NATIONAL BURNING PROJECT

Australasian Fire and Emergency Service Authorities Council (AFAC)
***and* Forest Fire Management Group (FFMG)**

National Guidelines for Prescribed Burning Operations:

Case Study 5 – Semi-arid mallee and mallee-heath burning in South Australia

National Burning Project: Sub-Project 4

afac

An Australian Government Initiative

FFMG

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This document is constructed by GHD from consultation and research between Forest Fire Management Group (FFMG) and AFAC, its member agencies and stakeholders. It is intended to address matters relevant to fire, land management and emergency services across Australia and New Zealand.

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This case study, prepared by Paul de Mar (GHD) and Mike Wouters (Department of Environment, Water and Natural Resources), is a synthesis of semi-arid mallee and mallee-heath fuels, fire behaviour and burning information documented in reports from South Australia (SA), Victoria and Western Australia (WA). It incorporates burn operations planning and implementation practice information as well as the relevant fire science on which current procedures are founded.

1 Risk management overview

Semi-arid mallee and mallee-heath dominated vegetation occurs in central and northern South Australia, western Victoria, western NSW and south-eastern WA.

Mallee dominated landscapes typically have low population densities, and modest local capacity for fire suppression. The majority of mallee area burnt is by large, unplanned summer fires, burning when seasons with abundant fuel conditions, ignitions and adverse fire weather coincide. Fire suppression efforts on established fires often have little impact on the eventual fire size and impact area, other than to provide life and property protection at specific locations during the fire. Fire extent and impact are influenced to a much greater extent by the presence of low fuel areas in the landscape which restrict fire spread until the arrival of weather conditions that extinguish the fire or facilitate its containment. Low fuel areas in mallee can be created by unplanned fires, prescribed burns, or mechanical treatments. Mallee landscapes also contain ‘natural’ areas of low fuel, for example lake beds, chenopod shrublands and areas of bare ground.

Figure 1 Mallee-heath

Prior to the 1980's little prescribed burning was attempted in mallee vegetation. Fire regimes at that time can be characterised as low ignition frequency, dominated by small numbers of large, unplanned summer fire events of moderate to high intensity, often resulting in low seral stage diversity. In some areas of SA mallee, fragmentation significantly affected fire regimes such that they burnt in an 'all or nothing' pattern across isolated blocks. Mallee at Ngarkat conservation park appears to have had a fire history in the 1980's to late 1990's of successive (some areas burning up to 6 times) large bushfires leaving only some 10% of the area 'long unburnt'. There is contested evidence that this regime differs substantially from pre-European settlement fire regimes which were dominated by Aboriginal burning, comprised of higher ignition frequencies, much smaller fire size, with a much higher proportion of small, low to moderate intensity fires, and providing greater seral stage diversity in the landscape.

From the 1980's land management agencies have explored ways to limit the size and impact of unplanned fires that inevitably occur during the landscape drying phases which follow high rainfall years. During these periods, long-term fuel build-ups in long-unburnt overstorey mallee and heath vegetation and short-term growth pulses of ephemerals coincide, maximising fuel continuity and quantity across broad areas. To break up the continuity of heavy fuel accumulations, fuel-breaks are created usually through a combination of mechanical means (e.g. scrub-rolling) and prescribed burning.

'Conventional' burning approaches developed in forest environments (burning blocks at low to moderate Fire Danger Rating (FDR)) are impractical in mallee. Accordingly, mallee burning techniques involving partially bounded or unbounded burning of narrow strips with the wind under high FDR have been developed. Long relatively narrow strips of burnt mallee make highly valuable firebreaks that assist wildfire suppression and limit the growth potential of summer wildfires, thereby inducing a greater degree of seral stage diversity.

2 Fuel dynamics and fire behaviour context

Mallee vegetation grows in semi-arid environments with typically harsh growing conditions of long hot dry summers and low nutrient soils. Hence vegetation growth and fuel accumulation rates are typically much slower than in higher rainfall areas. Exceptional growth periods can however occur, particularly during extended wet periods when the addition of ephemeral grass growth in combination with accelerated growth of elevated fuels can result in fuel accumulation surges.

In average seasonal rainfall conditions, mallee younger than 6 years old is near-impossible to burn under FDR's up to the Very High range. Fuel discontinuities are high with around one third of the ground bare. Dead fine litter fuels are negligible (< 0.06 t/ha), and near surface fuels are around 2 t/ha, mostly consisting of live green young shrub growth. Fuels in the elevated fuel layer and canopy (typically averaging less than 1 metre high at age 6) are chiefly live/green foliage. In aggregate semi-arid mallee fuels less than 6 years constitute a sparse, live fuel complex that will only sustain fire under severe fire weather conditions. Heath fuels less than 6 years may sustain fire spread under less severe conditions than 6 year old mallee, but not within limits prescribed for planned burning.

As mallee and heath continue their growth through the 6 to 20 year age period, their ability to sustain fire spread increases. This is principally due to a significant increase in the quantity and proportion of dead fine fuels in the near-surface and elevated fuel layers and an increasing contribution of suspended bark (in mallee). While litter fuels also increase, they only attain a thin and discontinuous cover giving a low surface hazard.

For practical purposes, a suspended fuel moisture content no greater than 9% in mallee, and 13% in heath is required for successful burning. A minimum 10 metre wind speed of 15 km/h will be required, although in older fuels a minimum wind speed of 20 km/h is preferable. Under such conditions, headfire behaviour will normally involve a vigorous surface fire and either intermittent or sustained crown fire. When fire behaviour transitions to crowning, rate of spread increases abruptly and short distance spotting becomes more prolific, aiding the sustainment of forward spread by allowing the fire to more readily cross fuel discontinuities.

As mallee further grows and ages through the 20 to 50+ age period, fuel quantity in the near-surface and elevated layers remain relatively constant. However there are modest increases in litter under mallee crowns and an increase in bark accumulations and dead woody fuel in the 6 to 25mm size class which extends fire residence time. The maximum 9% suspended fuel moisture threshold remains relevant, however the increase in bark quantity can bring about crowing and spotting more readily than in younger mallee.

A feature of planned burns in semi-arid mallee and mallee-heath fires is that while wind-driven headfires burn vigorously through elevated and canopy fuels, flank and back fires typically sustain little if any spread.

The abovementioned suspended fuel moisture and wind speed thresholds for sustaining forward fire spread are rarely achieved at Fire Danger Indexes (FDIs) much less than 20. Under very mild burning conditions, with FDI less than 5, little if any fire spread can be achieved in mallee. With FDI in the range of 5 to 10 range (as is commonly favoured for dry eucalypt forest burning), some spread may occur but the result is most often a very patchy burn that fails to achieve objectives.

2.1 General issues, opportunities and constraints

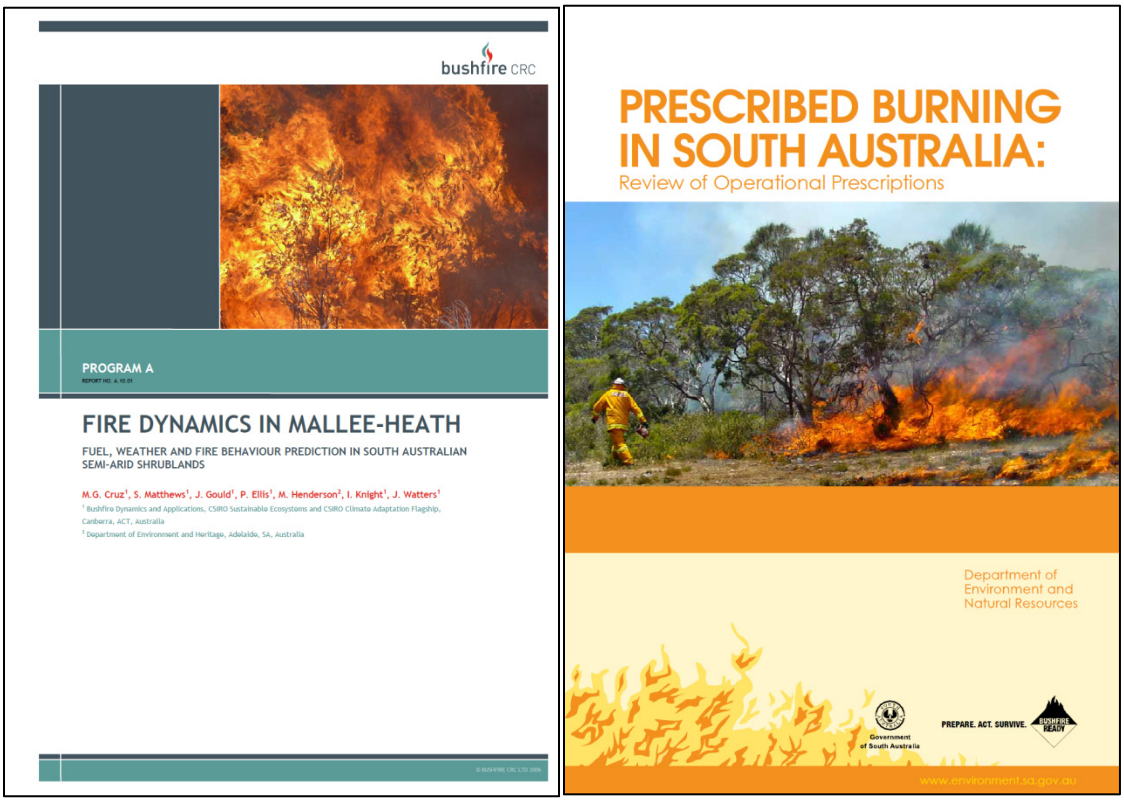
It is not feasible to conduct low-intensity burning across broad areas in semi-arid mallee-heath as mallee-heath burning will generally involve sustained crown fire.

In a high proportion of landscape areas where mallee burning is considered, roads and fire breaks are absent or only available in limited areas. Therefore, selection of weather conditions with consistent wind direction, and when overnight conditions are conducive to back and flank fire self-extinguishing, and headfires petering out and also self-extinguishing will be optimal. Selection of burn areas such that the headfire runs into low fuel areas is advantageous.

3 Mallee-heath burn planning-considerations and general approach

While there has been a body of scientific research into mallee-heath fire behaviour and burning over the last three decades, the most consolidated and contemporary research program was completed by Cruz *et al.* (2010) for the Bushfire Cooperative Research Centre.

Figure 2 Key scientific reports underpinning SA mallee-heath burning practice



The Department of Environment and Natural Resources (SA) has published prescribed burning prescriptions for semi-arid mallee and mallee-heath in *Prescribed Burning in South Australia: Review of Operational Prescriptions*.

3.1 Burning season selection

For burn security, it is best to burn before grasslands in the surrounding landscape begin to cure. It is also necessary to burn during periods when days with FDI sustained above 20 will occur, but before seasonal weather patterns bring on periods of weather when the FDI reaches into the high 30's and low 40's for consecutive days. Early to mid-spring offers the best opportunities for such conditions to occur, particularly late September to mid-October, before the onset of sustained bouts of adverse weather and whilst surrounding grass country remains green. Burning opportunities are rare prior to mid-spring due to the short day length being insufficient to dry dead fine fuels out to the moisture contents suitable for initiating and sustaining fire spread.

Spring also offers the best chance of burn-days when overnight weather conditions will reduce to the low FDI range (for 3 or 4 hours) sufficient for the burn to self-extinguish.

While burning can be undertaken in autumn if surrounding pastures have largely been eaten out over summer, the cumulative effects of hot dry summer conditions can mitigate against fires self-extinguishing overnight. Therefore escape risks on days subsequent to the burn are generally higher than in spring. When autumn burning is practiced it is mostly smaller scale burns, and in younger fuel ages (typically less than 15 years old) to reduce the risk of overnight burning in coarse fuels and subsequent re-ignition from flanks the following day.

3.2 Planning of burn area dimensions

Burning in semi-arid mallee and heath is almost always done with the wind in order that fire spread across fuel discontinuities is sustained.

Accordingly, burning in long ‘strip’ patterns (sometimes referred to as fingers) is the most common approach. Spread rates of sustained fires generally do not fall below 1 km/hr and can attain spread rates in the order of 5 km/hr on days when the 10m wind speed is in the vicinity of 20 km/hr (when crowning often occurs). Hence burnt strips of 10km or longer are achievable. The width of strips will be a function of the width of the initial line ignition, and the degree of variation in wind direction during the fires spread. For large burns in extensive mallee areas, widths in the order of 1 to 2km are typical. The ignition line width necessary to achieve such a width will vary, principally depending on how steady the wind direction is during the period of the burn.

Burn strip widths and lengths can be constrained by burning adjacent to, or toward low fuel areas such as young mallee regrowth (<5 year old) or adjacent green grass areas.

3.3 Burn timeframe and duration

Mallee-heath burns are generally planned to have a single day burn-out timeframe (although some smouldering combustion may persist beyond this timeframe – particularly in older fuels), with burns undertaken during conditions in which fire will self-extinguish overnight. This short burn time duration is well within normal Bureau of Meteorology weather forecasting timeframes (3-4 days) allowing selection of stable atmospheric conditions, when favourable wind direction and overnight fuel moisture recovery conditions are forecast.

The time period during the day available for burning in mallee is generally during the afternoon.

During autumn, suspended fuel moisture conditions appropriate to sustaining fire spread are not usually attained before midday. Sunset times during April/May are around 5:30 to 6:00pm. At this time of year, on days when the FDI peaks in the 20 to 30 range, fire spread in mallee will typically decline to creeping/smouldering surface fire within an hour of sunset. Thus a maximum afternoon sustained fire period of around 4 to 5 hours or less is typical.

For spring burns, late September/October is among the windier months in mallee areas, and it is relatively common for wind speeds in the range of 15 to 20 km/hr being attained during the afternoon (such wind speeds are necessary for mallee fires to sustain spread), and declining significantly after sunset. There are exceptions to this pattern when wind speeds will stay high into the night, and care needs to be taken to properly assess the potential for this to occur.

3.4 Limiting conditions

There is a range of conditions in which semi-arid mallee-heath burning should not be conducted:

- On days when the FDI is forecast to exceed 30 as fire behaviour prescription will almost certainly be exceeded[1];
- In conditions which are likely to facilitate overnight spread as next-day escape risk is too high;
- On days when there is more than 50% cloud cover or rain as it is highly likely to be unsuccessful;
- On days when the 3 pm relative humidity is forecast to exceed 50% as it is highly likely to be unsuccessful – (this is an uncommon occurrence in mallee areas); and
- In mallee-heath fuels less than 5 years old as there is insufficient dead fine fuels in surface and near-surface layer to sustain spread in prescribed burning conditions.

The key to successful burning in semi-arid mallee and heath is choosing conditions in which:

- Forward fire spread can be sustained – ideally minimum wind speeds of 15 km/h at 2 metres above the ground will be required;
- Wind direction during the burn period is relatively consistent;
- Sunny days with clear skies are optimal;
- Fire behaviour remains within acceptable parameters namely: a standard prescription limiting forward spread to less than 1.5 km/h currently applies in SA; no spread-rate limits are prescribed in Victoria, NSW or WA but usually spread rate is less than 5 km/h is preferred; and
- Overnight conditions are favourable for fire to self-extinguish.

3.5 Determining the burn prescription

Suspended dead fuel moisture content (suspended) is a key fuel attribute for setting prescriptions in mallee-heath shrubland fuels:

- For heath shrublands, the standard prescription range (in SA) for
    - Old/heavy fuels (very high – extreme adjusted surface fuel hazard): 8 – 13%;
    - High hazard: 7 to 12%; and

[1] There may be some circumstances, driven by specific burn objectives, and facilitated by favourable surrounding vegetation condition, when burns can be conducted in conditions when the FFDI will peak above 30

    - For low to moderate fuel hazard: 5 to 10% (burning in low to moderate fuels is not a common occurrence).

  In practice, burning crews prefer a dead average fuel moisture content in the range of 8 to 10%; and

- In mallee fuels, FMC needs to be toward the lower end of these prescription ranges to adequately sustain fire spread – usually 9% or less. Temperature and relative humidity conditions which achieve these FMC ranges need to be selected using the CSIRO *Quick Guide for Fire Behaviour Prediction in Semi-Arid Mallee-Heath* (Cruz 2010).

Published burning guidelines in SA for semi-arid mallee and mallee-heath specify a maximum rate of spread prescription of 1.5 km/hr. In practice, this upper-bound prescription is difficult to achieve.

Semi-arid mallee and mallee-heath burning is generally undertaken in fuel ages greater than 15 years old, and mostly in fuels over 20 years old with some small-scale burns for life/asset protection undertaken in fuels younger than 15 years. In fuels older than 20 years, fuel hazard ratings (FHR) are generally in the High range (whether using the SA *Adjusted Surface Fuel Hazard Rating System* (DENR 2012) or the CSIRO *Elevated Fuel Hazard Score* system).

To achieve a rate of head fire spread less than 1.5 km/h in High FHR fuels in heath-shrublands (with mallee cover less than 5%), if burning at a FMC of 13% (the maximum FMC level considered suitable for achieving sustained fire spread), then a wind speed of not more than 10 km/h at eye level will be required (equating to a 10 metre wind speed of 12 to 20 km/h depending on vegetation structure). Burning under such conditions is likely to be marginal for sustaining fire spread. Burning with FMC in the favoured range of 8 to 10%, with an eye level wind speed at the favoured threshold speed of 15 km/h will give a predicted rate of spread in the range of 3.4 to 4.2 km/h greatly exceeding the upper-bound rate of spread prediction.

In mallee, the situation is more difficult still. Mallee burning guidelines recommend a maximum FMC of 9% to sustain fire spread. At 9% FMC, in High FHR fuels, an eye level wind speed of just 5 km/h is predicted to generate a rate of spread exceeding 2 km/h. Such low wind speeds are sub-optimal for achieving sustained fire spread. At 9% FMC, in High FHR fuels, with an eye level wind speed of 15 km/h, the predicted rate of spread will exceed 7 km/h.

This serves to highlight the narrow prescription range in which burn practitioners must operate. In most conditions suitable for burning in mallee-heath, it will be necessary to request approval to exceed the 1.5 km/h rate of spread standard prescription.

For setting wind prescriptions, 10 metre wind average speeds in the range of 15 to 25 km/h are usually selected – 15 km/h being a low-end wind speed necessary to achieve sustained fire spread, and 25 km/h being a level above which standard rate of spread prescriptions will almost certainly be exceeded. Burning can be undertaken at higher wind speeds, however vigorous fire behaviour including crowning and short distance spotting will occur, and therefore non-standard fire behaviour prescription approval may be required.

4 Burn plan preparation

SA fire and land management agencies have in place a structured burn plan preparation process. Standards for burn planning are set out in inter-agency procedures. The burn planning process entails:

1. Specify the burn context and objectives;
2. Determine vegetation types, and hazard levels within the burn area and adjacent;
3. Determine minimum and maximum fire behaviour to achieve objectives, level and patterns of desired fuel modification, and the fire behaviour likely during the burn based on standard prescriptions and lighting practice assumptions;
4. Determine whether the burn's risk profile is acceptable using the SA Bushfire Risk Assessment Tool[2] (BRAT);
5. If necessary, modify the weather, burn site or lighting parameters to reduce the level of risk to acceptable levels whilst maintaining acceptable fire behaviour to achieve the burn objectives;
6. Identify and plan how to manage the burn risks and record action requirements in the burn plan, including resources required to implement actions;
7. Complete the rest of the standard burn template sections and checklists including preparation of the operations map, preparation and notification requirements, command and control arrangements, contingencies and logistics, and record taking requirements; and
8. Prepare a pre-burn operations brief and submit plan for peer review and approval process.

All burning needs to comply with the DEWNR Fire Management Policy & Procedure Manual. Burn Standard prescriptions are documented in the Operational Prescriptions Guide which are fuel type-specific. All burn plans are completed using the on-line Fire Management Information System (FIMS) which incorporates standard prescriptions and produces compliant plan products.

5 Operational preparations

Depending on the site circumstances where a mallee shrubland burn is to be undertaken, there will be a range of preparations which need to be made before burning can be approved and commenced. These typically include such things as:

- Mobilising and deploying portable communications gear;
- Preparing containment and contingency lines;
- Conducting protective works around at-risk assets;

[2] The Bushfire Risk Assessment Tool (BRAT) is a spreadsheet that calculates consequence categories based on a comprehensive list of factors relating to fuels, vegetation, boundaries, weather, landscape context and topography. The BRAT also calculates fire behaviour predictions such as rate of spread and flame height.

- Organising and mobilising agency and local partner resources for the burn;
- Setting up command and control points and logistical support facilities (e.g. for aircraft or machinery); and
- Advising neighbours and stakeholders of any preparedness actions they should take.

Due to the lead times for organising burning operations in relatively remote areas, these preparations need to be completed at least two days and preferably longer before the burn is scheduled to take place.

6 Burning Operations Implementation

6.1 Obtain weather forecasts for the burn area and verify with on-site conditions

Weather forecasts for the planned burn site should be obtained from the Bureau of Meteorology, relevant for the location where burning will be carried out. Upon arrival at the burn site, field weather readings should be checked for alignment with and variance with forecast conditions, and fuel moisture readings taken in surface and near-surface and suspended fuels. Dead fuel moisture content should be compared with predicted fuel moisture using the CSIRO *Quick Guide for Fire Behaviour Prediction in Semi-Arid Mallee-Heath*.

Figure 3 CSIRO mallee-heath fire behaviour prediction


2010

Quick guide for fire behaviour prediction in semi-arid mallee-heath

The purpose of this guide is to provide a systematic method for predicting the probability of self-sustained fire propagation and associated rate of spread in prescribed burn operations in semi-arid mallee-heath woodlands. The tabular outputs of this guide have been simplified. For more accurate outputs and information on other fire behaviour characteristics (e.g., flame dimensions) use the models in the report **Fire Dynamics in Mallee-heath**. Copies of the report and this guide are available through bushfire CRC (www.bushfirecrc.com).

CSIRO

bushfire CRC

Government of South Australia
Department of Environment and Natural Resources

Disclaimer: The fire behaviour information provided in this field guide should be used as a guide only. It has been developed from the best research available at the time of writing. No warranties, or indemnities are given as to its accuracy or usefulness in any particular case. Use by trained personnel is advised.

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6.2 Operational preparations and briefings

Routine procedures for staff and equipment checks and preparedness are undertaken and planning information distributed to burn crews. A routine pre-burn operations briefing is conducted and crews dispersed to take up planned sectors and roles as per the burn plan and briefing which follows a standard SMEACS[3] format. Authorisation to proceed with ignition is requested and obtained from the nominated Incident Controller.

6.3 Conduct fire behaviour prediction and test fire

Once fuels are within the desired moisture range (as predicted, measured or both) conduct fire behaviour prediction using both the BRAT and the CSIRO *Quick Guide for Fire Behaviour Prediction in Semi-Arid Mallee-Heath*. Select an exposed area location for field weather observations to base dead fuel moisture and fire behaviour predictions on.

Based on the fire behaviour predictions and test fire results (if necessary), refine the pre-planned lighting schedule and pattern to achieve the burn objectives and desired fire behaviour.

For mallee-heath burning this typically entails considering the desired burn dimensions and where the head fire end-point will be, and what ignition location, timing, and pattern will be best to achieve this (or in the reverse; considering where the fire will go, how far and with what behaviour given a fixed lighting location, and determining if that is acceptable).

6.4 Implement burning operations

Subject to successful conduct of the test burn (if unsuccessful the test burn is put out), lighting operations are executed in accordance with the burn plan and any lighting pattern modifications that arise from the test burn.

Mallee-heath burns are typically lit using a line ignition, either from the ground using a drip torch, or from the air using an aerial drip torch under-slung beneath a helicopter. An aerial drip torch is strongly preferable to aerial incendiary capsules due to the relative sparse and thin cover of surface fuels in mallee-heath vegetation.

Once a successful ignition has been established, monitoring of the fire direction and rate of spread is undertaken, and spread predictions generated for where the fire will travel during the burn period. Fire behaviour and on-site weather need to be monitored throughout the burn, with results recorded at least hourly and to check conditions remain within prescription. With mallee burns, once a burn is lit and spreads away from the ignition line location, there is generally not much can be done even if prescription are exceeded.

Burns require continuous monitoring, to identify and address potential escape points. Where mineral earth boundaries are used along burn edges, mop-up activity may need to be applied. If overnight fuel moisture recovery is genuinely in the prescribed range (which typically occurs in the middle of the night after resources have been demobilised) then mop up can usually be completed

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[3] A model used in emergency management for operational briefings. The acronym stands topics to cover in the briefing including Situation, Mission, Execution, Administration, Command/Control/Coordination and Communication and Safety.

the following day, and no further action required. If smouldering in coarse woody fuels is present and persists on vulnerable boundaries, then patrol and mop up can take several days.

Once burn operations are completed and any edge mop-up activity winds down, the burn supervisor will need to assess the extent of unburnt fuels remaining, and assess overnight fire behaviour potential, to make a decision on patrol requirements, in particular if or when resources can safely depart the burn site overnight and the timing of patrol checks the following day, if any are required. These decisions need to be made based on forecast weather overnight and on the days following the burn.

Assessment also needs to be made of likely smoke transport and settling locations to inform placement of smoke hazard signs on public roads and any other prudent smoke management actions.

7 Appraisal

Post burn assessment involves making estimates of the burn area extent, assessing if the burn objectives have been met, and identifying and recording the requirements for any rehabilitation or action to address environmental issues arising from the burn.

Larger and more remote burns may be mapped using satellite imagery (typically some weeks or months after the burn).

8 Acknowledgements

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9 References and further reading

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