Planned burning in Tasmania. III. Revised guidelines for conducting planned burning

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Abstract

Planned burning is the deliberate use of fire under specified conditions for the purposes of fuel management, ecological management, promoting agricultural green pick and weed management. The Tasmanian fire management agencies, the Tasmania Fire Service, Forestry Tasmania and the Parks and Wildlife Service, through the Tasmanian Fire Research Fund, have conducted a review of Tasmanian planned burning guidelines and methodologies. The aim of this review was to minimise the risk of adverse outcomes from planned burning, whilst also ensuring that the burning is performed safely and meets fire management objectives. This information has been summarised into a series of papers covering current practices and supporting information, fire risk assessment, and (this paper) revised planned burning guidelines. The current paper reviews and presents revised guidelines for performing planned burning in dry eucalypt forests and woodlands, heathlands, dry scrub, wet scrub, buttongrass moorland and grassland, and for weed management (mainly gorse removal).

Introduction

This paper is the third in a series reviewing the systems used for conducting planned burning in Tasmania. The first paper in this series covered the supporting information for conducting planned burning in Tasmania and reviewed the available literature (Marsden-Smedley 2011). The second paper in the series covered fire risk assessment for planned burning and the development of the Burn Risk Assessment Tool (BRAT; Marsden-Smedley and Whight 2011). This paper covers the revised guidelines for conducting the burning.

Published guidelines for conducting planned burning in Tasmania have been available since the 1980s (Forestry Commission and Tasmania Fire Service 1984), with these guidelines being progressively updated as a series of training manuals published by Forestry Tasmania (latest version: Forestry Tasmania 2005b). However, the previously published guidelines for conducting planned burning had been developed iteratively, primarily from expert opinion, with minimal documentation of how they had been developed. The current series of papers (Marsden-Smedley, 2011a; Marsden-Smedley and Whight 2011) and supporting report (Marsden-Smedley 2009) address this issue by comprehensively revising and updating the systems used for planned burning in Tasmania, and compiling this information into a single location. The planned burning guidelines were reviewed using the published and "grey" literature, workshops with practitioners experienced at performing planned burning, fire risk assessments using the BRAT, and the outputs from fire behaviour prediction models. This allowed identification of suitable weather, fuel and site conditions for conducting safe and effective planned burning (Marsden-Smedley 2009).

Table 1. Possible planned burning objectives and their corresponding outcomes.

Objective	Target outcome
All burns	
- burn performed safely	- no reportable safety incidents;
- no escapes	- fire contained to planned area;
- fire outcomes and effects recorded	- fire data collected and recorded on databases; - post-fire monitoring performed;
- minimise adverse community impacts	- effective community consultation and notification at planning, implementation and post-burn stages; - smoke impacts minimised;
- fire management targets achieved	- ≥90% of burns in asset protection zones and ≥75% of other burns conducted within 2 years of target date.
Fuel management burning: asset protection	
- reduce fuel-hazards	- reduce elevated and bark fuel-hazard to low and burn >70% of fuel across >70% of block within 250 m of the boundary; - reduce overall fuel-hazard rating to low across entire block.
Fuel management burning: strategic management	
- reduce fuel-hazards	- reduce overall fuel-hazard rating to low or moderate; - minimise impacts to community and ecological values.
Ecological management burning: broad-scale	
- manage for the full range of values	- ecological requirements of target associations recorded; - area of target associations stable or increasing; - 40-70% of block burnt, dependent on management aims; - unburnt patches scattered throughout the block; - burns conducted with a variable fire regime; - effective pre- and post-burn monitoring and documentation.
Ecological management burning: species management	
- maintain target species	- ecological requirements of target species documented; - target species numbers stable or increasing; - effective pre- and post-burn monitoring and documentation.

Considerations for conducting planned burning

Planned burning in Tasmania is conducted for fuel management, ecological management, agricultural green pick and/or weed management, in the following vegetation associations: dry eucalypt forests, heathlands, dry scrub and wet scrub, buttongrass moorlands and native grasslands. Planned burning for weed management is mainly for gorse removal.

Planned burning is not performed in wet eucalypt forests and rainforests. The fuel array in these vegetation associations is such that, when they are dry enough to burn, their typically high fuel loads result in excessive fire intensity and difficult fire control. In addition, rainforests are classified as a fire-sensitive vegetation association (Pyrke and Marsden-Smedley 2005) and so fire is an inappropriate tool for their management.

These guidelines form a structured method of providing the objectives, weather and site inputs required when practitioners perform planned burning. The guidelines have been developed from the information in the two accompanying papers (Marsden-Smedley 2011; Marsden-Smedley and Whight 2011).

Planned burning objectives

The objectives targeted during a burn will depend on the goals of the agency performing the burn, along with the requirements of the land owner. However, regardless of the objectives targeted, a fundamental aspect of planned burning is the identification of these objectives and desirable post-burn outcomes prior to ignition.

Use of the BRAT (Marsden-Smedley and Whight 2011) identifies the factors controlling the level of risk associated with a planned burn. The practitioner can then balance different factors to still meet the objectives of the burn. For example, in order to maximise the reduction in fuel-hazard in dry forests (in particular, the bark hazard), planned burns need flame heights over 2-4 m. However, fires of this intensity will also have relatively high rates of spread and a high potential to cause spot fires. Therefore, if planned burning is being conducted in asset management zones (where the objective is to minimise the level of post-fire fuel-hazard; Table 1), it will be necessary to ensure sufficient fire suppression resources are available to control the planned burn, and/or its boundaries are adequate to stop spread of the fire.

Fuel management burning is undertaken in asset-protection and strategic fuel management zones, and requires fires of sufficient intensity to meet objectives whilst ensuring safety standards are not compromised and escapes are minimised. Fuel management burning aims to reduce the suppression difficulty of unplanned fires and/or increase the likelihood that fires will self-extinguish. The primary aim in asset-protection zones is to minimise wildfire risk. Management in asset-protection zones requires the use of intensive fuel management (typically 5 to 10 years between fires) to minimise risk levels. Other values (e.g. ecological values, viewfields or recreational opportunities) are of secondary importance. The primary aim in strategic fuel management zones is to reduce the level of wildfire risk whilst minimising adverse impacts to other values. In strategic management zones, the normal situation is to burn 70% of fuels over 70% of the site (see Marsden-Smedley 2011 for a discussion on the coverage required during planned burning).

As the name implies, fuel management burning aims to reduce fuel-hazards so that the potential for wildfire suppression and/or the likelihood that wildfires will self-extinguish is increased. Thus, it is critical that the fuel-hazards immediately adjacent to assets and/or sources of ignition are prioritised (Luke and McArthur 1978). Typical fuel management burning objectives are to conduct the burn safely, minimise escapes, reduce the level of fuel-hazard (and in particular bark fuel-hazard) to low or moderate, keep scorch within acceptable limits, and burn a specified amount of the fuel over a specified proportion of the site.

The characteristics of planned burning in ecological management zones will depend on the requirements of the species and/or vegetation associations being managed, and may include species regeneration, habitat manipulation and development of mosaics of burnt and unburnt areas. Ecological management burning will aim to increase or promote fire-dependent species or associations (e.g. orange-bellied parrots), and/or to reduce or remove unwanted species or associations (e.g. weeds). These objectives typically include species regeneration (fire frequency used will vary between different species), habitat manipulation to increase native animal food availability, and development of mosaics of burnt and unburnt areas.

Green-pick burns are used to a limited extent in bushruns on agricultural land to regenerate native grasses, herbs and forbs for stock food (Kirkpatrick and Bridle 2007). This is mainly due to plants normally having a much increased palatability in their first one to three years of regeneration (JB Kirkpatrick and JB Marsden-Smedley, unpubl. data). Green-pick burning can also act to reduce the cover and dominance of woody species, which are normally unpalatable to stock.

In Tasmania, weed management burning is commonly targeted to removing gorse (*Ulex europaeus*) and to a lesser extent broom (*Cytisus* spp. and *Genista* sp.), Spanish heath (*Erica lusitanica*) and blackberries (*Rubus fruticosus*). A critical factor with the use of fire for weed management is that it should not be used unless follow-up treatment is undertaken, due to the potential for fire to promote and expand weed populations (Swezy and Odion 1997; Baeza *et al*. 2003, 2006; De Luis *et al*. 2004, 2005). The aim of burning for weed management is to remove adult plants and improve access for subsequent treatments, and to promote seedling germination to deplete seed banks reducing subsequent seedling germination. Follow-up weed treatments will need to be completed prior to the weeds reaching maturity and replenishing seed banks. Pre-burn spraying during follow-up treatments may also be used to increase the weed flammability by increasing the proportion of dead fuel (DiTomaso *et al.* 2006).

Examples of some planned burn objectives are in Table 1.

Performing planned burning

The Burn Risk Assessment Tool (BRAT; Marsden-Smedley and Whight 2011) can be used to predict fuel and weather conditions suitable for performing planned burning. The BRAT also predicts the probability of fires escaping (i.e. likelihood of an unintended impact), the potential of escapes to do damage (i.e. consequence), the effects of mitigation strategies in reducing the probability of adverse outcomes, and the potential for the burn to meet fire management objectives. Fire behaviour during planned burns can also be predicted using a behaviour prediction spreadsheet developed for southern Australia and adopted by the Tasmanian fire management agencies (Tolhurst KG, personal communication).

When planned burning is undertaken, the level of fire behaviour must be kept within acceptable bounds. In most situations, ensuring that the fire danger rating remains below the maximum levels specified in the guidelines will be the operationally practical approach to achieve this.

Planned burning in asset protection zones aims to minimise wildfire risk and maximise wildfire suppression potential. This requires fuel-hazard ratings to be reduced to low levels. In strategic management zones the aim is to reduce the level of wildfire threat and minimise wildfire spread rates and intensities. In ecological management zones the aims and objectives will be dependent on the species and/or association being managed, and will be specified in appropriate management plans. A critical aspect of ecological management burning is effective pre- and post-fire monitoring.

During dry eucalypt forest planned burns, the wind speed is measured at 10 m above the ground, while all other planned burns use the surface wind speed measured at 1.7 to 2 m above the ground surface.

The characteristics of the boundaries utilised during planned burning will depend on the type of planned burn and anticipated level of fire behaviour. If planned burns are performed with fire intensities below about 500 kW/m, or flame heights below two metres, then handlines and/or vehicle tracks one to four metres wide may be used. Where planned burns are performed with fire intensities of up to 2000 kW/m, or flame heights of up to three metres, fire breaks four to six metres wide will be required. However, if planned burns are performed in dry eucalypt forests which have very high or extreme bark hazards, then burns should be resourced to a higher level, wider boundaries used and/or the burn undertaken at lower levels of fire danger (e.g. higher relative humidity, higher fuel moisture, lower Soil Dryness Index and/or lower wind speed).

Integration of the burning parameters is a critical component of planned burning. If burning is conducted with all of the parameters at their maximum values (e.g. highest wind speed, lowest relative humidity, highest Soil Dryness Index and longest time since fire), then fires will burn with fast rates of spread, high intensities and a high likelihood of escapes. Conversely, if burning is conducted with all of the parameters at their lowest values, then fires may fail to sustain or the fire may burn with insufficient intensity to meet objectives.

The recommended process for selecting appropriate burning parameters is:
1. specify the objectives of the burn
2. determine the minimum and maximum fire intensity to achieve objectives, including the level of fuel modification required
3. use the BRAT to determine appropriate weather and site parameters and the risk profile of the burn
4. if necessary, modify the weather and site parameters to reduce the level of fire risk whilst maintaining acceptable levels of fire intensity
5. undertake the burn
6. undertake post-burn assessments to determine if burn objectives have been met (and develop strategies to address the issue if they have not been met), and record outcomes.

Fire age

Information on fire age (i.e. the time since the last fire) is normally obtained from fire crew records, fire history maps and/or ageing of the vegetation present at the site. A major issue with the collation of fire history information is recognising the potential for variation in fire behaviour across the site. Factors to be considered include the extent of the area burnt in the last fire, variation in fire intensity, and variation in fire history prior to the last fire.

A major assumption in site ageing is that fire is the principal disturbance factor. For many vegetation types, and especially those suitable for planned burning, this is a reasonable assumption due to many vegetation types undergoing pulse regeneration following fire. This results in the majority of the understorey dating from the time of the last fire (see Marsden-Smedley *et al.* 1999). However, in some vegetation types, such as coastal heath and riverine scrub, fire may not be the only disturbance agent and vegetation regeneration may be more closely tied to storms and/or floods. In other vegetation types, especially those not suited to planned burning, continuous regeneration may occur which is unrelated to fire (Jarman and Brown 1993).

When site ageing is conducted in Tasmania, the normal system is either counts of banksia nodes or basal annual rings (Marsden-Smedley *et al.* 1999). Provided these counts are done correctly, both techniques are robust and accurate. However, the banksia node count system has the major advantage of providing data rapidly and non-destructively in the field, while the basal ring count system is slower and much more labour-intensive.

Banksia node counts involve counting swellings on *Banksia marginata* branch junctions. Banksias normally form one new branch node per season (although occasionally they will miss a season, or less frequently form multiple nodes in one season). The nodes on banksias up to about 25 years of age are normally quick and easy to count. With care, banksias up to about 100 years old can be reliably aged although the nodes on the lower trunk are normally hard to count in individuals older than about 50 years.

Where it is not possible to age a site from banksias, basal ring counts should be made from tea-tree species (*Leptospermum* spp.) due to their reliable, easily counted rings. Ring counts should be made by taking cross sections from just above the ground, drying the stem, polishing it with up to 1200 grade sand paper and counting the rings, normally using a dissecting microscope. Where banksia node or tea-tree ring counts are made a minimum of six individuals should be sampled. If other species are used, such as eucalypts (i.e. *Eucalyptus* spp.) or paper-barks (i.e. *Melaleuca* spp.) a minimum of 10 individuals should be sampled due to their poorer ring structure.

For fire management purposes, accurate age data is required for ages up to about 25 years post-fire, after which fuel characteristics normally reach equilibrium. At most sites, the age will equal the median count plus one.

Fuel moisture

During planned burns, fuel moistures are normally measured from field samples, estimated from secondary characteristics, predicted using surrogates and/or predicted using models based on the prevailing weather (Marsden-Smedley 2011).

An indication of the relative flammability of different vegetation types and fuel removal during planned burns can also be made using the Soil Dryness Index (Mount 1972; Marsden-Smedley *et al*. 1999; Forestry Tasmania 2005a, 2005b; Marsden-Smedley 2009, 2011). For example, if buttongrass moorland burns are performed with the SDI below 10, wet scrub boundaries will be too wet to burn and will form safe fire-control lines. Similarly, wet gullies in dry forest may fail to sustain burning when the SDI is below about 25. The SDI also strongly influences the fuel moisture profile, with fuels under low SDI conditions (i.e. less than 10 in buttongrass moorlands and less than 25 in dry forests) typically showing a strong gradient in surface-fuels moisture between the moist lower fuels and drier upper fuels. This means that, for planned burning to be effective for fuel management, at least moderate SDI levels are required (e.g. in buttongrass moorland SDI between 10 and 25, and in dry forests SDI >50). In contrast, during ecological management burns the aim may be to leave significant amounts of fuel unburnt, and this can be achieved by burning with a low SDI (e.g. in buttongrass moorland an SDI between five and 10, and in dry forests an SDI between 25 and 50). The relationships between vegetation flammability and SDI are shown in Table 2.

Lighting pattern techniques used during planned burning

The most common ignition patterns utilised during planned burning are back fire ignition, flank fire ignition, head fire ignition, spot fire ignition, centre fire ignition and perimeter fire ignition.

Back fire ignition is where fires are lit such that their direction of fire travel is back into the prevailing wind direction and/or down slope, resulting in the rate of fire spread and intensity being kept to a minimum. This technique is normally utilised when fuels are relatively dry and/or weather conditions are such that head and/or flank fires would burn with excessive rates of fire spread, intensity, scorch and/or spotting. Hence, the critical aim of this lighting strategy is to keep the level of fire behaviour as low as practical. Flank fire ignition is where fires are lit as lines parallel to the direction of fire spread and/or straight up-down slopes, resulting in intermediate level rates of fire spread and intensity. Head fire ignition is where fires are lit as lines with the wind and/or straight across slopes, resulting in rate of fire spread and intensity being maximised. This technique is normally used when fuels are relatively moist and/or under mild weather conditions. Spot fire ignition is where fires are lit as a series of independent spot fires so that the spots will join up in the cool of the evening and/or burn into and self-extinguish in less flammable fuels (e.g. gullies or south to southeast slopes). The aim of this technique is normally to

Table 2. Vegetation flammability at different levels of Soil Dryness Index[1].

SDI	Community type	Flammability
≤10	buttongrass moorland	high
	wet scrub, dry eucalypt forest	very low
	all other vegetation types	non-flammable
11-15	buttongrass moorland	very high
	wet scrub, dry eucalypt forest	low
	wet-eucalypt forest	very low
	rainforest[2]	non-flammable
16-25	buttongrass moorland	very high
	wet scrub	high
	dry eucalypt forest, wet-eucalypt forest	mod
	rainforest[2]	non-flammable
26-50	buttongrass moorland	very high
	wet scrub, dry eucalypt forest	high
	wet-eucalypt forest	mod
	rainforest[2]	low
>50	buttongrass moorland, wet scrub, dry eucalypt forest	very high
	wet-eucalypt forest	high
	rainforest[2]	mod

[1] Table summarised from Marsden-Smedley *et al.* (1999), Forestry Tasmania (2005a, 2005b).
[2] Rainforest normally requires moderate or higher fire danger rating to burn.

Table 3. Spacing of incendiary capsules and spacing of lines required to burn out block[1].

Hours available to burn out block	Fire potential spread rate (m/min)							
	0.5	0.75	1.0	1.5	2.0	2.5	3.0	5.0
	Incendiary capsule spacing (m)							
1	5	10	20	40	70	110	125	250
2	10	40	70	125	200	275	325	600
3	30	80	135	225	325	440	525	925
4	60	130	200	325	450	600	725	1250
5	90	180	250	425	600	775	925	1500
6	125	225	325	525	725	925	1125	2000
	Spacing (m) between lines if using aerial or handheld drip torch							
1	20	30	50	75	100	140	170	300
2	50	75	100	175	240	300	370	630
3	75	125	175	270	370	470	570	960
4	100	175	225	370	500	635	765	1300
5	140	225	300	470	635	800	965	1625
6	175	275	370	570	765	965	1160	2000

[1] Calculated using quasi-steady state rates of fire spread and estimates of fire build-up time using relationships in Cheney and Gould (1995); spacing of incendiary lines assumes lines 10 m long are lit.

minimise fire junction zones and excessive levels of fire behaviour. However, if fuels are relatively moist and/or the weather conditions are mild, this technique can be used to intensively light up areas, with the fire junction zones acting to increase the level of fire behaviour and reduce the burnout time. Centre fire ignition is where fires are lit in the centre of a block so that the fire creates its own wind and pulls the fire away from the boundary. This strategy is most effective when the wind speeds are low, the atmosphere is unstable (increasing the potential for the fire to form updrafts) and/or where the block has a central hill so up-slopes can be utilised. Perimeter fire ignition is where the block is lit, normally as strips from pre-existing fire breaks (e.g. roads, tracks and/or rivers), and allowed to burn into the block.

When planned burns are lit, the main ignition methods are hand lighting using drip torches or incendiary launchers, or aerial ignition using incendiary capsules or aerial drip torches.

A major issue associated with planned burn ignition is balancing the intensity at which the burn is lit (e.g. the length of fireline lit and/or the number of incendiary capsules used) against the required level of fire behaviour. If fires are lit with a close spacing there will be a high potential to rapidly form junction zones, cause enhanced local wind speeds and resultant increases in the rate of fire spread, intensity and potential for spot fires. Where lines of fire shorter than 10 m are used, the fire build-up time will be slower, and faster if lines longer than 10 m are used. The recommended ignition spacing for planned burning is shown in Table 3.

Test fires can be used to indicate the likely level of fire behaviour expected once the main fire has been lit. However, in order to be effective, test fires need to be applied in sites representative of the main burning block, and be allowed to expand until they reach their quasi-steady state. This will require fireline lengths of at least 50 m, meaning that, if the level of fire behaviour is too high, fire suppression will normally be very difficult and may be impossible. If information is collected from test fires burning with shorter fire-line lengths, the predicted level of fire behaviour will need to be increased.

Revised guidelines for conducting planned burning

Dry eucalypt forest planned burning guidelines

Planned burning in dry eucalypt forest is conducted for fuel and ecological management. In asset protection zones, surface, near-surface, elevated and bark fuel-hazard ratings must be reduced to low, requiring fires to be conducted with flame heights of two to four meters. In strategic management zones, the aim will be to reduce overall fuel-hazards to low or moderate.

Fuel-hazard rating (Hines *et al*. 2010) is used when performing pre-burn and post-burn assessments. The fuel-hazard guide for dry eucalypt forest (Hines *et al*. 2010) is given in Table 4 (a similar guide is not yet available for other vegetation types). The guidelines for dry eucalypt forest planned burning are in Table 5.

Heathland, dry scrub and wet scrub planned burning guidelines

Planned burning in heathlands, dry scrub and wet scrub is conducted for fuel management and ecological management. During heathland, dry scrub and wet scrub burning, the sharp threshold between sustaining and non-sustaining fires can result in minor increases in wind speed and/or slope, along with decreases in fuel moisture, rapidly transforming low-intensity fires, requiring intensive lighting, into high-intensity fires. The heathland, dry scrub and wet scrub planned burning guidelines are in Table 6.

Table 4. Dry eucalypt forest fuel-hazard guide.

Hazard rating and description	
Surface fuel-hazard	
Low	litter depth including duff: <15 mm, <4 t/ha.
Mod	litter depth including duff: 15 - 25 mm, 4 - 8 t/ha.
High	litter depth including duff: 25 - 35 mm, 8 - 12 t/ha.
Very high	litter depth including duff: 35 - 50 mm, 12 - 20 t/ha.
Extreme	litter depth including duff: >50 mm >20 t/ha.
Near-surface fuel-hazard	
Low	fuel cover <10%, little or no influence on fire behaviour.
Mod	fuel cover 10 - 20% of tussock grasses, low sedges and rushes, hummock grasses and low shrubs with little or no suspended bark and leaves.
High	fuel cover 20 - 40%, 5 - 20% dead of tussock grasses, low sedges, rushes, ± suspended bark and twigs; fuel cover 20 - 35% cover of hummock grasses; fuel cover 20 - 40% of low shrubs, ± suspended bark and twigs.
Very high	fuel cover 40 - 70% cover with 20 - 30% dead of tussock grasses, low sedges, rushes; fuel cover 40 - 70% cover of hummock grasses; fuel cover 35 - 60% of low shrubs.
Extreme	>70% fuel cover of tussock grasses, low sedges, rushes with >30% dead grass, leaves and bark; >60% fuel cover of hummock grasses or low shrubs.
Elevated fuel	
Low	very little elevated fuel.
Mod	<20% fuel cover or no fine fuel within 1 m of the ground, little or no dead material.
High	fuel cover 20 - 50% cover or little fine fuel within 0.5 m of the ground, <20% dead material or, if the vegetation is 5+ m tall then it has little fine fuel within 2 - 4 of the ground.
Very high	20 - 50% cover of dead material, high vertical and horizontal density and continuity, fuel particles mostly <1 - 2 mm thick, average height >0.5 m and usually >1 m high, 50 - 80% of fuel >0.5 m and usually >1 m high.
Extreme	>20% cover of dead material, high vertical and horizontal density and continuity and at least 2 - 3 m tall, >10 t/ha, large amounts of suspended leaves, twigs and bark, >70% of fuel cover >1 m (and usually >2 m) tall.
Bark fuel	
Low	stringybarks: 100% of trunk charred; platy/subfibrous barks: >90% of trunk charred; smooth/gum barks: no bark ribbons.
Mod	stringybarks: bark tightly held, >90% of trunk charred; platy/subfibrous barks: bark very tightly held onto trunk; smooth/gum barks: no long bark ribbons.
High	stringybarks: few pieces of loosely held bark, bark tightly held, 50 - 90% of trunk charred; platy/subfibrous barks: bark tightly held onto trunk, long unburnt; smooth/gum barks: long ribbons of bark but smooth trunk.
Very high	stringybarks: significant amounts of loosely held bark, 10 - 50% of trunk charred; platy/subfibrous barks: bark loosely held onto trunk; smooth/gum barks: long ribbons of bark hanging to ground level.
Extreme	stringybarks: outer bark weakly attached and easily dislodged, <10% of trunk charred; platy/subfibrous barks and smooth/gum barks: does not occur.

Table 5. Dry eucalypt forest planned burning guidelines.

Parameter		Units	Range
Weather	wind speed at 10 m	km/h	<30
	relative humidity	%	40 to 80
	Soil Dryness Index	dimensionless	<125
	temperature	°C	10 to 25
Hazard-stick moisture	within the burning block	%	14 to 17
	adjacent to burning block	%	>24
Fuel moisture	within the burning block	%	10 to 15
	adjacent to burning block	%	>20
Fire frequency	fuel management	years	4 to 10
	ecological management	as specified in management plans	
Forest Fire Danger Rating	fuel management	dimensionless	5 to 10
	ecological management	dimensionless	≤10
Fire intensity: flame height required	asset protection	m	2 to 4
	strategic management	m	1 to 4
	ecological management	as specified in management plans	

Table 6. Heathland, dry scrub and wet scrub planned burning guidelines.

Parameter		Units	Range
Weather	wind speed at 1.7 to 2 m	km/h	5 to 20
	relative humidity	%	40 to 80
	temperature	º C	10 to 25
Wet scrub only	Soil Dryness Index	dimensionless	15 to 25
	Hazard-stick moisture: within burning block	%	14 to 20
	adjacent to block	%	>24
Fire frequency	fuel management	years	5 to 10
	ecological management	as specified in management plans	
Scrub Fire Danger Rating	all planned burns	dimensionless	≤20

Buttongrass moorland planned burning guidelines

Buttongrass moorland planned burning is conducted for fuel management and ecological management. The most important issue influencing buttongrass moorland burning is the balance between boundary security and fuel removal. When the Soil Dryness Index (SDI) is below 10, natural boundaries (typically wet scrub) will have high moistures and a low potential to burn. Under these conditions, soil moistures will also be high, and fuel in the lower parts of the fuel array may be left unburnt as thatch. Where burns are conducted with boundaries wider than 250 m and a SDI below 10, burns may be conducted as high-intensity fast-moving fires with surface wind speeds of up to 20 km/h. Where burns aim to minimise thatch and maximise fuel removal, fires may be conducted with the SDI between 10 and 20 and wind speeds below 10 km/h. However, under these conditions scrub boundaries will be ineffective at containing fires, resulting in mineral earth boundaries, roads, tracks and/or watercourses being required. The interactions between the SDI and vegetation flammability are summarised in Marsden-Smedley (2011).

Table 7. Buttongrass moorland planned burning guidelines.

Parameter	Units	Range
Fuel management burning: secure natural boundaries		
Surface wind speed at 1.7 to 2 m	km/h	≤20
Relative humidity	%	40 to 90
Temperature	ºC	10 to 25
Days since rain (>2 mm)	days	2 to 10
Soil Dryness Index	dimensionless	≤10
Fire frequency	years	5 to 10
Moorland Fire Danger Rating	dimensionless	≤10
Fuel management burning: mineral earth boundaries		
Surface wind speed at 1.7 to 2 m	km/h	≤10
Relative humidity	%	40 to 90
Temperature	ºC	10 to 25
Days since rain (>2 mm)	days	4 to 10
Soil Dryness Index	dimensionless	≤20
Fire frequency	years	5 to 10
Moorland Fire Danger Rating	dimensionless	≤ 5
Ecological management burning		
Surface wind speed at 1.7 to 2 m	km/h	≤20
Relative humidity	%	40 to 90
Temperature	ºC	10 to 25
Days since rain (>2 mm)	days	2 to 10
Soil Dryness Index	dimensionless	≤10
Fire frequency will be specified in management plans		
Moorland Fire Danger Rating	dimensionless	≤10
Unbounded burning: overnight conditions required for fires to self-extinguish		
Surface wind speed at 1.7 to 2 m	km/h	≤5
Relative humidity	%	>60
Temperature	ºC	<10
Rain and/or dewfall to 09:00 on the following day	mm	≥0.1
Site productivity	dimensionless	low

Table 8. Native grassland planned burning guidelines.

Parameter	Units	Range
Surface wind speed at 1.7 to 2 m	km/h	≤20
Relative humidity	%	40 to 80
Temperature	ºC	10 to 25
Days since rain (>2 mm)	days	2 to 10
Curing (percentage dead fuel)	%	>60
Grassland Fire Danger Index	dimensionless	≤5

Unbounded burning may be performed in low productivity areas where the aim is to have fires self-extinguish without burning to boundaries, leaving part of the site unburnt.

Low-productivity buttongrass moorlands occur in western and south-western Tasmania and are underlain by quartzite and/or quartzite-derived geologies. Buttongrass moorlands underlain by other geologies and/or in other parts of Tasmania are classified as medium productivity. The buttongrass moorland planned burning guidelines are in Table 7.

Table 9. Guidelines for gorse management using fire[1].

Parameter	Units	Range
Surface wind speed at 1.7 to 2 m	km/h	≤20
Relative humidity	%	50 to 85
Temperature	º C	10 to 25
Days since rain (>2 mm)	days	<2
Soil Dryness Index	dimensionless	≤20
Hazard-stick moisture	%	14 to 20
Scrub Fire Danger Index	dimensionless	≤10

[1]Integrated post-burning follow-up is a critical aspect of the management regime

Native grassland planned burning guidelines

Native grassland burns in Tasmania are mainly conducted for agricultural green pick and for ecological management to maintain species and structural diversity. The critical factors controlling fire behaviour are fuel moisture, fuel load and continuity, curing (ie percentage of dead fuel) and wind speed. The guidelines for native grassland planned burning are in Table 8.

Guidelines for gorse management using planned burning

The main weed species where fire is used for management are gorse (*Ulex europaeus*) and to a lesser extent broom (*Cytisus* spp. and *Genista* sp.), Spanish heath (*Erica lusitanica*) and blackberry (*Rubus fruticosus*). Fire is a major issue in areas dominated by gorse due to its ability to sustain burning over a wide range of conditions, and its rapid post-fire regeneration. Therefore, integrated pre and post-fire treatments are essential. Treatment effectiveness can be enhanced by pre-burning herbicide spraying, scrub rolling and/or slashing to maximise burn intensity, and biomass consumption (to kill shallowly buried seeds and/or enhance seedling germination of deeper buried seeds) and improve post-fire access for follow-up treatments. Pre-burn treatment can also be used to broaden the burning window by increasing the weed's flammability and allowing the fire to be performed under higher fuel moisture conditions, reducing the likelihood of fires spreading to other vegetation types. The guidelines for gorse management using fire are in Table 9.

Conclusions

This paper is the third in a series reviewing (Marsden-Smedley 2011) and updating (Marsden-Smedley and Whight 2011) the systems used for conducting planned burning in Tasmania, and covers the revised guidelines for conducting planned burning. The information and systems in these three papers will allow for enhanced application of planned burning for fuel management and ecological management.

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