3. Savanna fire regimes

by Dick Williams and Garry Cook

Fire regimes

Frequent and extensive fires in northern Australia are a consequence of the region's monsoonal climate with its marked summer wet season and long and warm winter dry season. The wet season generates heavy growth of grasses and other herbs, and the trees are continually dropping leaf litter throughout the dry season. This dries out or 'cures' during the dry season into tinder-dry, fine fuels for fires. Dry thunderstorms during the build-up and early wet season have always produced lightning.

Aboriginal people used fire widely across most of Australia and continue to do so across much of the north. Thus, for thousands of years there has been the combination of annual supplies of dry, fine fuel and ignition sources that can sustain regular, frequent fires.

European settlement has caused significant change to the fire patterns of northern Australia in the last century. The challenge for today's land managers is to work out the optimum mix of fire patterns at the landscape scale—hundreds to thousands of square kilometres—that protect life and property, maintain the productive potential of the land and conserve biodiversity. To do that, we need to understand the factors that determine the fire regimes in the savannas.

What are fire regimes?

The term 'fire regime' describes when and how often an area is burned, as well as the intensity, size and patchiness of fires (for example, yearly late dry season fires that are intense and extensive). Fire regimes can have different impacts on fuels, fodder and biodiversity by changing the composition of plant species and by altering habitats. Different fire regimes may be needed for different land management goals, and no single regime is best for all land management purposes.

How much savanna burns each year?

Hundreds of thousands of square kilometres of northern Australia are burnt each year. The area burnt varies with state or territory; in the northern savannas usually more country is burnt in the NT than in either northern WA or Queensland.

When do the fires occur?

Fires can occur from March to December, but most areas are burnt late in the dry season (Figures 1.1 and 3.1). Of the nine operational districts of the Bushfires Council of the NT for example, only one region east of Darwin has more country burnt in the early dry than the late dry season.

Fires can occur in the wet season, especially in the early part (November–December) if there is available fuel and if weather conditions allow fires to spread.

How often is an area burnt?

In the higher rainfall savannas of the NT, for example the Darwin–Alligator Rivers region, 50–70% of the landscape may be burnt every year (Figure 3.3). Fires are less frequent in the semi-arid savannas; in the mid-1990s, nearly 80% of the area south of Katherine (NT) was either unburnt or burnt only once over a three-year period.

What determines fire regimes?

Regional fire regimes depend upon the weather, the amount of fuel and when it is available, ignition chance and type, fire behaviour, and the capacity of fire to spread through the landscape. Fire regimes are also the product of people; people are the most common source of ignition and they can manipulate fire regimes, by prescribing fire or by suppressing it. People also affect fire regimes by their influence on fuel loads as a consequence of land use. For example, the difference in fire frequency between the semi-arid and mesic regions of the NT may be partly related to climate, but also to land use.

In the mesic regions, the dominant pasture type is annual *Sorghum*, a relively unpalatable grass, whereas in the semi-arid savannas, the pasture species are more palatable perennial grasses so that cattle may reduce fuel loads by eating the grass. Property managers burn less extensively for fear of losing their feed reserves.

In the following sections we will review the factors that affect fire regimes.

Figure 3.1 Seasonal distribution of fires in Australia in 1998

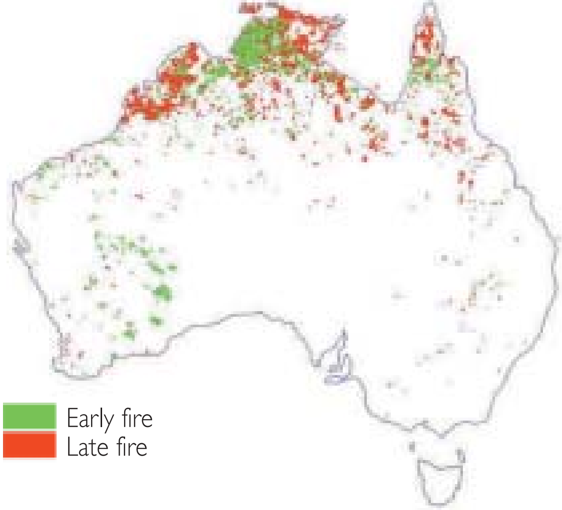
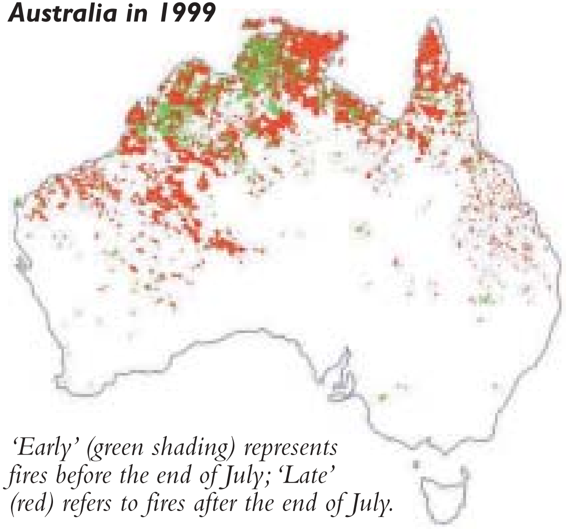
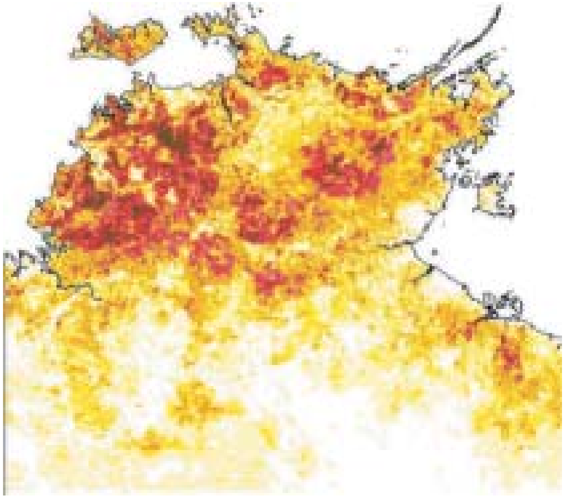


Figure 3.2 Seasonal distribution of fires in Australia in 1999



'Early' (green shading) represents fires before the end of July; 'Late' (red) refers to fires after the end of July.

Figure 3.3 Fire frequency



Frequency of fires (number of times burnt) in the Top End of the NT, 1993–2000

Times Burnt

- ⬜ Not burnt
- 🟨 Once
- 🟨 Twice
- 🟧 3 times
- 🟨 4 times
- 🟪 5 times
- 🟥 6 times
- 🟫 7 times
- 🟩 8 times

Fire weather and fire danger

Fire weather is a term used to describe the prevailing weather conditions as they relate to fire behaviour. The primary weather variables that determine fire behaviour are atmospheric humidity, air temperature and the strength of the winds. Variation in these factors in northern Australia is governed by the arrival and departure of the monsoon, hence there is strong seasonal variation in fire weather.

Fire weather variables, in conjunction with fuel variables, can be incorporated into indices that express fire danger. Fire danger is the product of the factors that determine chance of ignition, propensity to spread and ease of suppression. Summaries of fire weather and fire danger are given in the books by Luke and McArthur, and Cheney and Sullivan (see Further reading).

The two main fire danger indices used in Australia were developed by A. G. McArthur in the 1960s—the Forest Fire Danger Index (FFDI) and the Grassland Fire Danger Index (GFDI). FFDI includes a drought factor while GFDI includes a fuel-curing factor. Fire danger rating systems allow public fire weather forecasts to be made by the Bureau of Meteorology, and provide fire management agencies (or other land managers) with up-to-date, reliable information for purposes of fire control or suppression.

Both FFDI and GFDI rise as temperatures and wind speed increase and as relative humidity and soil moisture drop. The indices range from 0 to 100, with values above 50 considered extreme. Luke and McArthur indicate that an index of 100 represents the 'near worst possible fire weather conditions that are likely to be experienced in Australia', although Cheney and Sullivan indicate that such values have been exceeded on several occasions since 1966. A value of 100 would be produced by air temperatures of 40°C, relative humidities of 15%, wind speeds of 55 km/h, an extended period of drought of 6–8 weeks or more and abundant fuel. Fires that burn under extreme conditions are virtually impossible to put out without massive effort.

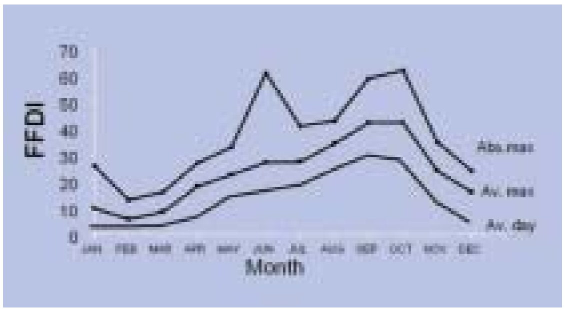
Both indices can be calculated easily using fire danger meters. In the savannas of northern Australia, fire danger is calculated using a modified Grassland Fire Danger Meter (Figure 3.4c) because savanna fires, even in woodlands, behave more like grass fires than forest fires. There are five operational classes of fire danger: Low (<2.5); Moderate (2.5–7.5); High (7.5–20); Very High (20–50) and Extreme (>50). Calculations are made by the Bureau of Meteorology with appropriate operational responses taken by the responsible fire management agencies (both rural and urban) and other land managers.

The indices may be used to compare seasonal variation in fire weather but there have been few systematic studies of this in the savannas. One such study, from Jabiru in the NT, examined seasonal variation in FFDI and GFDI based on 12 years of records.

The patterns of afternoon (3 p.m.) FFDI show strong seasonality (Figures 3.4a, 3.4b). The average daily FFDI is below five during the peak monsoon period of January to early March, and the vegetation will generally not burn. The wet season ends abruptly, and both atmospheric and soil moisture drop from late March onwards. Despite this, average daily FFDI in the early dry season (May–June) remains below 20, steadily increasing to average daily values of around 20 in the September–October period. However, the average maximum FFDI during this period of peak fire weather averages about 40—Very High. The highest value recorded was 60, and values >40 occurred in all months from June–October. These extreme values, despite being in the High–Very High classes, are below peak levels of 100 that can occur on extreme days in southern Australia, such as on Ash Wednesday in 1983.

The FFDI declines again with the onset of the wet season, but the maximum can still be around 20–30 on some days in November–December. Under such conditions, fire spread is possible, allowing wet season burning to be undertaken.

Figure 3.4a Forest Fire Danger Index, Jabiru

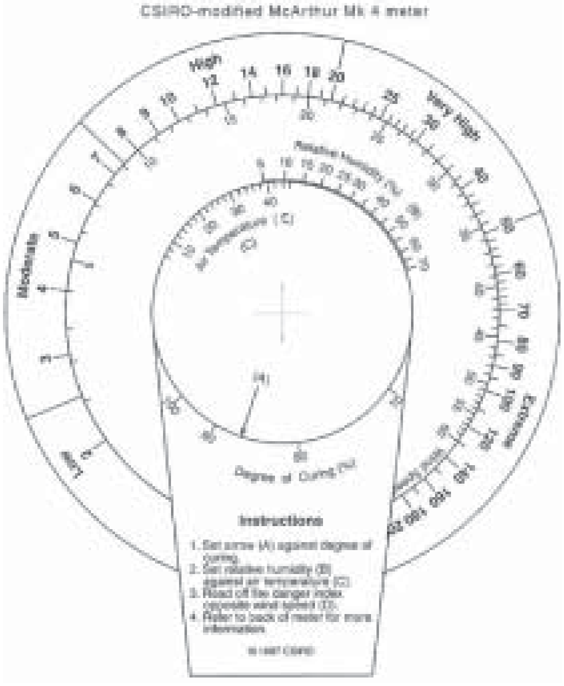


Forest Fire Danger Index increases as the dry season progresses, as temperatures and wind speed rise and relative humidity drops. Indicies based on 3 p.m. weather data from 12 years' records at Jabiru, NT; average annual rainfall 1300 mm. Source: Gill et al. (1996)
Abs. max=absolute maximum FFDI
Av. max=average monthly maximum FFDI
Av. day=average daily FFDI

Figure 3.4b Grassland Fire Danger Index, Jabiru

Grassland Fire Danger Index for 100% cured grass fuels. GFDI also increases as the dry season progresses, as temperatures and wind speed rise and relative humidity drops. Data and legend as in Figure 3.4a

Figure 3.4c Grassland Fire Danger Meter



Instructions
1. Set arrow (A) against degree of curing.
2. Set relative humidity (B) against air temperature (C).
3. Read off fire danger index opposite wind speed (D).
4. Refer to back of meter for more information.

Source: Cheney and Sullivan (1997)

Fuel dynamics

There is no fire without fuel. The amount of fuel—its height, mass, composition and architecture—all vary annually and seasonally, and with land use. Fuel load is an important determinant of fire intensity but, unlike the weather, it is something the landholder can manipulate.

What burns?

Most savanna fuels are fine fuels, less than 6 mm in diameter in at least one dimension. Grass provides most of the fine fuel although trees can drop increasing amounts of leaf and twig as the dry season progresses. The amount of tree leaf litter in the fuel bed increases with increasing tree density, which in turn rises with increasing annual rainfall. In higher rainfall areas, tall annual grasses such as *Sorghum* create fuel loads that dry quickly after flowering.

The ribbons of bark and layers of shrubs that create 'ladder' fuels in the eucalypt forests of southern Australia rarely occur in northern Australia. Thus the flames in savanna fires generally remain within 5 m of the ground, and severe 'crown fires' in tree canopies rarely occur.

Fuel dries out as the dry season progresses. The tall annual grasses start drying during the late wet season (March–April) while perennials can last until the early dry season (June).

In the semi-arid savannas where the ground layer is dominated by perennial grasses, fine grassy fuels may accumulate to levels similar to those in the wetter savannas. Tall annual grasses are rare in these savannas; where annuals occur they are usually short and sparse and often preferentially grazed. They usually have little bulk, especially in the dry season and, if burned, would support only patchy low-intensity fires.

Termites are abundant on the less fertile soils of the north, and their total body weight per unit area may be greater than that of large herbivores. They remove considerable grass stem and litter during the dry season.

Fuel loads fluctuate through the years and seasons, and can be modified by grazing. Grass builds up rapidly during the wet season, but in pastoral lands some may be eaten by stock. In practice, pasture land may have to be rested, with stock totally removed for one good wet season to allow enough fuel to accumulate so that fire can occur.

Fuel cover over the ground needs to be relatively unbroken with more than 50% ground cover needed to support a continuous fire front.

How much fuel accumulates?

Fuel loads need to be understood to assess the risk of wildfire or for planning prescribed fires. The fuel load is the oven-dry mass of fuel in a given area.

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Dry grass provides the bulk of the fuel. A continuous fire front needs at least 50% ground cover.

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Tree leaf litter can be a significant component of the fuel. It increases as the dry season progresses and with increasing tree density.

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Termites gather stems of Sorghum *and wiregrass.*

Fuel loads can be expressed in different units—tonnes per hectare, kilograms per hectare, kilograms or grams per square metre.

Annual inputs of fine fuel from grass growth and litter fall are about 2–8 tonnes of dry matter per hectare. Under annual burning, fuel loads generally remain around these levels in both higher rainfall and semi-arid savannas. If country remains unburnt, the fuel loads rise but do not generally increase above the equivalent of a few years' grass growth and leaf fall because the litter breaks down quickly during each wet season.

Various studies have measured how fuel loads vary in different types of savanna country.

In the wetter regions, fuel loads can reach an equilibrium (between accumulation and decomposition) of about 10 t/ha, 2–3 years after fire.

Perennial grass pastures near Katherine, NT (950 mm rainfall) had grass fuel levels of 2–4 t/ha when burnt every two years and reached 6 t/ha when protected from fire for four years.

In Rockhampton, central Queensland (890 mm rainfall), loads reached 3 t/ha in annually burnt savannas, and 6-7 t/ha after three years without fire.

In sparse woodland with spinifex, where fires are less frequent, fuel loads can reach 10–20 t/ha after 5–10 years. However, in the spinifex-dominated landscapes of the stone country in the wetter savannas, for example the Arnhem Land Plateau, fuel loads may reach such levels in less than five years if unburnt.

Where exotic grasses invade and are not eaten, fuel loads can increase dramatically. With some introduced species such as gamba grass, fuel loads may be 20 t/ha, 4–5 times the normal fuel load for a savanna.

What is fuel curing?

Curing refers to the 'greenness' of the fuel; it indicates the moisture content of the fuel, its flammability and thus the potential rate of fire spread. Curing starts as soon as a grass has flowered and its stem becomes brittle; this is greatly accelerated by the sudden onset of the dry season.

Fuel curing can vary greatly across the landscape according to position in the landscape, the dominant grasses and the season. Effective fire management over broad areas has to take this into account. For example, grasses such as annual *Sorghum* on sandy soils will cure rapidly and therefore be flammable much earlier than perennial grasses on cracking clays. In general, by the end of the dry season, the fine grassy fuels of the savannas are fully cured.

Satellite imagery can help identify areas in different states of curing across the landscape. Hence we can identify those areas at greatest risk from uncontrolled fire, or those that are ready for prescribed fuel reduction burning and how prescribed fires are likely to be spread.

One way to 'view' such features of the landscape is by using NDVI (Normalised Difference Vegetation Index), derived from satellite imagery. Maps of NDVI show areas of different chlorophyll reflectance, indicating fuel 'greenness', and therefore how cured the fuel is. Photographic standards can be used to estimate the degree of fuel curing (see Chapter 7. Monitoring vegetation greenness).

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Grass fuel loads accumulate with time, unless eaten by animals or until the old leaf decomposes during the wet season. In the savannas, fine fuels tend not to accumulate above 10 t/ha. Light grazing (left) and heavy grazing (right)

Photo standards illustrating fuel loads 1.6–4.5 t/ha, in the VRD region, NT


NTDPIF

1.6 t/ha in ribbon grass/Flinders grass


NTDPIF

2.4 t/ha in black speargrass


NTDPIF

3.5 t/ha in white grass


NTDPIF

4.5 t/ha in bluegrass

Photo standards illustrating green, uncured fuel (in March) and fully cured fuel (in October) on red earths and black cracking clays, VRD region, NT


NTDPIF

Fuel on red soil, March
1.9 t/ha; 35% cured; 40% moisture content


NTDPIF

Fuel on red soil, October
2.2 t/ha; 95% cured; 10% moisture content


NTDPIF

Fuel on black soil, March
1.3 t/ha; 35% cured; 55% moisture content


NTDPIF

Fuel on black soil, October
1.5 t/ha; 90% cured; 15% moisture content

Exotic grasses and fire


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Gamba grass on roadside, Darwin region, NT


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Mission grass on roadside, Darwin region, NT


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Trees burnt by fire in gamba grass, NT


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Ignition line in gamba grass, NT

Gamba grass (*Andropogon gayanus*) and mission grass (*Pennisetum polystachion*) are African perennial species used for pasture trials at Katherine in the 1940s and '50s. Gamba grass has been successful as a pasture species, but both species have become serious environmental weeds in the Darwin region and parts of Cape York when not managed.

On the rural–urban interface of Darwin where development and disturbance coincide, these grasses grow and spread prolifically. The establishment of gamba grass on flood plain margins and wetter *Melaleuca* uplands is enhanced by soil disturbance while in *Eucalyptus* woodlands disturbance is not essential. Establishment of gamba grass is significantly higher in *Eucalyptus* woodland that has recently been burnt.

These introduced grasses produce flammable material up to five times greater than fuel loads in native grasses (which are typically 2–8 t/ha), cure later in the year (June–July versus April) and maintain a tall, upright structure. Fire intensities and flame heights are increased and have severe impacts on the less fire-tolerant native grasses, shrubs and trees. Recovery from fire by these exotic perennials is rapid.

Gamba grass has a relatively short-lived seed bank with only 1% of buried seed remaining viable within a year; thus gamba grass infestations can be eradicated over a couple of years. Glyphosate herbicide is effective on gamba grass and mission grass especially if fire can be used to remove rank growth first.

by Trevor Howard

Further reading

Flores, T. (1999). Factors affecting the recruitment of *Andropogon gayanus* Kunth (Gamba Grass), Honours Thesis, Northern Territory University.

Panton, W. (1993). Changes in post World War 11 distribution and status of monsoon rainforests in the Darwin area, *Australian Geographer* **24(2):** 50–59.

Fire behaviour

Fire behaviour describes the physical attributes of individual fires—the height and depth of the flames, the speed with which the fire moves, the size and shape of the various fronts, and the intensity of the fire. Many of these attributes can be inferred from post-fire features of the burnt landscape, such as the height of blackened or scorched leaves, the size of standing twigs consumed by the flames, and the degree of fuel consumption, i.e. fire patchiness. Knowledge about fire behaviour is important to understand the likely extent and effectiveness of fires—be they wanted or unwanted—that may affect our patch of land, and so that we can understand the effects of fires on the landscape and atmosphere.

What is fire intensity?

One measure of fire behaviour is 'fire intensity'. This represents the rate at which energy is released, and is measured as kilowatts (a unit of work) per metre of fire front. It is a function of the heat yield of the fuel (heat per unit mass burnt as kilojoules/kg), the amount of fuel per unit area (kg/m^2) and the rate of forward spread of the fire front (m/second).

These three components of fire intensity can be measured or estimated.

Fuel loads can be determined by direct harvest, by using indirect pasture-estimation techniques such as BOTANAL or by using calibrated, photo-graphic fuel standards (see p. 20). It is important to estimate the degree of fuel consumption, i.e. the proportion of the available fuel that will be burnt.

Heat yield is often assumed to be 20,000 kJ/kg for mixed fuel types. However, the heat content of various fuel components varies between species.

Rate of spread is the hardest component to measure, but it can be estimated if the time to arrival of the flame front at three or more points can be determined accurately (within one second). The most important determinants of rate of spread are wind speed (see Fire Behaviour p. 24), relative humidity and fuel moisture. These factors vary throughout the day and seasonally, from early dry season to late dry season. Rate of spread—and hence intensity—can therefore be manipulated by careful consideration of ignition time—both during the day (or night) and from month to month.

Savanna fires generally move at speeds of 0.1–2 m/s. Fuels loads are generally in the range of 2–8 t/ha, with fine fuel consumption rates of 50–100%. Fire intensities in general range from 500 to 10,000 kW/m, and rarely exceed 20,000 kW/m. In southern Australian eucalypt forests where fuel has accumulated to near maximum levels (in excess of 30 t/ha), fire intensities can be as high as 50,000–100,000 kW/m.

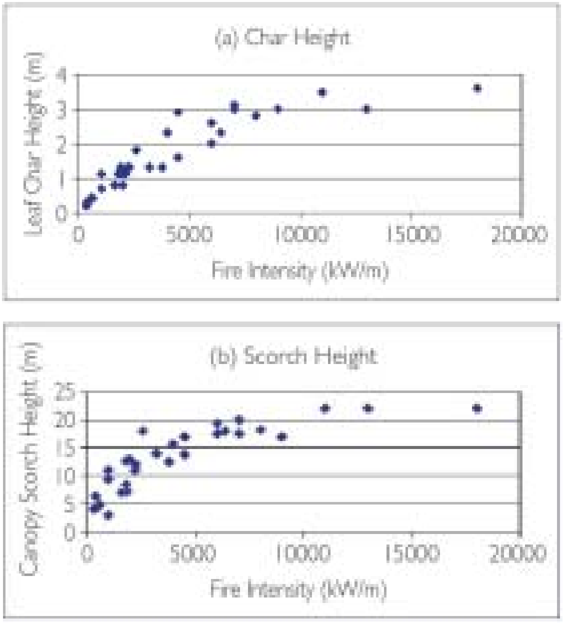
Over a five-year period at Kapalga in Kakadu National Park, early dry season fires (lit in early June) averaged about 2000 kW/m whereas late dry season fires (lit in late September) averaged about 8000 kW/m.

Flames from 500–1000 kW/m fires are less than 1 m high, but can reach 2–4 m if the intensity is above 5000 kW/m.

A visual estimation of fire intensity is illustrated on page 25.

An indication of flame height is given by char height—the height above ground of blackened leaves that are still attached to trees or shrubs. Char heights increase by about a metre for every 2500 kW/m (Figure 3.5a).

Figures 3.5a and 3.5b Char and scorch height



The height of charring (blackened leaves) and scorching (brown leaves) on woody plants can be used to gauge the intensity of a fire.

Leaf scorch height—the height above ground to which the leaves in the tree canopy are killed, and thus 'browned'—also varies with intensity. Scorch height increases by about 3 m for every 1000 kW/m of fire intensity up to about 8000 kW/m (Figure 3.5b). At higher intensities the tops of the canopies of even the tallest trees are scorched.

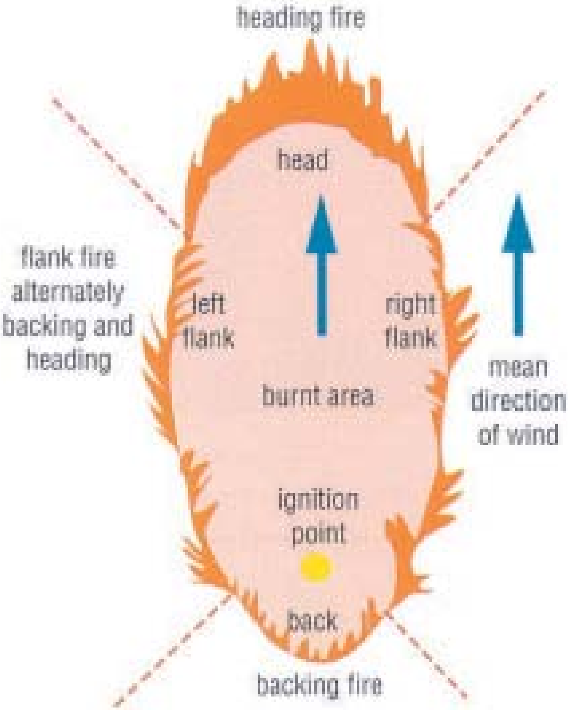
Fires greater than 2000 kW/m tend to burn all the available fuel whereas less intense fires create a mosaic of burnt and unburnt patches across the landscape.

These rules of thumb concerning crown and ground scorch can be used to gauge the intensity of a fire after it has passed.

Ignition type is an important factor affecting fire behaviour. Point sources of ignition lead to elliptical-shaped fires (Figure 3.6). Only the country at the head of the ellipse is burnt with maximum intensity; the flanking country on the sides and back end of the ellipse is burnt at much lower intensities. Thus there is considerable variation in fire intensity across the landscape.

Line ignitions, such as those along roadsides, lead to fires burning on a broad front; such fires accelerate to maximum rates of spread very quickly—in minutes. Thus, compared with a point-source ignition, fire intensity is more uniform across the front, more of the country is affected by the heading fire, and there is less variation in intensity across the landscape. Perimeter fires—lighting up lines on more than one front—can also create broad, fast-moving, more intense fires. These variations in behaviour, as a consequence of ignition type, have implications on how we may use fire and why, as is illustrated in more detail in Chapter 6.

Figure 3.6 Elliptical-shaped fires



Fires that start from point sources develop an elliptical shape. The ellipse consists of a heading fire, flanking fires and a backing fire, all of which vary in flame and combustion characteristics. Source: Cheney and Sullivan (1997)

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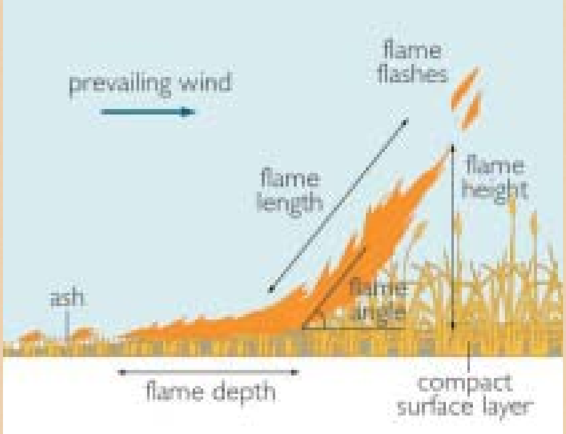
Elliptical-shaped fires

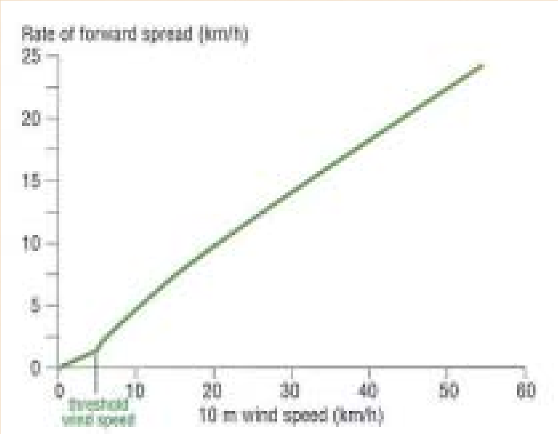
Fire behaviour

Flame characteristics



The height of flames depends upon the degree of combustion of standing grass; depth of flame depends on the amount of fuel in the compacted surface layer. Source: Cheney and Sullivan (1997)

The rate of forward spread



The rate of spread of a fire depends on wind speed. Source: Cheney and Sullivan (1997)

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A heading fire (top) and a backing fire (bottom)

Estimating fire intensity

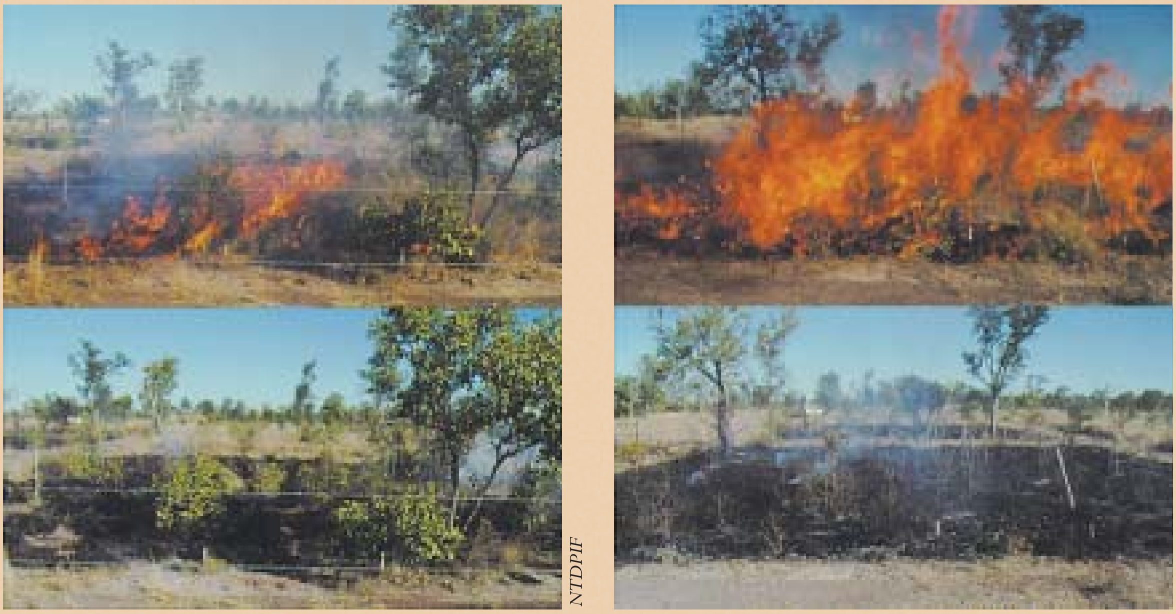
A quick estimate of fire intensity can be obtained from the equation

Intensity = 500 x W x R

where W is the fuel consumed in t/ha and R is spread in km/h

Thus an annual *Sorghum* grassland with 2 t/ha spreading at 5 km/h will have a fire intensity of

Intensity = 500 x 2 x 5 = 5000 kW/m



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Low-intensity fire (1.4 t/ha; 2700 kW/m fuel—left) and moderate intensity fire (6.7 t/ha; 5200 kW/m fuel—right) in woodland with perennial grass understorey at Kidman Springs, Victoria River District, NT

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High-intensity fire (20,000 kW/m) in open forest at Kapalga, NT

Fire regimes and landscape management

Traditional Aboriginal burning

Indigenous people have traditionally used fire for a variety of reasons—ease of travel, communication, 'cleaning' country, hunting and to maintain food sources. In Kakadu, for example, they started burning very late in the wet season (March) as soon as the country began to dry out, and continued for 9–10 months until the monsoon arrived. There was a peak of activity in June–July, but relatively little in August–September.

Current fire regimes on Aboriginal lands may not reflect past traditional practices because people are no longer dispersed through the country, and because traditional knowledge may not have been passed on to the current generation. Fires arising from Aboriginal lands today can cause conflict with neighbouring landholders if their land management goals are different.

It is important to continue learning about traditional indigenous fire regimes. Today, fire agencies endeavour to employ traditional burning practices, where possible, as a means of establishing a diverse set of fire regimes across the savanna landscape.

Early dry season burning

Early dry season burning is often prescribed in all land tenures in the savannas, primarily to reduce fuel. The early dry season burn results in a mixture of burnt and unburnt country and the risk of extensive, intense fire in the later part of the dry season is reduced. Early dry season fire can also be used to stimulate 'green pick' in pastoral country.

Late dry season fires

Most of the area burnt in northern Australia results from late dry season fires—wildfires rather than planned and controlled operations. Most late dry season fires are undesirable as they are difficult to suppress, consume vast tracts of country, and can be detrimental to plant and animal life.

However, intense, late dry season fires do have some uses. They can be used to kill or reduce the amount of woody sucker or shrub growth that may have accumulated in unburnt or heavily grazed savanna country. They can be used in integrated programs to control exotic woody weeds such as rubber vine (*Cryptostegia grandiflora*) in Queensland.

Wet season burning

The opportunity for a burn during the wet season depends on the chance of a dry break during the monsoon. For wet season burning, a body of cured grass and fuel needs to be retained through the dry season and then lit during the wet season after a couple of

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days without rain. Burning soon after the first storms, or when storms are imminent, removes old rank grass just before the new growth of the next season and so improves the quality of fodder for livestock or native fauna.

An increasingly important use of wet season burning in the Top End of the NT is to manage stands of annual sorghum. If annual sorghum is burnt after germination but before seed set, it can be eliminated locally because it does not have a persistent seed bank. This can reduce fuel loads in country with sorghum by 50%. However, the effectiveness of wet season burning depends very much on timing. If too early in the wet season, before about 100 mm of rain has fallen, there may be ungerminated seed left in the soil. If too late, e.g. after the monsoon has set in, fire may not spread.

Early wet season fire or 'storm burns' can also be used to control the density of *Melaleuca* shoots in the grassy wetland country on Cape York and to manipulate the composition of the grasses in the grasslands. This is an important tool in the management of habitats for species such as the golden-shouldered parrot.

Fire regimes—past, present and future

There has been considerable change to the fire regimes in the savannas over evolutionary, pre-historic, historic and contemporary times.

Fires undoubtedly became more frequent as the climate began to dry out during the Tertiary period over 20 million years ago. Before Aboriginal people arrived in the savannas, fires probably started at the very end of the dry season when there was dry fuel and the early storms produced lightning.

Aboriginal people modified the timing of fire by burning earlier in the dry season. Now, much of northern Australia, particularly the wetter parts, is dominated by a regime of frequent, extensive fires in the late dry season (Figure 1.1 p. 1). These extensive, late dry season fires appear to be more common now than before European settlement in northern Australia. This regime of frequent, intense, extensive fires is cause for concern in virtually all savannas.

In much of the semi-arid country, the dominant land use is pastoralism for which reserves of grass need to be protected from fire. Fires have been actively suppressed, which has probably resulted in a decrease in fire frequency and extent.

A change in fire regimes brings with it a change in impacts of fire on the landscape. We therefore need to know the ways in which various regimes impact upon the plants and animals of the savannas, and how we can manipulate fire regimes so that desired impacts are maximised and undesirable ones are minimised. The following chapters provide more detail on the impacts of various regimes and how we can manipulate fire regimes to achieve the types of savanna landscape we want.

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Further reading

General

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