the water off the graded area and/or create water restraining banks, similar in structure to a speed hump, across the road. These need to be a minimum height of 400mm and a minimum of 500mm wide or if used in a high traffic area up to double the width of the firebreak. These banks should be placed in the firebreak when the firebreak exceeds one degree. At one degree there should be a bank every 150 metres, and as the slope increases the distance between banks should reduce by 20 metres for every degree increase.

Slope (Degrees)	Bank Distance Apart (metres)
1	150
2	130
3	110
4	90
5	70

Table 3: Bank distances as slope increases to reduce erosion[17]

Road Gradient	Clay-silt-fine sand-ash	Sand-very fine gravel-pumice	Gravel with some sand	Clean gravel
5%	200	300	400	500
10%	100	150	200	250

Table 4: Culvert/Turnout Maximum Average Spacing (metres)[18]

[17] McGuffog, undated, *The 'how-to' of firebreaks and aerial burns*, Bushfires Council, Northern Territory
[18] PNG, 1995, Papua New Guinea Logging Code of Practice, Department of Environment and Conservation, Boroko, Papua New Guinea

Grade (degrees)	Grade (%)	Gradient
0.6	1	1 in 100
1.2	2	1 in 50
1.7	3	1 in 33.3
2.2	4	1 in 25
2.9	5	1 in 20
3.4	6	1 in 16.7
4	7	1 in 14.3
4.6	8	1 in 12.5

Table 5: Grade in degrees and percentage and gradient comparisons[19]

Notes:

- Material differentiation is on the basis of particle size. Mixtures of materials should be assessed to provide the maximum spacing for the predominant water transportable particles.
- Maximum spacings are in metres for either culvert pipes or turn outs.
- The maximum spacing for 300mm pipe culverts is 185m. The maximum spacing for 375mm pipe culverts is 325m.
- Culvert and turn out spacings (maximum average) can be calculated from the formula:

  Spacing (metres) = **factor**/road gradient (%)

  The **factors** are:

Clay – Silt – fine sands	1000
Sand – very fine gravel – pumice	1500
Gravel with some sand	2000
Clean gravel	2500

Table 6: The factors to use in the spacing formulae for water turn outs and culverts

For example the spacing of a water turn out on a slope of 3° is calculated for clay as 1000/3 = 333 metres.

[19] Australian Centre for Minesite Rehabilitation Research, 1997, Short Course on Mine Rehabilitation: principles and practice, Kenmore, Queensland

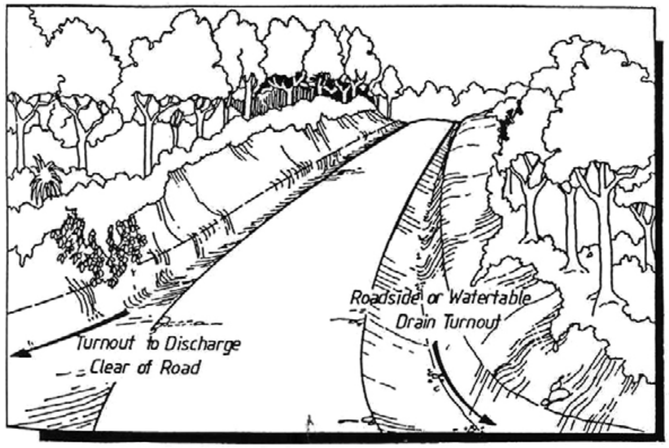

Figure 4: Diagram of the water table turnout[20]

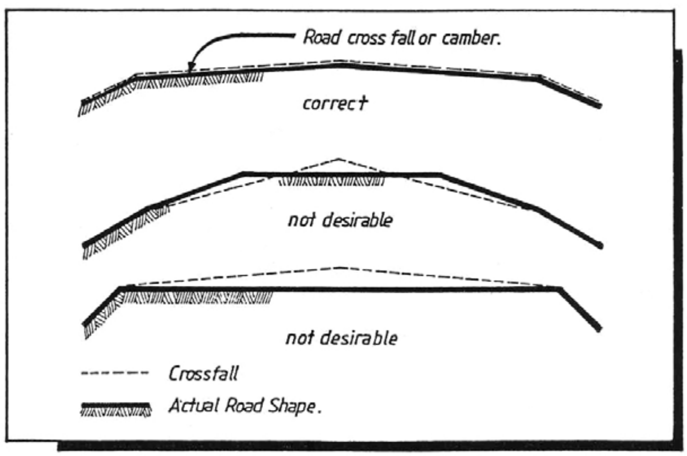

Figure 5 : Road cross fall or camber required to minimise erosion[21]

When water erosion is likely to become an issue as a consequence of the frequency, duration or intensity of the rainfall, it is very important to consider the effects the accumulated rainfall will have on the firebreak (road) surface. Where the firebreak will become a catchment that contains the water and encourages it to flow down the graded surface mitigation work will be required. It is very important to minimise the water movement down or across surfaces that have an increased propensity to erode such as a graded firebreak. The shape of the firebreak surface can lead to erosion and where appropriate road cross fall or camber should be built into the exposed surface.

[20] PNG, 1995, Papua New Guinea Logging Code of Practice, Department of Environment and Conservation, Boroko, Papua New Guinea
[21] PNG, 1995, Papua New Guinea Logging Code of Practice, Department of Environment and Conservation, Boroko, Papua New Guinea

Other Forms of Firebreaks

- **Herbicide[22] use** – herbicides are very effective if applied at the appropriate time for a creating a mineral earth break that retains the root matter in the soil and reduce the potential for erosion.

- **Managed grazing** – animals managed to graze the required fuel reduced zone can create appropriate reduced fuel areas, and still ensure that the root zone remains to hold the soil structure together and minimize erosion.

- **Strategic placement of aerial and hand burning** – this burning needs to create a width of between 300 metres and 1000 metres as not all fuels will be consumed during the burning and small isolated pockets will remain partially burnt or unburnt. The unburnt pockets must be relatively small and not able to be linked by short distance spotting or direct flame contact.

- **Combination of grading and burning** – An alternative system may be to have a series of graded firebreaks 300 metres apart and to burn out one parallel area each subsequent year. A fire would therefore run into a graded firebreak and a burnt buffer within 300 metres of the boundary.

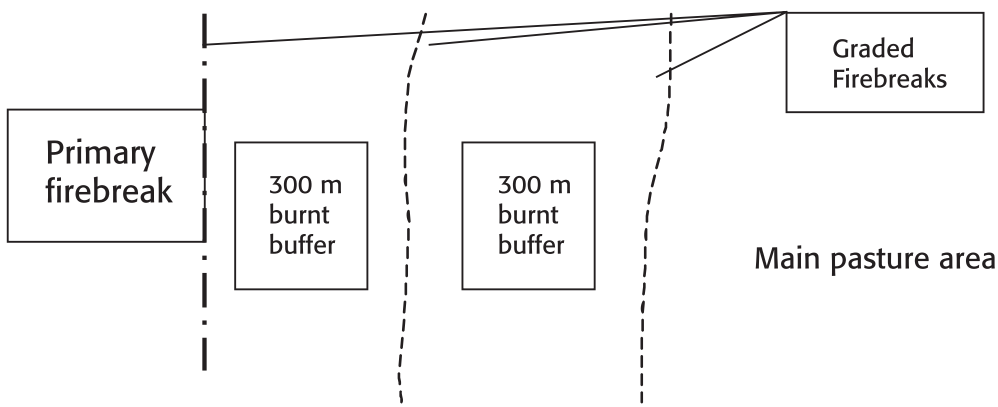

Figure 6: Alternative grading and burning strategic firebreak system

[22] G A Robertson, 1987, Soil Management fore Sustainable Agriculture, Resource Management Technical Report No. 95, WA Department of Agriculture

Placement of Firebreaks

Slope

Firebreaks need to be placed so that they fill all or most of the desired outcomes, as in all situations there will be some compromise between an ideal firebreak location and soil conservation, fencing requirements, practicability and cost. The firebreak should therefore be located so that it will either stop the low intensity fire, provide a back burning buffer from which to undertake the burning, provide access to key infrastructure or other areas of value.

Bush fires travel faster upslope than downslope. It is therefore more desirable to place the firebreaks lower in the profile, and where possible to place the firebreak so that it runs parallel to the contour. Where the firebreak cuts across the contour the chance of erosion is increased and measures must be undertaken to mitigate the risk.

Location

Firebreaks should be located to achieve four objectives:

1. Provide a mineral earth break so that unplanned fires do not enter the property – strategic external threat protection break
2. Provide a mineral earth firebreak so that unplanned fires do not leave the station – strategic internal threat protection
3. Prescribed burns do not escape the prescribed burn area – strategic burn boundary
4. Provide access to the critical areas of the station so that fire suppression activities can be undertaken – pre-determined back burning boundary.

Each type of firebreak has important components that must be met.

• Provide a mineral earth break so that unplanned fires do not enter the property – strategic external threat protection break

These firebreaks must be located close to the boundary of the property and of sufficient width to minimise the chance of the radiant heat or direct flame contact with vegetation.

It is estimated that these firebreaks need to be a minimum of 12 metres wide (3 grader blade width breaks) but will frequently be 16 metres wide (4 grader blade width breaks).

It may also be appropriate to have both sides of the boundary fence graded depending on the ownership or management of the neighbouring land.

An alternative system may be a combination approach with a series of graded firebreaks 300 metres apart and to burn out one parallel area each subsequent year. A fire would therefore run into a graded firebreak and a burnt buffer within 300 metres of the boundary.

• **Provide a mineral earth firebreak so that unplanned fires do not leave the station – strategic internal threat protection**

These firebreaks must be located close to the boundary of the property and of sufficient width to minimise the chance of the radiant heat or direct flame contact with vegetation.

It is estimated that these firebreaks need to be a minimum of 12 metres wide (3 grader blade width breaks) but will frequently be 16 metres wide (4 grader blade width breaks).

It may also be appropriate to have both sides of the boundary fence graded depending on the ownership or management of the neighbouring land.

• **Prescribed burns do not escape the prescribed burn area – strategic burn boundary**

These firebreaks must be located close to the boundary of the burn and of sufficient width to minimise the chance of the radiant heat or direct flame contact with vegetation on the area not planned to be burnt.

These breaks need to be a minimum of 1 metre wide, but for burn security it is recommended that the breaks be 3 metres wide, particularly when the grasses are greater than 60% cured.

• **Provide access to the critical areas of the station so that fire suppression activities can be undertaken – pre-determined back burning boundary**.

The provision of access is critical both for pastoral station management and bush fire management. If a firebreak is to be used primarily as an access track they need to be formed and maintained so that a constant vehicle speed can be maintained and also they do not become gullies for erosion to occur. For these factors to be met the firebreak needs to have erosion control measures implemented and maintained. One method of achieving this is to grade the firebreaks in the beginning of the dry season and then return immediately before the onset of the wet and return the windrow back across the firebreak.[23]

Whilst this soil return process is an option, the preferred option is the establishment and maintenance of appropriate water turn outs and firebreak banks. The establishment and maintenance of appropriate water turn outs and firebreak banks is recommended because mid dry season unseasonal rainfall will not cause the firebreak to erode or degrade. If the erosion control measures are built into the firebreak at construction, the erosion control will work regardless of the ability of the pastoralist to implement additional erosion control measures that are time and access dependent later in the season.

[23] McGuffog, undated, *The 'how-to' of firebreaks and aerial burns*, Bushfire Council NT

Rainfall

As previously described water erosion occurs when the soil is unable to cope with the rainfall when it falls faster than the ground can soak up the water. This inability to cope with the rainfall may occur because the soil is at storage capacity, surface infiltration is impeded or the hard setting nature of duplex soils restrict infiltration. All of these result in increased overland flow of the water. The various types of water erosion all manifest themselves by transferring soil from one location and depositing it elsewhere. The site that suffers the soil loss may expose the less durable soils to further erosion problems

To determine the potential sediment load in the surface water runoff the following formulae are provided. In all the examples provided they are based on a default catchment of 500 hectares. The following formulae have come from the book by J C Hannan, 1984, *Mine Rehabilitation A Handbook for the coal mining industry* and are provided as a guide to assist in more finely determining individual requirements.

$$Tc = \frac{L}{27\sqrt[5]{S}} \quad \text{.........(1)}$$

Where

Tc = time of concentration
L = length (in metres) of the main watercourse from discharge point to the catchment boundary
S = average slope of the main watercourse in per cent

Figure 7: Time of concentration

The above figure is the shortest time necessary for all points within a catchment to simultaneously contribute to flow past a given point in the catchment.

Example:

L = 500 metres
S = 2°

Tc = 500/31.0148
Tc = 16.12

$$Qp = \frac{CIA}{360}$$

Where

Qp = peak discharge in m^3/sec
C = coefficient of runoff
I = maximum rainfall intensity in mm/hr
A = catchment area in hectares

Figure 8: Peak discharge (maximum rate of run off)

This is the maximum rate of runoff, expressed in cubic metres per second, which can be expected from a catchment for a particular rainfall event.

Example:

C (from the table below) = 25, 5, 10, 5 = 45

I = 75mm/hr

A = 500

Qp = 16875/360

Qp = 46.88

The coefficient of runoff table is the ratio to rainfall expressed as a decimal fraction. The coefficient of runoff is affected by rainfall intensity, the infiltration capacity of the soil, by surface slope and vegetation cover and by other forms of surface storage and detention. Some interpolation is often required when using this table as some of the conditions in the various boxes need to suit particular situations.

Catchment Characteristics	Run-off		Producing		Characteristics			
Rainfall Intensity	75-100 mm/hr	30	50-75 mm/hr	25	25-50 mm/hr	15	<25 mm/hr	5
Relief	Steep, rugged, av. slopes above 20%	10	Hilly. av. slopes 10-20%	5	Rolling av. slopes 5-10%	0	Relatively flat, av. slopes 0-5%	0
Surface Retention	Negligible, few surface depressions, watercourses, steep, overland flow thin	10	Well defined system of small watercourses	5+	Considerable surface depressions; overland flow significant; some ponds and swamps; some s/c earthworks	5	Poorly defined and meandering streams; large surface storage; s/c earthworks on 90% of land	0
Infiltration	No effective soil cover; either solid rock or thin mantle	25	Slow infiltration, eg. solodic soil when surface sealed	20	Loam soil or well structured claysoils, eg. Chernozem	10	Deep sand or well aggregated soild, eg. Kraznozems	5
Cover	No effective plant cover	25	Sheet eroded native pastures; less than 10% under good pasture; clean cultivated crops	20	50% of area with improved pasture; not more than 50% cultivation or open woodlands	10	About 90% of area with improved pasture or forest	5

1. To determine run-off coefficient, select the most appropriate description of each of the five characteristics and use the total of the values as a decimal fraction (eg. a total of 75 becomes a coefficient of 0.75).
2. Reduce total by 5 for increased infiltration in hot climates (mean air temperatures above 25°C during rainfall).
3. Reduce total by 10% for rainfall interception in thick forests.

Table 7: Determination of Coefficient of runoff for various catchment conditions

Qt = 0.222 Tc (CIA)......................................(3)

Where

Qt = total runoff volume in cubic metres

C = coefficient of runoff

I = peak rainfall intensity in mm/hr.

A = catchment area in hectares

Figure 9: Total discharge

This figure is the total discharge from storms of up to 2 hours duration.

Example:
C = 0.45 (as previously determined)
I = 75mm/hr
A = 500
Tc = 16.12
Qt = 0.222.(16.12)(0.45.75.500)
Qt = 3.58 (16875)
Qt = 60,412[24]

Therefore the water management associated with firebreaks must ensure that they can handle large volumes of water over short durations.

[24] Hannan J C, 1984, *Mine Rehabilitation A Handbook for the coal mining industry*, New South Wales Coal Association, Sydney

Pastoral Station Fire Management Planning

Contents

Aim of the Plan

The aim of the plan should be clearly stated and it is suggested that this should be to reduce the number and minimise the impact of bush fires on the pastoral station. The aim of a strategic pastoral fire management plan is to document fire prevention requirements of any defined area. A further aim could be to reduce the occurrence of bush fires, and, thereby reducing the threat to life, property and the environment.

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Objective

This is a list of achievable and measurable goals of the plan. Examples are:

- Illustrate areas where values are located. This is closely related to:
    1. primary production sites, eg. high carrying capacity areas,
    2. rivers, creeks, drainage lines and water points,
    3. infrastructure, eg. homestead, stockyards
    4. cultural heritage sites
    5. environmental protection sites
- Define and rank fire hazard areas.
  (this relates to different fuel types and loadings (fuel age) as well as to flammability of fuels (level of fine dead material in the crowns of plants)).
- Define an assessment procedure which will evaluate the effectiveness and impact of proposed, as well as existing, fire prevention work and strategies.

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Description of the Area

Wherever possible the information should be recorded on a map and supported by text

- **General**

A general overview, possibly a map, of the area that describes the physical, and cultural features of the area.

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- **Climate**

Describe the growing season, dry season, rainfall, length of fire season, worst fire weather conditions and/or wind direction and frequency and month of lightning.

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- **Topography**

A description or map of the topography of the area (eg. flat, undulating, steep, broken up by river systems) and could be the entire station or a component of the station.

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- **Bush Fire Fuels**

A description or map of the vegetation types and quantities

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- **Assets**

A general overview or map of the location of assets within the area of the plan. This could include town sites, remote aboriginal communities, historical sites, aboriginal cultural sites, plantations, cropping areas or bush areas of high conservation value (a map may be appropriate).

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- **Access**

A description and map of the type and quality of roads, tracks and firebreaks, eg. two way two wheel drive or one way four wheel drive. Natural barriers should be noted, eg. rivers, swamps, large bush areas (wattle areas) and sand ridges.

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- **Water sources/points**

A map of the location and type of water sources or water points

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Fire Management Strategies

Any action or work proposed within each subsection may be highlighted on a map and supported by text where required. It should also be included in the station works program.

- **Hazard Management**

This sections addresses fuel management within each different area on the station, eg. pasture areas, homestead zone, unproductive areas .

Hazard management may also address fire breaks or strategic fire breaks and low fuel buffers, especially around assets.

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- **Access and Strategic Fire Breaks**

Determine, list and map the location of access and strategic fire breaks, specify minimum standards, where required (please refer to the FESA Kimberley firebreak location, construction and maintenance guidelines and supporting papers). Include a works program for construction and maintenance.

Is the cost of fire prevention work (eg. Installation and maintenance of fire breaks or low fuel breaks) offset by a reduction in personal or economic loss or by a saving in fire response resources?

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Guidelines for Pastoral Station Fire Management Planning

Contents

Purpose

The purpose of the pastoral station fire management plan is to provide guidance as to how to prepare a plan for and manage the potential bush fire threat on a pastoral station or within specified areas of the station. These areas can be single paddocks through to the whole station. The template has been developed to assist with bush fire planning on stations by providing a framework.

The following topics may also be addressed:

- What will be achieved by applying this plan?
- What strategic firebreaks are required, eg. burning and firebreak selection and placement required to protect this station and its primary assets?
- What pasture management requirements are required as a component of this plan?

The following should be specified to ensure that the plan remains up to date:

- A time limit for the revision and accompanying update of the plan (this may be every 5 years).

Objective

To provide a template to assist in guiding pastoralists when developing strategic pastoral fire management plans.

Note: It is acknowledged that **not** all components of the template will be required by all pastoralists.

Requirements

The specific objectives and needs of the pastoralist for strategic pastoral fire management planning need to be clearly identified and recorded within the plan

Maps Required

1. Carrying capacity map
2. Vegetation map
3. Soils map
4. Topographic map with contours
5. Fire foot print
6. Cultural heritage map
7. Environmental protection
8. Rainfall

Recommended Process

The following is the systematic process recommended to develop a Pastoral Station Fire Management Plan.

Each step should be worked through.

Step 1

Fuel load/age analysis – field work and report. Know your fuels.

Step 2

Maps – review the maps and compare opportunities with risks.

(a) Vegetation

(b) Infrastructure

(c) High value pasture (carrying capacity)

(d) Cultural heritage

(e) Environmental protection

(f) Rainfall

(g) Soil types

Step 3

Identify plan components – values/risks/options

Step 4

Implement plan

(a) Phase 1 – development/training

(b) Phase 2 – Operational implementation/mentoring/review/adapt

Protection Burning

1. Identify the key values requiring protection
   (a) Infrastructure
   (b) High value pasture (carrying capacity)
2. Cultural heritage
3. Environmental protection
4. Analyse vegetation map and fire footprint
5. Apply fire management principles for the hard spinifex and pasture grasses (tussock grass) buffers
6. Pasture grasses (tussock grasses) burn plan
7. Analyse primary risk of ignition
8. Set objectives for a strategic break (300m-1,000m)

Burning for Pasture Management

1. Pasture growth rates/senescence rates
2. Regeneration requirements
3. Methods of regeneration

Firebreaks

Grading

1. Identify the key values requiring protection
   (a) Infrastructure
   (b) High value pasture (carrying capacity)
   (c) Cultural heritage
   (d) Environmental protection
2. Analyse soil type, soil structure, propensity to erode
3. Water
4. Wind
5. Slope
6. Firebreak width
7. Cut offs width/length/spacing (linear)
8. Method of grading
9. Production rate

Chemical

1. Identify the key values requiring protection
   (a) Infrastructure
   (b) High value pasture (carrying capacity)
   (c) Cultural heritage
   (d) Environmental protection
2. Analyse soil type, soil structure, propensity to erode
   (a) Water
   (b) Wind
3. Impact of chemical on target/non-target species
4. Impact of root contact/water movement on target/non-target species
5. Application rate/concentration of chemicals
6. Spraying unit operating speed
7. Mode of operation/grass height/root development

Herbicide should be applied towards the end of pasture growth between late February and March and whilst the non-treated plants are still actively growing. The actual period of treatment will depend on the height of plant growth required to develop a suitable root growth to minimise erosion, whilst not being so tall that the grass growth does not break down and prevent a mineral earth firebreak being established.

During spraying, drift and run-off management are critical to ensure non-target species and locations are not affected by the chemical. Root transference of the chemical is also important to minimise off-target impacts.