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 2 –Burning young silvertop ash regrowth forests in NSW

National Burning Project: Sub-Project 4

An Australian Government Initiative

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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.

TABLE OF CONTENTS

FIGURE INDEX

TABLE INDEX

This case study has been prepared by Paul de Mar (GHD) incorporating a synopsis of Forestry Commission NSW Research Paper 16 – A Prescribed Burning Guide for Young Regrowth Forests of Silvertop Ash (N.P. Cheney, J.S. Gould and I. Knight, 1992) – with incorporation of operational practice components in consultation with Tim McGuffog and Marty Linehan of Forests NSW (2013)

1 Fuels and fire risk management context

1.1 Risk management context

Young regrowth forests being managed for timber production and other values can suffer significant damage, timber value degrade, and productivity loss from fires of sufficient intensity to cause excessive stem or crown damage. Therefore forestry organisations may seek to reduce the risk of future tree crop damage by wildfire, through conducting fuel reduction burning in regrowth forests that are suitably resilient to low intensity fire.

While many mature dry eucalypt forest types are resilient to low intensity prescribed burning, the same forests are often vulnerable to damage during their juvenile/early regrowth phase. The issue therefore arises as to when burning can be reintroduced into young regrowth stands, and how can the burning be done so as to avoid or minimise damage. These were challenges faced by the NSW Forestry Commission (FCNSW) in the late 1980's. After a number of high intensity fires that killed extensive areas of young silvertop ash regrowth with adverse environmental, water, and future log supply impacts, FCNSW sought to make greater use of prescribed burning to manage fire risk across the regrowth forest estate. They commissioned CSIRO to undertake research to develop a prescribed burning guide for young regrowth forests of silvertop ash (*Eucalyptus sieberi*) on the far south coast of NSW.

Figure 1 Silvertop ash plantation

1.2 Fuel dynamics and fire behaviour issues

Research from experimental fires in young silvertop ash regrowth stands found that:

- The mean surface fuel load in silvertop ash regrowth forests is relatively constant at around 10 t/ha, and the near-surface fuel layer added up to a further 3 t/ha. Fuel loadings were similar through a range of understorey types;

- Satisfactory resilience to low intensity burning develops in silvertop ash regrowth stands when future crop trees have a stem diameter at breast height greater than 9cm or a tree height greater than 12m;

- For fires less than 750kW/m, crown scorch and damage to the upper stems is typically limited to only 10% of the trees in the 9 – 12cm diameter class. Trees greater than 12cm diameter or higher than 15m will receive little damage to the crowns or upper stems;

- Tree damage principally occurs on the smaller trees in the stand (those less than 6cm diameter) for which the proportion of trees with cambial damage was 60-80% (in contrast to only 10% for trees greater than 9cm diameter). Tree deaths are very strongly associated with trees less than 6cm diameter. Very few trees in the 12-15cm diameter class were damaged, and the damage was limited to relatively minor damage; and

- In typical fuels (around 13 t/ha of combined surface and near surface fuel comprised of low shrubs, wire grass, bracken, other grasses, trailers and suspended litter) fire burning at the fire intensity limit of 750 kW/m will have a rate of spread around 2.3 m/min, flame heights of 2m and scorch height to 12 m.

The conclusions from the research were that:

- Burning should not be attempted until the diameter of the future crop trees is greater than 9cm or the tree height greater than 12m;

- Burning prescriptions should aim to produce a burn with an upper limit on fire intensity of 750 kW/m (this intensity will produce flames 2m high and an average spread rate of 2.3 m/min); and

- The optimum range for fire intensity is 250-500kW/m which will facilitate a reasonable range of burning conditions.

1.3 Other issues and constraints

Due to the history of logging in the silvertop ash forests on the NSW far south coast, there is generally good availability of mineral earth tracks and trails that can be used as boundaries for burn containment.

Silvertop ash forests occur across a large altitudinal range from near sea level to around 1100 metres, often being situated in hilly to mountainous terrain. Accordingly, in steeper terrain, fuel moisture patterns can be highly variable and this needs to be taken into account when planning burns.

2 Burning Block Analysis Phase

2.1 Burning season selection

In southern NSW where the majority of burning under young silvertop ash is conducted, the rainfall peak is during winter, typically with a drying trend through spring followed by a typically low rainfall period over summer when severe fire weather conditions can be expected. Accordingly, spring burning can be risky as by the time fuels have dried sufficiently to support successful burning, the summer conditions are approaching and if below average rainfall is experienced in spring there is a high risk of fire smouldering and subsequent re-ignition on dry hot windy days in early summer. For this reason, burning is usually conducted in Autumn (typically March-April) after late summer/early autumn rainfall events have reduced drought indices from the summer peaks, but before conditions become too moist to burn.

Optimal conditions are generally provided in years when good late summer rainfall has zeroed or greatly reduced the soil dryness index from its summer peak, and then a sustained steady drying trend unfolds in March. When coincident with stable burning weather in March/April, this provides for optimal burning conditions.

If dryer than normal conditions through January and February persist, conditions in March may be unfavourable due to conditions being too dry. On the other hand, conditions in March when a succession of rainfall events keep the soil dryness index below favourable levels can make conditions less than suitable for burning.

2.2 Planning of burn area dimensions

As burning is intended to reduce fuels and therefore fire risk in regrowth stands being managed for future timber harvesting, and is targeted to young regrowth age classes of regeneration, burn area selection and size is often dictated by logging coupe dimensions and arrangements. Typically burns will range from around 40ha (single coupe burn) to around 1000ha (multiple compartment burns where wildfire has homogenised age classes across a large area).

At the planning stage, the location of mineral earth trails for use as burn boundaries will be an important factor in determining burn block dimensions.

For larger burns, a combination of ground operations for edge burning and aerial ignition for core burning is undertaken. For smaller burns, ground operations are used. For larger burns, it is desirable to plan these adjacent to low fuel areas from recent burning in previous years (or from previous wildfires), in particular placing the downwind burn edge (assuming adverse wind direction) adjacent to a low fuel area where possible.

2.3 Burn timeframe and duration

Due to the potential for adverse windy days to occur even in the generally stable and mild autumn period, planning for fire to burn-out target fuels within normal weather forecasting timeframes (3-4 days) is advisable. On the main ignition day (core burn) selection of conditions when wind direction will be consistent throughout the day is generally desirable, and unstable days are avoided and typically days with a temperature below 25°C are prescribed.

In autumn, on days when weather variables will remain within prescribed limits, it can be anticipated that only those aspects and ridge top locations where fuels are exposed to solar radiation during the morning will be able to sustain spreading fire during the late morning period. Around midday and early afternoon less exposed fuels can be expected to reach satisfactory fuel moisture content (FMC) to sustain fire spread. Planning of ignition patterns should take these diurnal trends into account.

To keep fire intensity below 750kW/m, wide head fires and junction zones need to be minimised during peak afternoon conditions, therefore spot ignition patterns that join up after fuel moisture conditions have bottomed and are on a rising trend are usually optimal. Planning of burn timing and lighting patterns should take this into account.

2.4 Burn staging and sequencing

Where there is significant variability in topography and fuel moisture conditions across a large burn site, multi-stage operations may be required. First dryer-site fuels are edge burnt, then subsequently when landscape drying has advanced, edge burning of sheltered positions can be completed. Core burning should be undertaken when fire behaviour on ridges and exposed positions within the burn area can be kept within prescription. If large areas of fuel remain unburnt within the burn boundaries, a further burning stage to ignite sheltered positions within the core may be necessary (noting that exposed positions must have already been burnt prior). Where burns are not large and topography is not complex, single stage burning is often possible, but will require well organised and expedient execution and favourable wind conditions in order to get edge burns and core burns ignited and substantially burnt-out in the one day.

Figure 2 Prescribed burning in silvertop ash

2.5 Limiting conditions

The key to successful burning under young silvertop ash regrowth is to keep fire intensity below 750kW/m (and preferably between 250 and 500 kW/m), and to minimise crown scorch. To achieve this, dead fine FMC should ideally be in the 12-18% range. Burning should be avoided in conditions when FMC will fall below 12% for any more than about an hour, unless fire spread during the low FMC part of the day will be in fuels low in the topography where FMC can be expected to be higher than ridge top locations (e.g. as can be the case when downslope burning is commenced on ridges during the late morning and has burnt down to lower slopes by the time FMC will reach its low point around 12% by mid-afternoon).

Wind speed is another important variable governing rate of fire spread and intensity. As a general rule, burning should not be planned for days when the wind speed in the open will exceed 15 km/h. In broken topography on aspects aligned with wind direction, wind penetration under the forest canopy can be significantly higher than in other areas, so at wind speeds approaching 15 km/h in the open, rates of spread at or exceeding the upper end of prescriptions can be expected. Backing fire (fire against the wind or downslope) can be used to moderate fire intensity in these locations.

3 Operational Planning Phase

3.1 Developing prescriptions for the burn

The key aim of prescriptions for burning under young silvertop ash regrowth is to achieve fire intensity in a desirable range of 250 – 500 kW/m and limiting any unavoidable exceedences to less than 750kW/m (this principle is also applicable to young regrowth of many other dry and moist eucalypt forest types). This means burning under milder prescriptions than is typically undertaken in more mature forests which possess higher levels of fire-resilience.

Accordingly, the following prescriptions are used in burn planning for young silvertop ash in southern NSW:

Table 1 Silvertop ash burning prescriptions

Weather variable/ fire behaviour attribute	Prescribed Range	Comments
Drought Index (using KBDI)	Less than 100	For broad area burning of larger blocks all weather and fire behaviour variable should be within prescription.
Dry bulb temperature	Less than 20^{o}C	
Relative humidity	Higher than 50%	
Wind speed	Less than 15km/h at 10m (or 0 – 6 km/h in the forest at 2 m)	For burning of coupe size blocks, burning at temperatures up to 25oC OR relative humidity falling to 40% may be undertaken but only if FFDI and forward rate of spread remain within prescription.
3pm Forest Fire Danger Index	Less than 6	
Surface Fuel Moisture Content	12 to 18%	Wind speed is average speed – gust speeds may exceed prescriptions.
Forward rate of spread	Less than 2 metres per minute	Rate of spread prescription is for fuel and weather conditions on windward slopes.
Flame height (average)	1 to 1.5 metres	
Scorch height (max)	6 – 9 metres	

3.2 Pre-planning of lighting patterns for the burn

Field assessment of proposed burn sites is vital for all burns, in order to factor in stand characteristics and fuel variability into planning of lighting sequences and patterns.

It is particularly important during field inspection to identify:

- Areas with steep slopes (greater than 25 ^{o}) – it will be near-impossible to keep head fires on steep slopes within fire behaviour prescription (particularly if a shrubby fuel layer is present), and therefore such areas may need to be protected and reconsidered for burning when the forest is taller;
- Areas within a burn block that have a significant proportion of trees less than 9cm diameter – only backing fire should be planned for these areas;
- Areas on windward slopes with a well-developed and near-continuous near-surface fuel layer more than 0.5 metres high – planning to burn these areas with backing fire or flank fire (using spot ignition patterns); and
- The adequacy of perimeter trails for fire containment should also be checked and potential weak areas identified for preparatory works and/or noting in the burn plan.

4 Operational Preparation Phase

4.1 Burn plan preparation

Site specific burn plans should be completed by the end of February, and burn crew rostering organised from early March in order to take advantage of the onset of favourable burning conditions, as soon as it occurs, in March and April. Any required preparatory works need to be planned and completed prior to the scheduled burn day, if not already completed prior to scheduling.

4.2 Burn day selection

The two key factors in burn day selection are fuel drying patterns and weather forecast for the period of the burn duration.

Monitoring of surface and near-surface fuel moisture trends is necessary to identify when the desired FMC is approaching suitable conditions for burning. Surface and near surface fuel drying trends are monitored by field staff using hazard sticks or fuel moisture meters.

Four and seven day weather forecast products from the Bureau of Meteorology are monitored to identify stable atmospheric periods when weather parameters are forecast to be within prescriptions.

Subject to resources being available, days when fuel moisture trends and forecast weather conditions will both be suitable and no adverse fire weather is foreseeable in the seven day forecast, are selected for burning.

Burn day scheduling should avoid Easter and first-term school holiday periods to avoid local air quality/visibility impacts during peak holiday/tourist visitation periods.

5 Burning phase

5.1 Obtain weather forecasts for the burn area and verify using on-site conditions

Spot weather forecasts for the planned burn site should be obtained from the Bureau of Meteorology, relevant for the location(s) where burning will be carried out. Upon arrival at the burn site during the morning, field weather readings should be checked for alignment or variance with forecast conditions, and fuel moisture readings taken in surface and near-surface fuels.

5.2 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 (the briefing follows a standard SMEACS format. Authorisation to proceed with ignition is requested and obtained.

5.3 Conduct fire behaviour prediction and test fire

Once fuels are within the desired surface fuel moisture range (12 – 18%) conduct fire behaviour prediction using the *Young Silvertop Ash Regrowth Burning Guide* (Cheney *et al.* 1992). Select an exposed aspect location for fuel moisture and wind speed measurement.

Inputs:

- Slope (degrees);
- Near-surface fuel height (metres);
- Near-surface fuel moisture (%); and
- In forest wind speed at 2m (km/h).

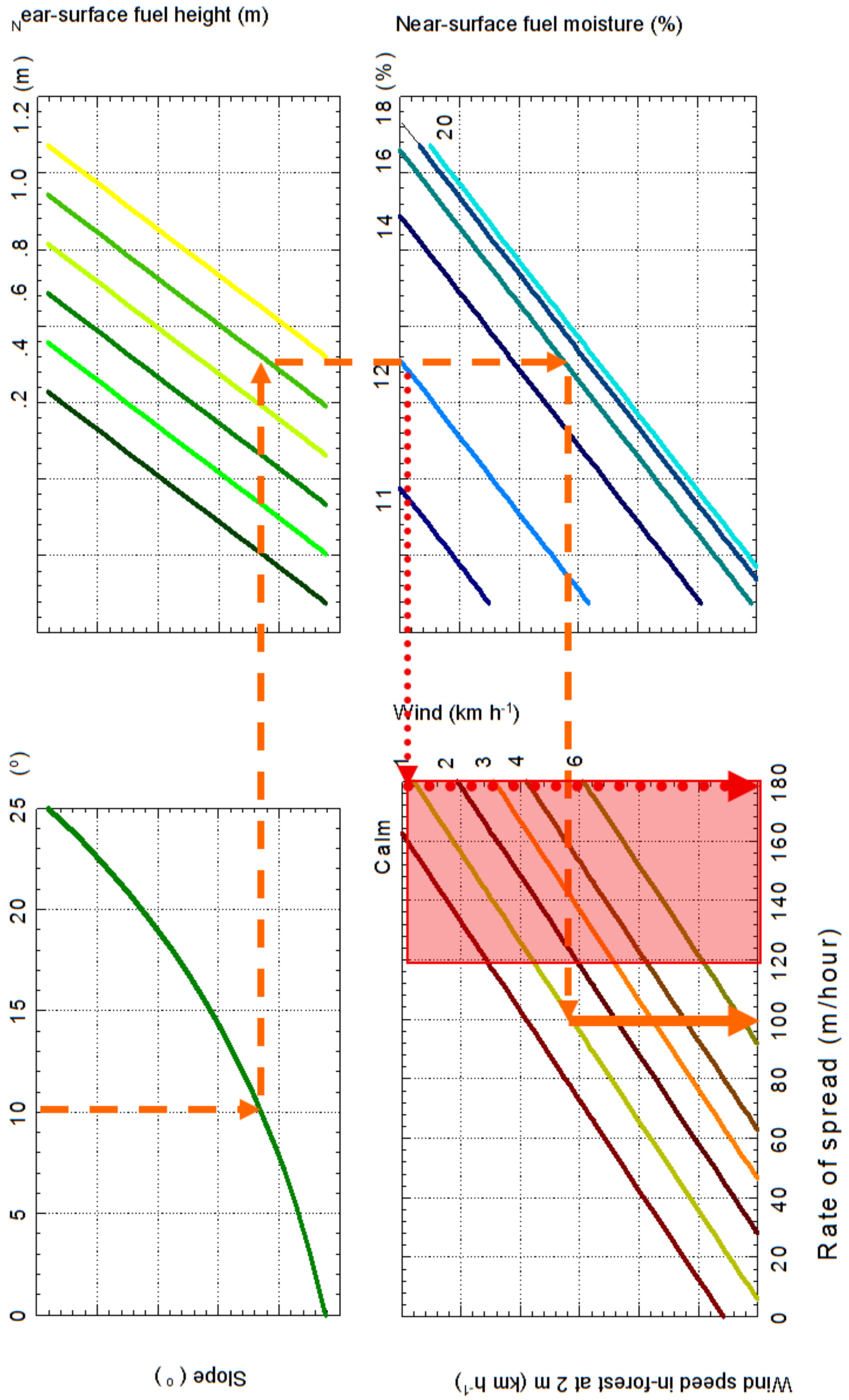
Calculate two sets of fire behaviour predictions:

1. Current – using measured fuel moisture and wind conditions at the current time; and
2. Mid-afternoon predicted – using forecast afternoon wind speed, and expected afternoon near-surface fuel moisture content.

Obtain predicted forward rate of spread, flame height and scorch height from the guide (fire spread prediction nomogram extract reproduced below).

Figure 3 Low intensity burning is silvertop ash

Figure 4 Fire spread prediction



Flame height and scorch height can be predicted using the rate of spread prediction by cross referencing the near surface fuel layer height and air temperature using the relationship curves in Figure 5 and 6.

Figure 5 Flame height prediction

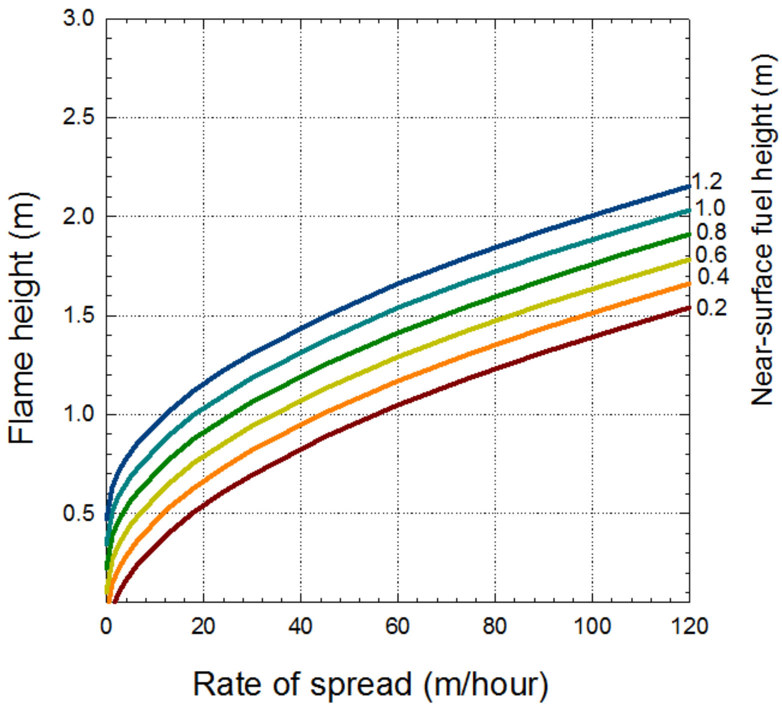
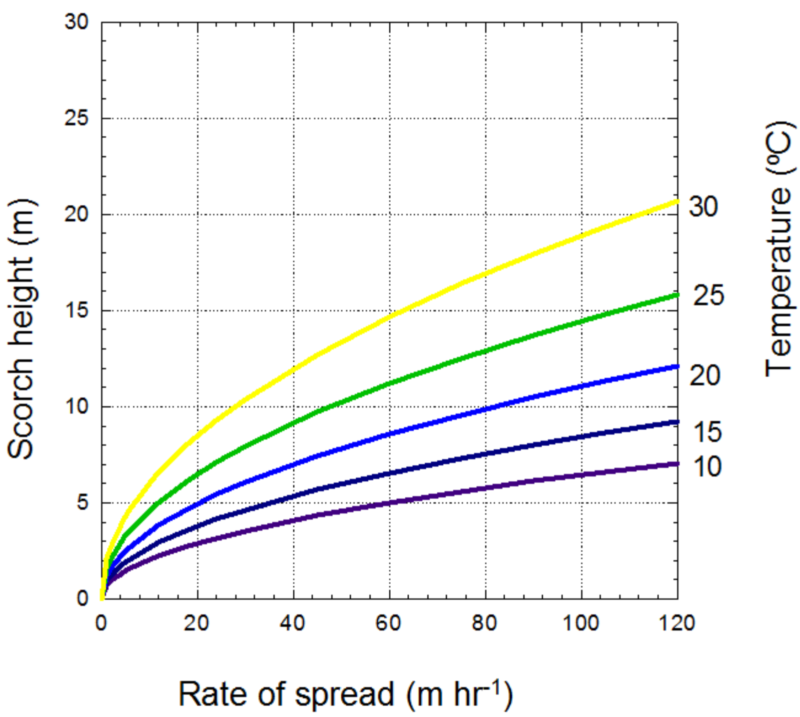


Figure 6 Scorch height prediction



Conduct a test fire using a strip ignition to observe rate of spread and flame height and compare with calculated fire behaviour predictions, to confirm fire behaviour is within prescription.

Consider the time of day the test fire is lit, the results of the test fire, and how fuel moisture and weather conditions are predicted to develop during the afternoon.

5.4 Conduct of 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.

While the burn plan typically provides a general level of information about burn stages/sequence, ignition methods (e.g. ground or aerial), and lighting direction, the more precise detail of lighting patterns (e.g. selection of line or spot ignition techniques, spacing of lines or spot ignitions, orientation of ignition direction to terrain features, wind direction etc.) is left to the burn supervisor to determine based on fire behaviour predictions and test-burn results.

Selection of lighting patterns appropriate to the local terrain, fuel and weather conditions will be based on:

- Where fire behaviour predictions and test-burn results fit within the acceptable range of prescribed conditions. For example, in FMC is toward the lower end of the acceptable range and weather conditions toward the upper end of the acceptable range, a conservative spot ignition pattern may be adopted to start with. On the other hand, if FMC is toward the high end and weather variable readings toward the low end of the acceptable range, a more closely spaced spot or line ignition lighting pattern may be selected. Lighting pattern selection must take into account fuel moisture and wind variability within a burn site; and

- Resources available to control the burn. It is generally desirable to conduct burning operations as efficiently as possible so that operational costs are contained to reasonable levels. Burn supervisors will need to select a lighting pattern that can be effectively delivered with the available resources, and with burn security able to be maintained throughout the burn.

As a general principle, it is best to start with a conservative lighting pattern and progress up to higher intensity patterns as required (rather than starting with a higher intensity pattern and subsequently having to back it off).

Fire behaviour and on-site weather need to be monitored throughout the burn (with results recorded at least hourly) to ensure conditions remain within prescription, and that where necessary, lighting patterns can be modified as conditions change.

Burn security and mop-up requires continuous monitoring throughout the burn, to identify and address potential escape points. The extent of active mop-up required will depend on weather conditions and the location/extent of fuels that could cause fire to escape boundaries through spotting or burning material or trees falling across control lines.

Once lighting operations are completed and 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/when resources can safely depart the burn site overnight and the timing of patrol checks the following day. These decisions need to be made based on forecast weather (overnight and 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.

6 Appraisal Phase

Upon completion of the burn, evaluation of burn results is undertaken.

The key areas for evaluation for young silvertop ash regrowth burning are:

- Appraisal of what proportion of the area within the burn boundary was burnt. From this it can be identified whether or not any follow-up work may be required, and whether coverage objectives have been met; and

- Appraisal of crown scorch extent and degree. Trees with more than 50% of their crown depth scorched can be considered to experience some negative impact (temporary) on growth as tree response is directed to epicormic growth to replenish the crown. Less than 50% crown depth scorch is considered unlikely to have a significant effect on growth. Further, for regrowth stands of 12 metres or more in height, full depth crown scorch is an indicator that fire intensity has most likely exceeded the 750kW/m typically associated with unacceptable levels of stem damage. Therefore, appraisal of the amount of area with more than 50% crown depth scorch can provide an indication of the extent of damage and growth retardation.

7 Acknowledgements

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8 References and further reading

A comprehensive *Prescribed Burning Guide for Young Regrowth Forests of Silvertop Ash* has been produced by CSIRO for the Forestry Commission of NSW (now trading as Forestry Corporation of NSW). The guide was published as:

NP Cheney, JS Gould and I Knight (1992) A Prescribed Burning Guide for Young Regrowth Forests of Silvertop Ash. Research Paper No. 16. Forestry Commission (NSW)

This case study is a synopsis of the original research report, with additional information about current operational practice incorporated. It is recommended that any persons wishing to make use of the fire spread prediction nomogram or relationship curves (for flame height and scorch height) reproduced in this synopsis should first read the original FCNSW Research Paper 16 to ensure an adequate understanding of the assumptions and experimental design and limitations of the underpinning research.