HAZARD REDUCTION BURN GUIDELINES

For Koala Habitat on the Tweed Coast

OCTOBER 2016

TWEED SHIRE COUNCIL

wildsite ecological services

Prepared by Wildsite Ecological Services for Tweed Shire Council.

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Cover photography: Hazard reduction burn in swamp sclerophyll forest. All photographs © Andy Baker 2015.

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Acknowledgements

These Hazard Reduction Burn Guidelines collate and build upon existing guidelines and prescriptions developed for this and other regions, as well as consultation with leading fire and koala experts. The guidelines have adapted many of the burn parameters of the *Planned Burn Guidelines: Southeast Queensland Bioregion of Queensland* (QPWS 2013) for use within koala habitat on the Tweed Coast.

John Turbill (NSW National Parks and Wildlife Service) laid the foundations for these guidelines through the development of a discussion paper for the Northern Rivers Fire & Biodiversity Consortium. Thanks to Mark Graham (NSW Nature Conservation Council) and Joshua Bull (Fireland Consulting) for providing draft guidelines for hazard reduction burns from their respective organisations. Thanks to Phil Paterson (Rural Fire Service) for insights into the management of fire and koalas on the NSW south coast.

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1 Introduction

1.1 Purpose

Hazard Reduction (HR) burns in koala habitat can achieve a range of complimentary outcomes, including to reduce the risk of wildfires i) killing koala individuals, ii) causing long-term koala habitat decline, and iii) threatening human life and property. However, it is essential that HR burns themselves, also avoid harming koala individuals and habitat. Additionally, HR burns should also avoid damaging other conservation values such as fire-sensitive vegetation and cultural heritage sites, and should ideally be done in a way to ensure the maintenance and restoration of koala habitat.

The main purpose of this guide is to assist land managers to undertake hazard reduction burning within koala habitat with minimal impact on:

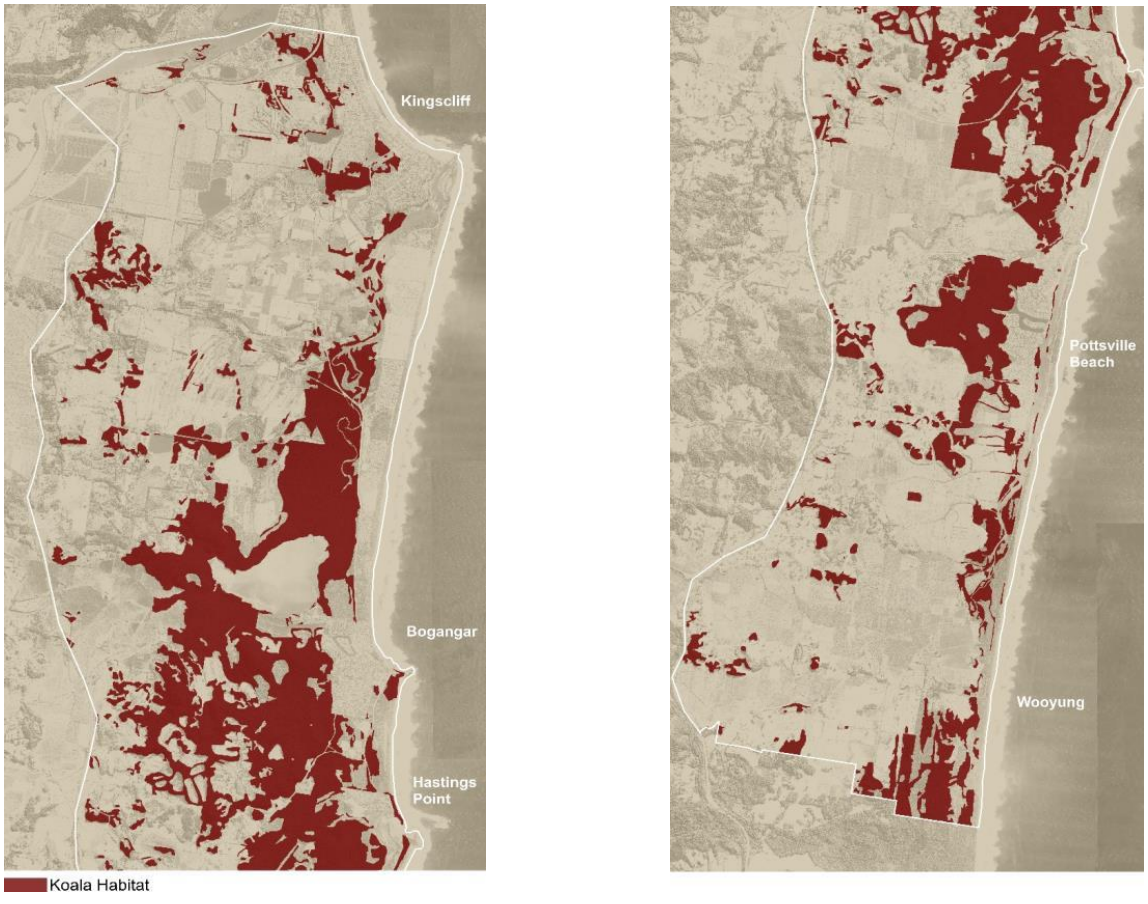
- koala individuals, canopy food resources and long-term habitat condition, and
- other values such as fire-sensitive vegetation and items of cultural heritage.

1.2 Where do these guidelines apply?

These guidelines apply to koala habitat within the *Southern Tweed Coast Koala Management Area* as shown in **Figure 1**. Importantly, these guidelines may also be broadly applicable to all koala habitat in the South East Queensland Bioregion, including the far north coast of New South Wales.

It is acknowledged that the mapped koala habitat in Figure 1 extends across a range of land tenures including freehold land, National Park and Council land. Land managers of respective tenures are recommended to apply these guidelines to all hazard reduction burns. Council will apply the guidelines to all works on Council land and may be able to provide technical or other assistance in other locations.

Figure 1. Koala habitat to which these guidelines apply.



1.3 Why burn in koala habitat?

Hazard reduction burning is the primary tool for reducing the risk of high intensity wildfires worldwide, and provides an invaluable tool for reducing the likelihood of adverse wildfires, including high intensity wildfires and peat fires.

The overriding premise of hazard reduction burning is to pre-emptively reduce fuels under controlled conditions (e.g. mild weather and coordinated deployment of fire suppression resources), rather than allowing accumulated fuels to ignite under extreme or catastrophic fire weather, and resulting in severe crown fires that are beyond fire suppression capabilities. By reducing the overall fuel hazard, HR burning reduces the rate of spread, flame height and intensity of wildfires, as well as the number and distance of spot fires (Gould *et al.* 2007). If a bush fire burns through an area where a hazard reduction burn has been carried out it will reduce the intensity of the fire, improve the likelihood of koala survival and make it easier for firefighters to control.

In addition to reducing wildfire risk, hazard reduction burning can offer additional benefit to maintain the natural role of fire as an ecological process in vegetation communities and koala habitat.

Within koala habitat, well-planned hazard reduction burning provides an essential tool to:

- reduce koala mortality by reducing the extent, intensity and frequency of bush fires, and to
- maintain koala habitat by:
    - encouraging ongoing recruitment of koala feed trees;
    - maintaining an appropriate soil environment (nutrient and microorganisms) for koala feed trees;
    - reducing the likelihood of peat fires; and
    - preventing habitat displacement by rainforest transition.

It is acknowledged that not all koala habitat can be assessed and protected during a hazard reduction burn, and that despite the best planning, procedures and intentions, koalas may still be at risk from injury during hazard reduction burns. However, through implementing these guidelines, Tweed Council aims to reduce the likelihood of koala injury during hazard reduction burns.

1.4 Basis of the Hazard Reduction Guidelines

These guidelines have been developed as part of the *Tweed Coast Koala Fire Management Plan* (Baker 2016), which outlines the rationale and underlying assessments informing their development. The guidelines collate and build upon existing guidelines and prescriptions developed for this and other regions, as well as consultation with leading fire and koala experts.

These guidelines adopt the recommended fire-intervals, and assumed hazard reduction burn intensities of the *Planned Burn Guidelines: Southeast Queensland Bioregion of Queensland* (QPWS 2013; **Table 1** & **Figure 2**). These SEQ Guidelines have been used in preference to the NSW-wide guidelines of Kenny *et al.* (2004) given that they:

- relate directly to the Tweed Coast, which forms part of the *'South Eastern Queensland'* Bioregion of the Interim Biogeographic Regionalisation for Australia (DSEWPaC 2012), based on common climate, geology, landform, and native vegetation communities.
- reflect recent developments in the scientific understanding of the interplay between fire interval and biodiversity conservation, particularly that the absence of appropriate fire has been and is continuing to cause structural change towards more closed forests, resulting in altered fuel/fire hazard, open forest decline and a loss of biodiversity (QPWS 2013).

These guidelines also adopt many of the burn parameters of QPWS (2013) for specific fire-management issues including:

- Peat-fire avoidance;
- Fire-sensitive vegetation protection;
- Cultural value protection; and
- Koala habitat maintenance.

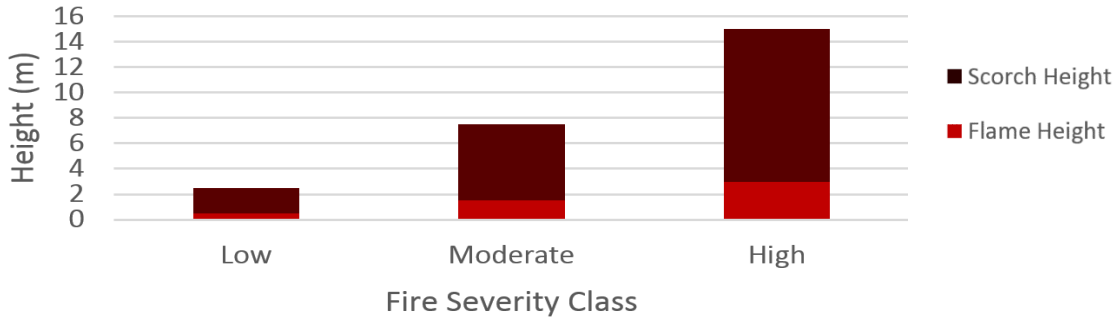
These guidelines also integrate recommendations from a range of other related documents, including:

- Cudgen Nature Reserve (Pony Club) Prescribed Burn: Inspection Report and Recommendations (Hopkins & Hetherington 2014)
- Cudgen, Cudgera Creek, & Wooyung Nature Reserves Draft Fire Management Strategy (NPWS 2012)
- Guidelines for Low Intensity Bush Fire Hazard Reduction Burning (RFS 2003)
- Level 2 Prescribed Burn Plan: TWKY Pony Club LMZ (NPWS 2015)
- Review of environmental factors: Pony Club Land Management Zone Hazard Reduction Burn, Cudgen Nature Reserve (NPWS 2014)
- Standard Operating Procedure (SOP): Koala Habitat Burning (Fireland Consultancy 2015)

Table 1. Recommended fire intervals for vegetation groups (adapted from QPWS 2013). Intervals are indicative only and should be adjusted through on-ground assessment of vegetation health, fuel accumulation and wildfire risk.

Vegetation Group	Minimum (yrs.)	Maximum (yrs.)
Wet Open Forest (Rainforest Understorey)	20	100
Wet Open Forest (Shrubby Understorey)	7	25
Wet Open Forest (Grassy Understorey)	3	6
Open forests and woodlands (Shrubby)	7	25
Open forests and woodlands (Grassy)	3	6
Melaleuca Communities (Sedge/Fern)	12	20
Melaleuca Communities (Heathy)	8	12
Melaleuca Communities (Grass/Shrub)	6	20
Coastal Fringing Forest (Swamp Oak)	7	20
Heathlands	7	20

Figure 2. Hazard reduction burn intensity classes likely under optimal planned burn conditions (adapted from QPWS).



1.5 Need for continual learning and development

While our knowledge about fire and koalas has many gaps, this guide is based on the best available information and experience. The authors acknowledge that this guide will need to change and improve as more information is obtained.

Observers of fire management operations can improve future editions of this guide by carefully recording what they see. Observations, comments and feedback can be emailed to tsc@tweed.nsw.gov.au.

2 How to Use the Guide

This guide has been kept concise and should not be considered as a standalone document. Managers planning a hazard reduction burn in koala habitat, should also refer to the following guidelines:

1. *Overall Fuel Hazard Assessment Guide* (Hines *et al.* 2010)
2. *Planned Burn Guidelines: Southeast Queensland Bioregion of Queensland* (QPWS 2013)

This guide is a tool to assist managers that are planning hazard reduction burns in koala habitat to:

1. **Determine if a hazard reduction burn is needed**
2. **Avoid impacts on koala individuals**
3. **Avoid impacts on koala habitat and other non-koala values**

An overview of the use of this guide to assess and plan a hazard reduction burn is outlined in **Figure 3** below.

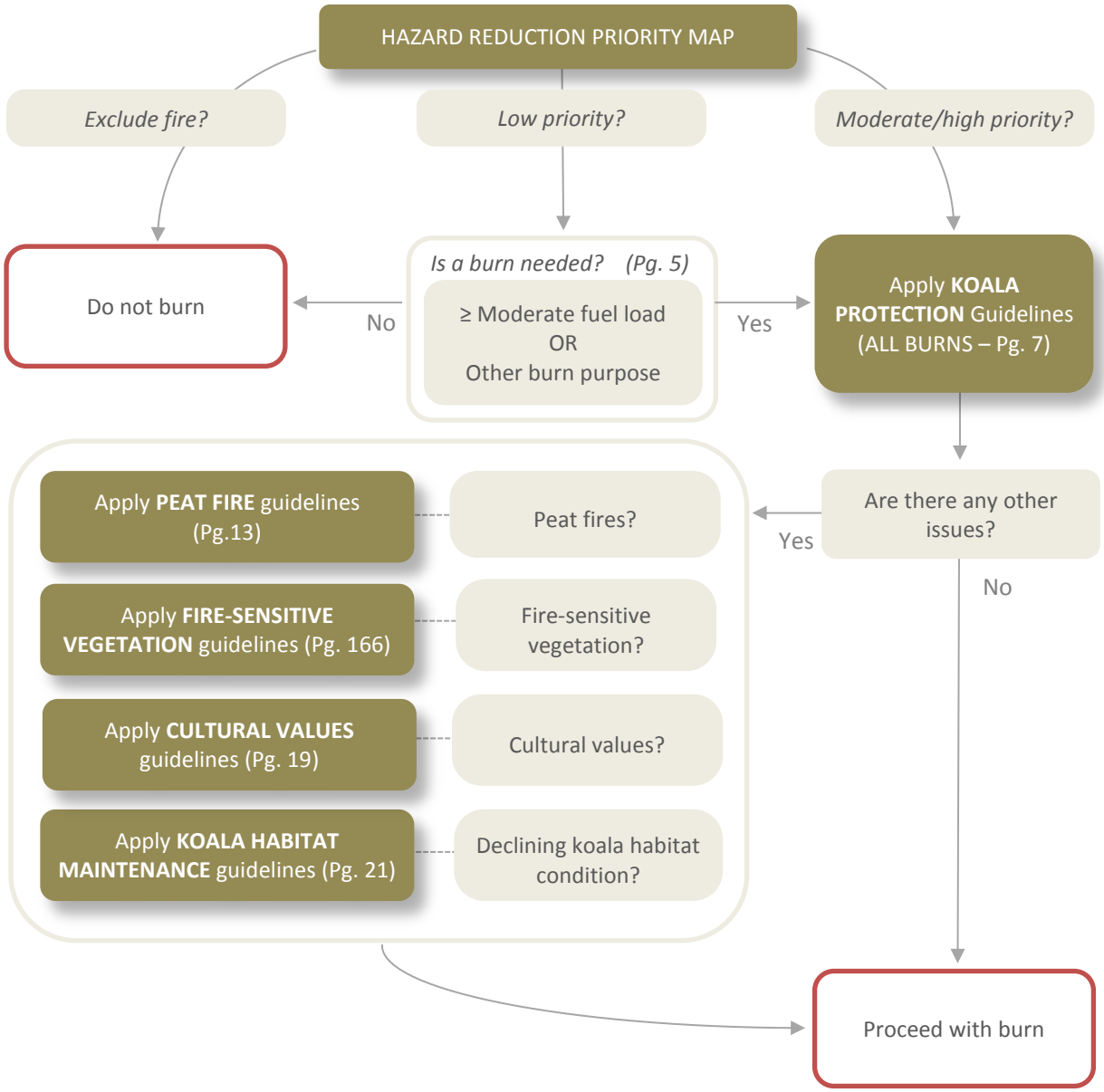


Figure 3. Approach for using the Hazard Reduction Guidelines

3 Is a Hazard Reduction Burn Needed?

3.1 Hazard Reduction Priority Map

Areas of koala habitat which require hazard reduction burning are indicated on the Tweed Shire Council Tweed Coast *Hazard Reduction Priority Map* (Map 5 of the *Tweed Coast Koala Fire Management Plan October 2016*). This map is updated annually and prioritises hazard reduction burns based on overall wildfire risk to koalas, including:

- time since last fire compared with recommended fire-interval for each vegetation type;
- the likelihood of koalas occupying the habitat, and therefore the risk of mortalities from wildfire;
- the risk of peat fires causing long-term habitat decline.

Once the hazard reduction priority of a site has been determined, the required action is then determined by reference to **Table 2**.

Table 2. Recommended responses to hazard reduction priorities.

Hazard Reduction Priority	Recommended response	Rationale
Exclude Fire	Do not burn	Vegetation is below ecological thresholds for fire.
Low Priority	Burn in accordance with guidelines if: • Overall Fuel Hazard Assessment is *Moderate* or above (section 3.2), or • burn is required for management purpose additional to hazard reduction (section 3.3) Otherwise, do not burn	Vegetation is ready for fire, however is in the earlier end of the burn window, has relatively low fuel hazard, and is not a peat fire risk.
Moderate Priority	Proceed to burn in accordance with relevant guidelines	Vegetation is: i) nearly overdue for fire (approaching the end of the burn window) and has a moderate fuel hazard, or ii) is in the earlier end of the burn window, but presents a peat fire risk.
High Priority	Proceed to burn in accordance with relevant guidelines	Vegetation is: i) overdue for fire and has a high fuel hazard, or ii) is nearly overdue for fire (moderate fuel hazard) and also presents a peat fire risk.

3.2 Overall Fuel Hazard Assessment

Field assessment of the overall fuel hazard (OFH) is required to determine if an area identified as *Low Priority* on the *Hazard Reduction Priority Map* has accumulated sufficient fuels to require a burn.

OFH assessment is to follow the *Overall Fuel Hazard Assessment Guide* (Hines *et al.* 2010). A hazard reduction burn is required where the final OFH score for all fuels combined (surface fuels, near-surface fuels, elevated fuels and bark hazard) is moderate or above. In general, *low priority* sites with low OFH should not be burnt, unless a burn can be justified for additional reasons (see **section 3.3**).

The OFH assessment is also used later in the planning process for all burns to:

- determine the likelihood of canopy scorch from a hazard reduction burn (Section 4).
- for preparing final burn plans.

Descriptive indicators of where a hazard reduction burn may be required include the following:

- The mid or lower stratum is difficult to see through or walk through.
- Abundant ladder fuels connect the ground layer to the canopy.
- An accumulation of coarse fuels with a diameter greater than six millimetres is present on the ground or perched in shrubs and trees.
- Ribbon bark, leaf litter and fine branch material is perched in shrub and sapling foliage.
- There is an accumulation of continuous surface fuels that will carry a fire.
- A high bark hazard is present.
- Dead material has accumulated around the base of grasses, sedges and ferns.
- Ground layer plants or shrubs are smothered by leaf litter in some areas.
- Shrub branches have significant dead material.

3.3 Burn for purpose additional to hazard reduction

A hazard reduction burn may still be justified on sites classed as both *low priority* (Hazard Reduction Burn Priority Map) and *low* OFH, where a burn will meet additional management purposes. Such additional purposes include:

- avoiding peat fire
- protection of cultural sites
- protection of fire-sensitive vegetation
- maintenance of koala habitat
- ecological burning for conservation values other than koalas
- Traditional Aboriginal Cultural activities

Importantly, all sites classed as *low priority* are within the appropriate burn window for maintaining ecosystem processes.

4 Koala Protection Guidelines

4.1 Overview

The primary objective for undertaking hazard reduction burns in koala habitat is to reduce high intensity wildfires, which are recognised as a leading cause of koala mortalities on the Tweed Coast. However, it is also essential that hazard reduction burns themselves avoid harming koala individuals and habitat. These *Koala Protection Guidelines* are to be applied to hazard reduction burns in koala habitat to ensure minimal risk to koalas before during and after burn implementation.

High intensity wildfires can incinerate or scorch even the tallest forest canopies in koala habitat on the Tweed Coast, leaving little or no refuge for resident koalas to survive. Importantly, these high intensity fires are highly dependent on severe weather conditions, including high temperatures and wind speeds, combined with low humidity and fuel moisture. Conversely, hazard reduction burns undertaken in mild weather conditions, and by using strategic burn tactics can typically be managed to limit flame and scorch heights below forest canopies where koalas reside.

4.2 Identifying Koala Risk Areas

4.2.1 Overview

Koala Risk Areas are those areas where i) the canopy is likely to be scorched during a hazard reduction burn, and ii) koalas are present at the time of burning. The critical factor is to avoid canopy scorch wherever koalas are present at the time of burning. This can be achieved by identifying areas of high risk, and managing these risks by fuel management, strategic burn tactics or exclusion from the burn area (**Figure 4**). Where these risks cannot be managed the burn should not proceed.

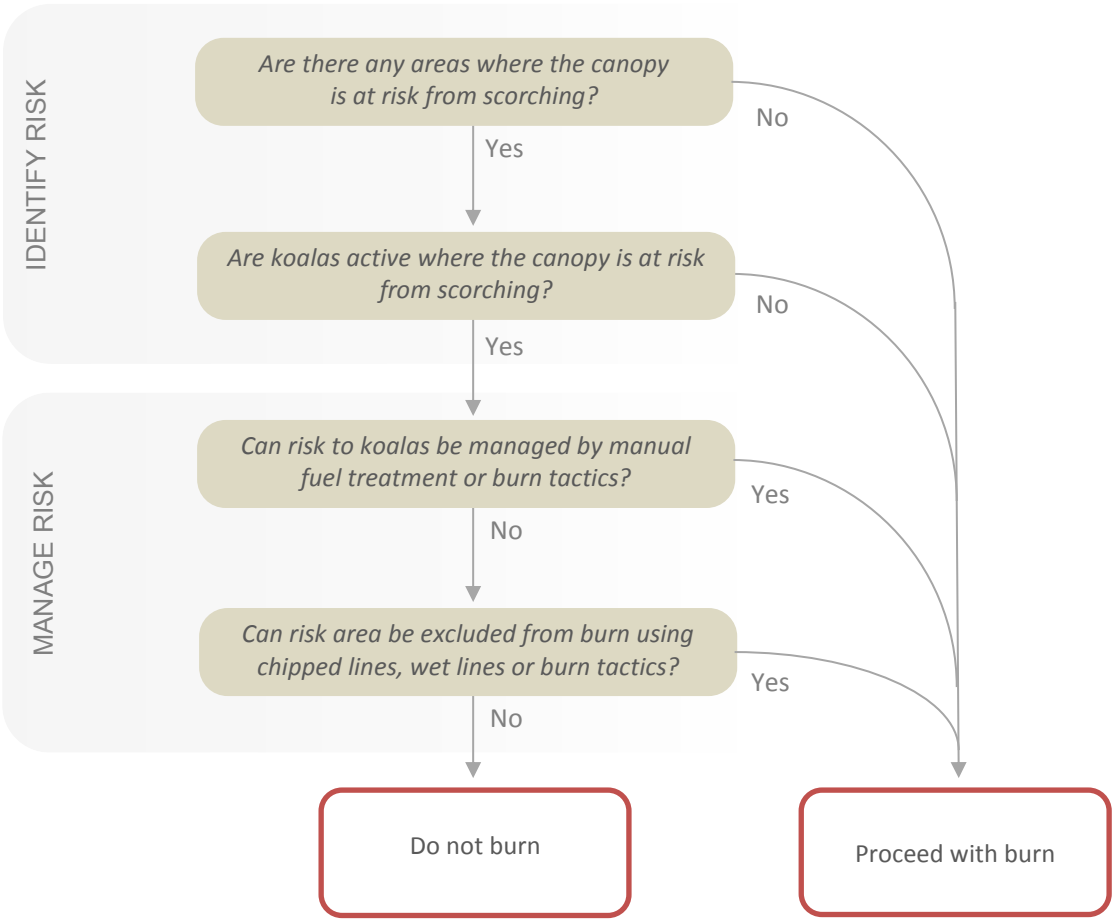


Figure 4. Decision framework for implementing hazard reduction burns in koala habitat.

Risk identification involves a two-step field assessment that includes:

1. Identifying areas of **Canopy Scorch Risk** by comparing fuel hazard with canopy height.
2. Identifying **Koala Risk Areas** by determining koala activity within Canopy Risk Areas.

The two-step process is designed firstly to focus koala survey effort on areas at risk of canopy scorch, and secondly to focus mitigation measures in areas where koalas are present within canopy scorch risk areas (Importantly, koala presence in a given area is subject to daily variation, and it is necessary therefore to ensure koala survey is undertaken on the day of the burn (**Figure 5**).

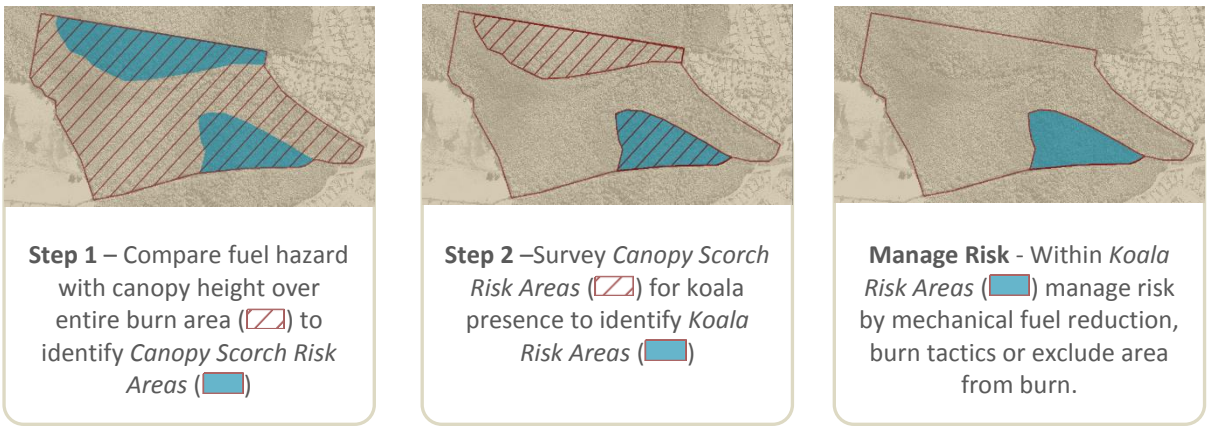


Figure 5. Overview of identifying Koala Risk Areas**.**

4.2.2 Identify Canopy Scorch Risk Areas

Canopy Scorch Risk Areas are areas with a high risk of canopy scorch due to a combination of elevated fuel hazard and low canopy height. An assessment must be undertaken across the entire proposed burn area to identify areas at risk of canopy scorch. The assessment is a two-step process:

1. Identify areas with an OFH score of moderate or above using the *Overall Fuel Hazard Assessment Guide* (Hines *et al.* 2010)
2. Determine areas of canopy scorch risk by comparison of OFH scores from above with canopy base height from **Table 3**

Table 3. Canopy Scorch Risk at FFDI <11 (low-moderate fire danger; adapted from QPWS 2013 & Gould *et al*. 2007).

Canopy Base Height (m)	Overall Fuel Hazard Rating				
	Low	Moderate	High	Very High	Extreme
25					
20					
15					
10					
5					

Canopy Scorch Risk No Canopy Scorch Risk

Figure 6. Area of koala habitat with low canopy scorch risk, due to the low overall fuel hazard and tall canopy base height (c. 15m), providing good separation from likely scorch heights and any koalas in the canopy.

Figure 7. Area of koala habitat with high canopy scorch risk, due to the presence of a high-extreme overall fuel hazard and a low canopy base height (c. 7m).

4.2.3 Identify Koala Risk Areas

Koala Risk Areas are limited to *canopy scorch risk areas* where koalas are active at the time of burning. Koala Risk Areas are identified through survey of all canopy scorch risk areas for the presence of active koala trees. Two surveys are to be undertaken, as follows:

1. At least one month prior to the burn, determine koala activity across all *canopy scorch risk areas* using the spot assessment technique (Phillips and Callaghan 2011) to guide the overall management strategy.

2. On the morning of the burn (prior to ignition), confirm koala activity across *koala risk areas* identified in step 1 using a strip transect method (Hopkins & Hetherington 2014), to ensure appropriate safety measures in place to protect individual koalas.

Alternative survey techniques used in other regions to determine koala presence, such as the use of koala detection dogs or unmanned aerial vehicles (i.e. drones) fitted with infrared cameras, should be trialed on the Tweed Coast where appropriate.

4.3 Managing Koala Risk Areas

The results of the initial koala survey (1 month prior) is to be used to guide the overall management response as per **Figure 8**. Actions for *koala risk areas* (koala presence + canopy scorch risk) must be implemented before the hazard reduction burn is allowed to proceed. Risk management actions may include one, or a combination, of the following:

- manual fuel management such as raking surface fuels and trimming elevated fuels away from the base of occupied trees in the koala risk area,
- strategic burn tactics which guide fire away from high risk areas or otherwise reduce fire intensity to acceptable levels (e.g. spot ignition; see section 4.4),
- exclusion of area from burn using chipped or wet lines,
- postponing fire until koalas vacate the area (considered only after other options exhausted).

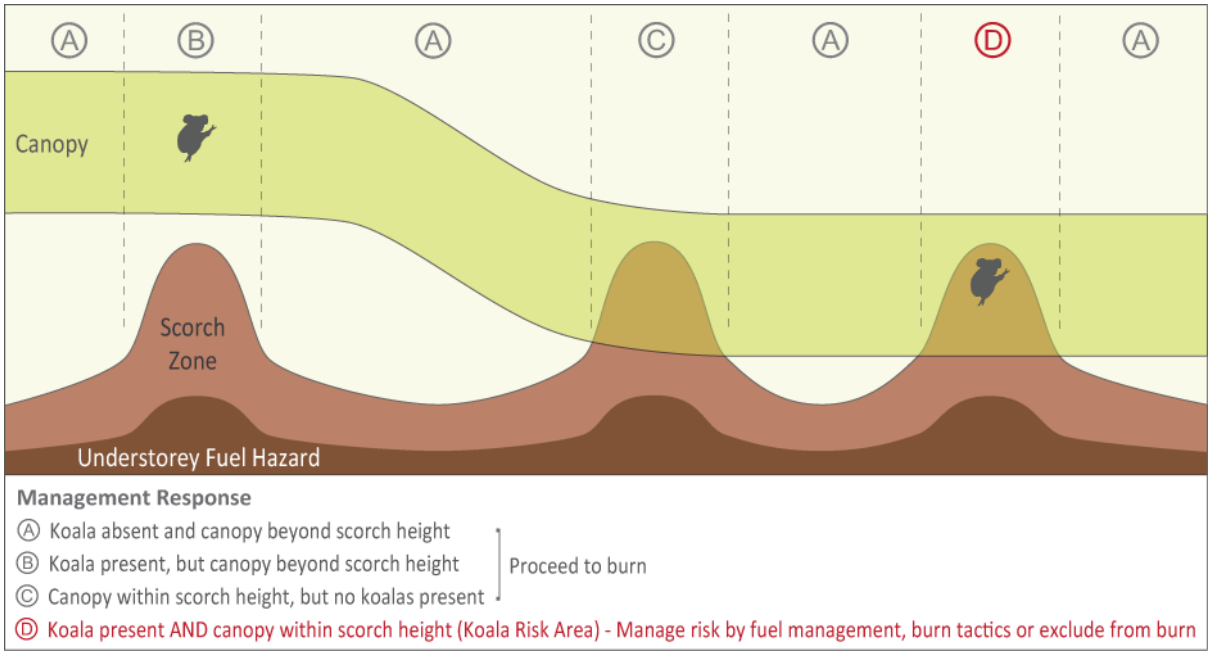


Figure 8. Management response to combined outcomes of OFH assessment and pre-burn koala survey.

4.4 Guidelines (Koala Protection)

Pre-burn treatments	Identify koala risk areas by undertaking Overall Fuel Hazard Assessments & pre-burn koala survey. Where necessary manage risk in *koala risk areas* through: • manual fuel reduction, including raking surface fuels and trimming of elevated fuels away from the bases of active trees, • wetting down around the bases of active trees prior to the burn, and/or • exclusion of area from burn using containment lines or sprinkler lines When establishing or maintaining Asset Protection Zones (APZs) • preferred koala food trees should be preferentially retained. • trees to be lopped or removed are to be checked for koalas prior to works. If present, the works must be postponed until the koala has moved on of its own accord. Treat environmental weeds which may be advantaged by the burn.
Fire Interval	Burn within the parameters recommended for the fire vegetation group (**Table 1**), but should aim for lower end of that range where strategic hazard reduction is required.
Season	March–September Burns should avoid koala breeding season (September to January)
FFDI	≤ 11 (Low - Moderate)
Soil moisture	Good soil moisture is desirable to reduce scorch height and limit leaf drop post fire.
Fire Intensity	Avoid high intensity fires that consume or scorch tree canopies. Within *koala risk areas* - Low and occasionally moderate intensity. Within *koala risk areas*, if flame height reaches 20% of height to base of canopy fire must be suppressed. Outside koala risk areas - Low to Moderate with occasional high intensity.
Burn Tactics	The following burn tactics should be considered in *koala risk areas* as appropriate. • **Test burn** the site to ensure canopy will not be scorched. • **Avoid a running-fire** toward the koala risk area. • Where the koala risk area occurs in low lying areas, **utilise the surrounding topography** to create a low-intensity backing fire that travels down the slope towards the area. • Use **appropriate lighting patterns along the margin** of the koala risk area, to promote a low-intensity backing fire that **burns away** from area; such as: ○ **commence lighting on the leeward (smoky) edge** using either spot or strip lighting or a combination of both. ○ **commencing lighting at active trees** to reduce intensity and ensure that fires burn away from active trees. ○ **spot ignition** can be used to reduce intensity of a fire in or adjacent to koala risk areas. Widely-spaced spot ignition will promote a slower-moving and more manageable fire, while spots closer together will result in a line of a greater intensity (as spots merge and create hot junction zones). ○ use **strip ignition** to draw fire away from the edge of koala risk areas. When more than one line of ignition is used it can create micro wind conditions that can draw fire away from non-target areas. *It is important to have safe refuges*

	when undertaking this type of burning. • **Afternoon ignition** can lower burn intensity, and result in fires that trickle along the edge and generally self-extinguish in the evening, particularly during winter. • Consider the use of **sprinkler lines** or **mechanical containment lines** where other burn tactics are considered insufficient. For all the remainder of the burn area (non-koala risk areas) a **running fire of a moderate intensity** may be desirable in unoccupied habitat to increase fuel reduction and stimulate regeneration.
Landscape mosaic	Proactive broad-scale management of surrounding fire-prone vegetation using mosaic burning will reduce the likelihood of wildfire encroaching koala risk areas. Habitat areas should be burned in sections to generate and/or maintain a mosaic pattern of vegetation with areas of varying age since fire. As mosaic burning practices become well developed, the extent and abundance of canopy scorch risk areas across the landscape should diminish because as areas of prolonged fuel accumulation are progressively treated.
Post Burn	The burn area should be patrolled during and after the burn to ensure that no animals have been injured. Patrols should be carried out by suitably qualified and equipped personnel. It is also important to ensure that any injured animals are promptly treated, rehabilitated and released back into their original home range. Avoid felling koala food trees during post-burn 'mop-up'. Undertake treatment of environmental weeds.

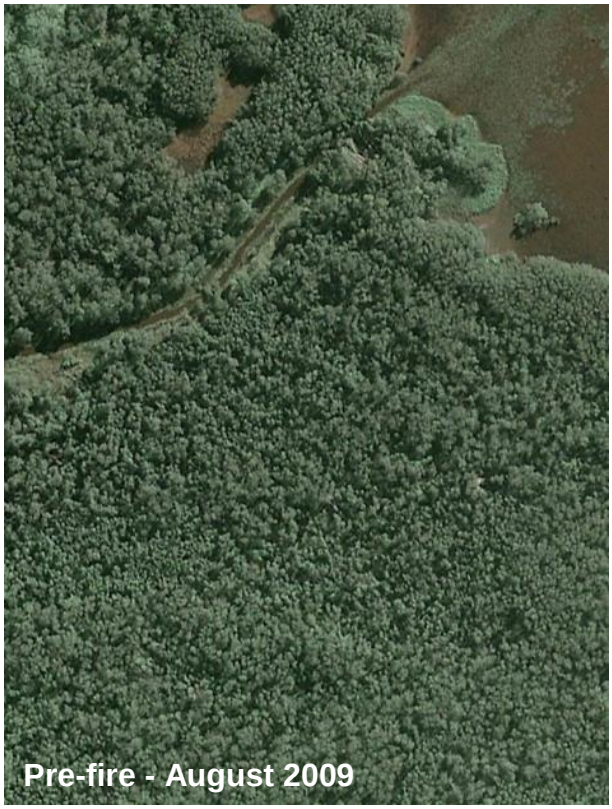
5 Peat Fire Avoidance Guidelines

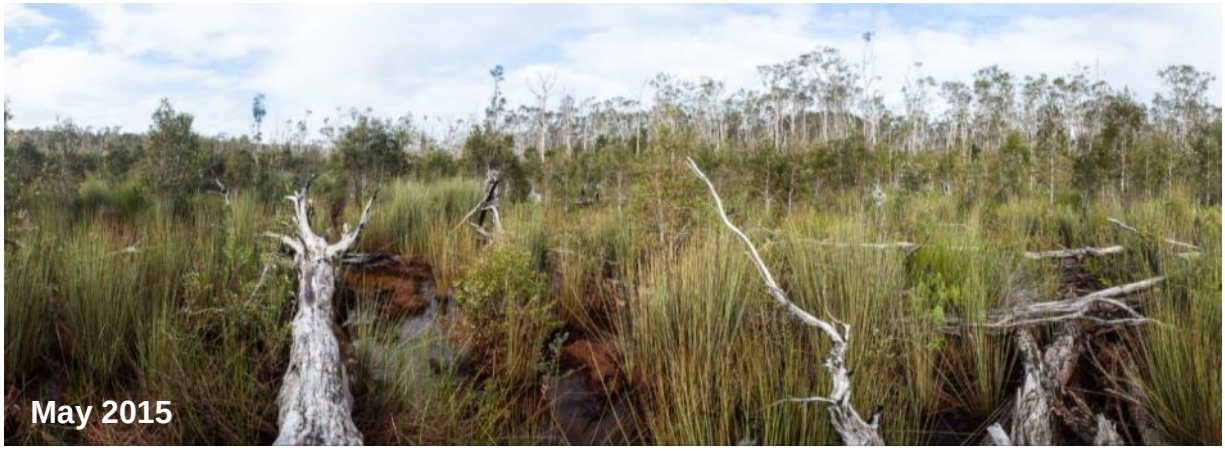
5.1 Overview

Many low lying vegetation communities on the Tweed Coast (including wet heath and swamp forests) occur on peat soils. These communities occur in areas that are often seasonally inundated, allowing the accumulation of partially decayed, densely packed vegetation which develop into peat soils over time. Due to its high carbon content and porous nature, peat is easily ignited when exposed by lowered water tables during dry periods. Peat fires can burn for weeks or months, and potentially cause re-ignition of wildfires and long-term damage to ecosystems.

On the Tweed Coast, a peat fire in 2009 was responsible for the collapse of 23 ha of Paperbark forest after widespread burning of tree roots and the surrounding peat soils.

Table 4. Collapsed Paperbark forest caused by peat fire in 2009.





5.2 Indicators of peat fire risk

Peat soils typically occur in areas of vegetation that are subject to continuous or prolonged-seasonal inundation. Areas of potential peat soils on the Tweed Coast are shown in **Table 5**.

The following wetland vegetation types are indicative of potential peat soils:

- forested wetlands (including Paperbark, Swamp Mahogany, Swamp Box and Swamp Oak forests)
- wet heathland
- sedgeland
- fernland

Table 5. Potential peat soils on the Tweed Coast.

5.3 Guidelines (Peat Fire Avoidance)

When applying fire in or adjacent to forested wetlands or wet heath, the condition of the peat should be checked to ensure that where fire encroaches, a peat fire will not be unintentionally ignited. A burn should ideally occur when peat soils are covered by standing water that covers the bases of sedges and grasses. In the absence of standing water, the peat should at least be water logged (it is possible to squeeze water out of it).

Fire Interval	Burn within the parameters recommended for the fire vegetation group (**Table 1**)
Season	Avoid burning during prolonged dry seasons.
FFDI	≤ 11 (Low - Moderate)
Soil moisture	**Standing water, or water-logged peat, are critical for avoiding peat fires.**
Fire Intensity	Melaleuca grassy/ferny open woodland – low to moderate Melaleuca forest/woodland with sedgeland understorey - moderate with small areas of high likely Wet Heathland – moderate (although small areas of high-extreme may be expected)
Burn Tactics	Where the conditions of standing water or water logged peat cannot be achieved, use tactics that will limit encroachment of fire (refer fire-sensitive vegetation). However be aware that the site is flammable and may not self-protect.
Landscape mosaic	Proactive broad-scale management of surrounding fire-prone vegetation using mosaic burning is one of the best ways to reduce the likelihood of wildfires resulting in peat fires.

6 Fire-sensitive Vegetation Guidelines

6.1 Overview

Fire-sensitive vegetation includes rainforest and mangroves. Fire sensitive vegetation located next to koala habitat on the Tweed Coast is shown in **Figure 9**.

Wildfires that occur in severe weather conditions, including drought, may encroach into fire-sensitive vegetation types. The main strategy to limit wildfire encroachment into these communities is to maintain low fuel levels in surrounding fire-dependent communities with mosaic burning to minimise the spread and severity of wildfire during severe weather events.

Under appropriate planned burn conditions, the edges of these communities are often self-protecting, with lower levels of understorey and surface fuels usually causing fires to self-extinguish. Under these mild conditions additional protective tactics are usually not necessary (QPWS 2013).

However, hazard reduction burns may potentially scorch rainforest margins where recent storms have left large amounts of debris in the understorey, or where dense stands of fire-promoting invasive grasses or lantana occurs. Dense stands of fire-promoting weed infestations may increase the severity of fire and can draw fire into rainforest edges, albeit over short distances. Reduction of lantana or invasive grasses along the edges of fire-sensitive communities should be considered prior to burning to reduce these risks.

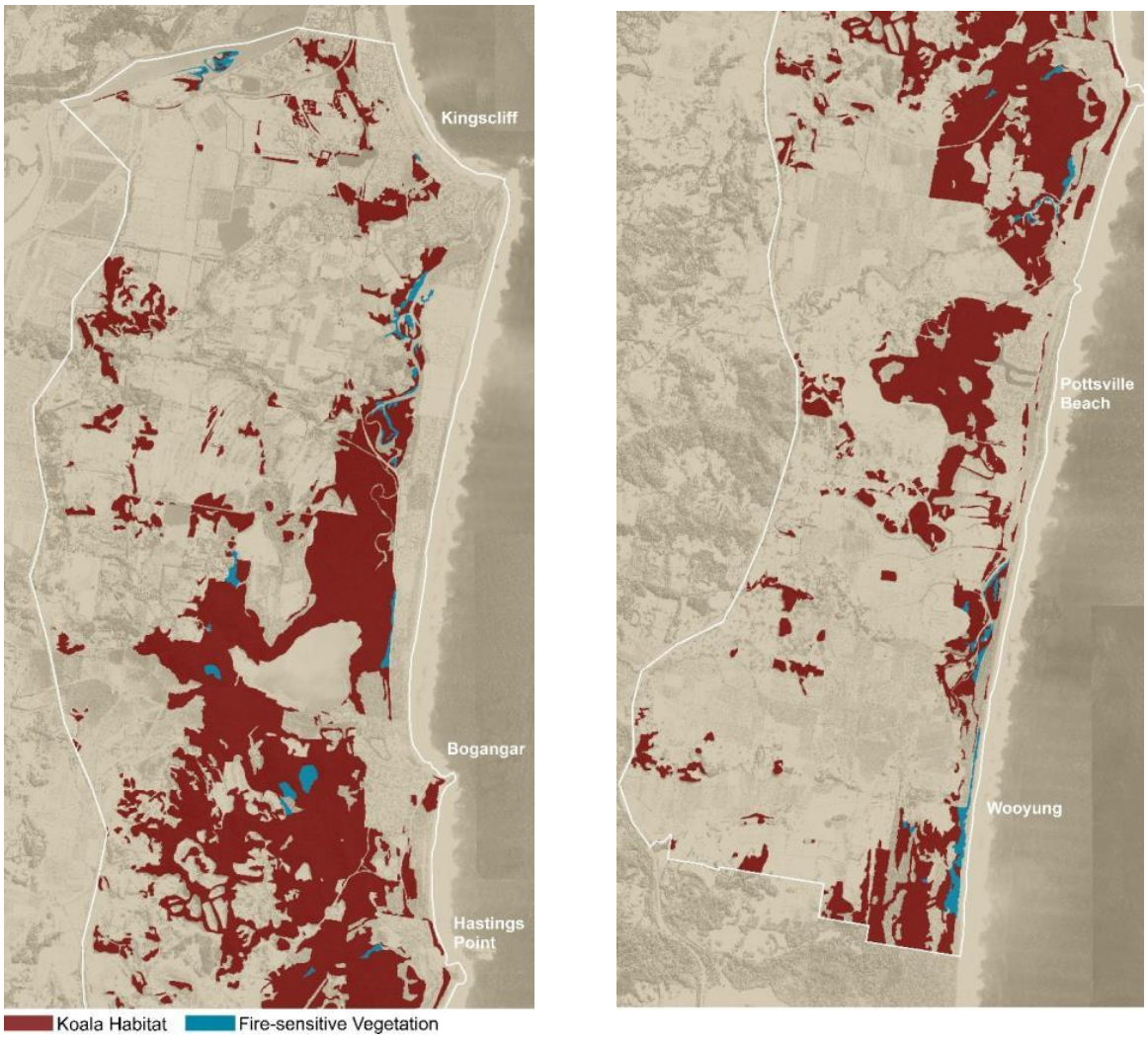


Figure 9. Fire-sensitive vegetation adjacent to koala habitat.

If suitable conditions cannot be achieved, specific tactics may be required to protect the fire-sensitive communities, such as burning away from rainforest edges.

Finally, rainforest saplings often invade open forest with prolonged fire exclusion. These populations of rainforest saplings are a transient component of fire-dependent forests – temporarily occupying habitat in the interval between fires. The presence of rainforest saplings in the understorey of open forest does not constitute fire-sensitive vegetation, and fire management should aim to maintain the open-forest community, not the transient rainforest understory species. Importantly, with ongoing fire exclusion, rainforest trees may ultimately capture the site and irreversibly displace the koala habitat.

6.2 Indicators of fire-encroachment risk

- Linear, or very small (<0.5 ha.), areas of fire-sensitive vegetation with a relatively high edge to area ratio.
- Invasive grasses or lantana invading rainforest or riparian edges.
- Severe storm damage with continuous dry fuel lying upon the ground in rainforest.

6.3 Guidelines (Fire-sensitive vegetation)

Proactive broad scale management of surrounding fire-dependent areas with mosaic burning should be the main strategy to reduce impacts of wildfire on fire-sensitive vegetation. While hazard reduction burns under mild weather conditions usually self-extinguish at the edge of fire-sensitive communities, additional burn tactics may be necessary to direct fire away in some circumstances.

Pre-burn treatments	Manually reduce dense lantana and tall introduced grasses where they occur along rainforest edges.
Fire Interval	Consult **Table 1** for the adjacent fire vegetation group being burnt.
Season	Avoid burning where recent storm activity has left large volumes of dry fuel lying on the ground in fire-sensitive vegetation.
FFDI	≤ 11 (Low - Moderate)
Soil moisture	Good soil moisture will minimise fire encroachment by reducing the flammability of the fire-sensitive vegetation.
Fire Intensity	Burn within the parameters recommended for the issue being addressed (e.g. koala habitat maintenance). A low-intensity fire in immediately adjacent fire-dependent communities will be less likely to encroach fire-sensitive vegetation.

Burn Tactics	If conditions are unsuitable (e.g. the fire-sensitive community is too dry to ensure fire will self-extinguish on its boundary or it is upslope of a potential run of fire), the following burn tactics should be considered as appropriate.
	• **Test burn** the site to ensure non-target communities will not be affected.
	• **Avoid a running-fire** toward the fire-sensitive community.
	• Where the fire-sensitive community occurs in low lying areas (e.g. rainforest), **utilise the surrounding topography** to create a low-intensity backing fire that travels down the slope towards the community.
	• Use **appropriate lighting patterns along the margin** of the fire-sensitive community, to promote a low-intensity backing fire that **burns away** from community; such as:
	  ○ **commence lighting on the leeward (smoky) edge** using either spot or strip lighting or a combination of both.
	  ○ use **strip ignition** to draw fire away from the fire-sensitive community's edge. When more than one line of ignition is used it can create micro wind conditions that can draw fire away from non-target areas. *It is important to*

	have safe refuges when undertaking this type of burning. • **Afternoon ignition** can lower burn intensity, and result in fires that trickle along the edge and generally self-extinguish in the evening, particularly during winter. • Consider the use of **sprinkler lines** or **mechanical containment lines** where other burn tactics are considered insufficient.
Landscape mosaic	Proactive broad-scale management of surrounding fire-prone vegetation using mosaic burning will reduce the likelihood of wildfire encroaching fire-sensitive vegetation.

7 Cultural Heritage Guidelines

7.1 Overview

Hazard reduction burns in koala habitat must ensure adequate protection of significant cultural heritage sites, items and places of Indigenous or European heritage. Cultural heritage sites which occur within native vegetation areas may be vulnerable to hazard reduction burns. However, impacts may be minimised by use of appropriate burn tactics or mechanical fuel reduction as required. Importantly, wildfires can also damage cultural heritage values, and hazard reduction burns for koala conservation may also assist in reducing the risks of wildfire damage to cultural heritage artefacts and sites.

In planning a hazard reduction burn in koala habitat, consultation and involvement should be sought from local Traditional Owners and the Office of Environment & Heritage (OEH) to help to identify any places, items and issues, and ensure their protection.

Table 6. Information sources to determine the location and appropriate management of cultural heritage items.

Cultural Heritage Group	Information Sources
Indigenous	• Tweed Byron Local Aboriginal Land Council • Aboriginal Heritage Information Management System (AHIMS)
Historic (European)	• Office of Environment & Heritage • Historic Heritage Information Management System (HHIMS)

Do not disturb any cultural heritage site or artefact. Leave all materials in place and treat the location with respect. If you are not sure whether the location or artefacts have been reported, consult the Tweed Byron Local Aboriginal Land Council, or the cultural heritage coordination units of OEH.

The protection of smaller items from flame and radiant heat may require the reduction of adjacent fuel levels though mechanical or herbicide treatments. While protection of larger sites may require the use of specific burn tactics to avoid hazard reduction burns encroaching these locations.

Finally, many places and landscapes of importance to Traditional Owners are themselves artefacts of cultural burning (e.g. wallaby increase sites), and need regular fire if they are to be maintained. For these areas, well-planned hazard reduction burning may serve the dual purposes of both koala conservation and maintenance of culturally important sites (**Figure 10**).

7.2 Key indicators of Indigenous cultural heritage sites:

- Raised mounds (especially with visible shell debris) or the presence of shell debris scattered on the ground can indicate the presence of shell middens.
- Engravings on trees or rock faces.
- Arrangements of stones or raised earth patterns on the ground, or artefacts scattered on the ground.
- The presence of trees that have been scarred or carved (e.g. large oval scars of missing bark).
- Presence of culturally significant landscapes or species (e.g. grassland openings within forest).

Figure 10. This area of grassy heathland adjoining koala habitat near Cabarita is likely to have been frequently burnt by Aboriginal people to promote edible tubers from orchids and lilies. A hazard reduction burn for koalas would likely compliment management of this cultural heritage place.

7.3 Key indicators of European cultural heritage sites:

- Ruined buildings, corrugated iron shacks, timber house stumps, fence posts, or stock yards, tomb stones, wells, graves, bottle dumps, old machinery and iron debris may all indicate the presence of a significant site.
- Quarries and old mines sites.
- Forestry artefacts including springboard trees (stumps or trees with axe notches cut into it to support boards) and marked trees.

7.4 Guidelines (Cultural Heritage)

Cultural heritage items can vary widely in their need for protection from hazard reduction burns. While some items may require complete protection from flames and radiant heat (e.g. timber structures), other sites require periodic fire for their maintenance (e.g. ceremonial grounds) and provide an additional justification for hazard reduction burning. Developing prescriptions for a hazard reduction burn that will impact cultural heritage items, should be done in consultation with local Traditional Owners and the Office of Environment & Heritage.

Pre-burn treatments	For smaller sites requiring protection from flame and radiant heat (e.g. timber structures) consider applying one or both of the following pre-burn treatments: • **manual fuel management** such as raking, clearing (e.g. creating a rake-hoe line), trimming or leaf blowing the surface fuels away from the site to limit the potential impacts, or • **wetting down the site** using a sprinkler line.
Fire Interval	Burn within the parameters recommended for the fire vegetation group (**Table 1**)
FFDI	≤11 (Low – Moderate)
Soil moisture	Burn with good soil moisture to help prevent impacts on cultural sites or artefacts.
Fire Intensity	Burn within the parameters recommended for the issue being addressed (e.g. koala habitat maintenance). Low intensity fires will be less likely to impact on cultural heritage sites.
Burn Tactics	For protection of larger culturally significant sites use **appropriate lighting patterns** along site boundary, to promote a low-intensity backing fire that **burns away** from the site such as: ○ **commence lighting on the leeward (smoky) edge** using either spot or strip lighting or a combination of both. ○ use **spot ignition** to reduce fire intensity. Widely-spaced spot ignition is preferred around cultural heritage sites as it will promote a slower-moving and more manageable fire. ○ use **strip ignition** to draw fire away from the site edge. When more than one line of ignition is used it can create micro wind conditions that can draw fire away from cultural sites. *It is important to have safe refuges when undertaking this type of burning.* ○ use a chipped or wet line around the site so the resulting backing fire can be extinguished or self-extinguishes at the chipped or wet line. For sites requiring regular fire for maintenance (e.g. wallaby increase sites), apply fire to the site as per recommendations for the fire vegetation group (**Table 1**).
Landscape mosaic	Proactive broad-scale mosaic burning of surrounding fire-dependent will reduce fuel hazard and the likelihood of wildfire impacts to cultural heritage artefacts and sites.

8 Koala Habitat Maintenance Guidelines

8.1 Overview

Fire plays an essential role in maintaining koala habitat, including i) ensuring ongoing recruitment of koala food trees, ii) preventing rainforest transition, and iii) creating a diversity of age classes and habitat structure. A brief overview of these is given below and discussed in more detail in the *Tweed Coast Koala Fire Management Plan.*

8.1.1 Maintaining koala feed tree recruitment and condition

Fire is essential for broad scale recruitment of koala feed trees, and understorey removal and sun exposure of the bared soil in large gaps following fire is generally a prerequisite for the successful establishment of canopy replacing cohorts. Importantly, only a very small number of canopy and mid-stratum recruits are needed to provide variety in age and for eventual replacement of mature canopy species.

Some areas of koala habitat on the Tweed Coast are heavily disturbed or immature systems due to previous land use. In these systems, the canopy may be under- or overstocked with regeneration or be limited to a uniformly aged population. A more varied and mature system should re-establish over time through the use of fire in line with these guidelines, as long as the habitat has a healthy understorey structure.

Fire is also essential for maintaining the condition of established feed trees and long-term fire exclusion can cause profound changes in dry and moist eucalypt forest soils which negatively impact on tree health, including altered pH, nitrogen availability and alteration of mycorrhizal and other microbial communities. The development of a rainforest midstorey following fire-exclusion can further exacerbate these changes, and has been attributed to crown decline and premature mortality of dominant overstorey Eucalyptus trees.

8.1.2 Preventing rainforest transition

Rainforest trees often recruit into the understorey of open forests in the interval between fires, but are periodically removed or suppressed by regular fire. However, with continued fire exclusion, the developing rainforest midstorey can shade out flammable ground layer vegetation, thereby inhibiting further fires and enabling continued rainforest development. This transition not only displaces a large proportion of the original understorey diversity, but can also inhibit koala feed tree recruitment and promote premature decline of mature feed trees. On the Tweed Coast, *introduced* rainforest species, such as Camphor Laurel and Umbrella Trees, also cause and accelerate rainforest transition.

Importantly, wet open forest communities on the Tweed Coast form a shifting ecotone between closed rainforest communities and dry open forest, primarily driven by fire interval. Open forests with a well-developed rainforest understorey will only burn during wildfire in extreme conditions, while forests with a grassy or shrubby understorey should be a high priority for maintenance with planned burning.

It is important to recognise early signs of broad-scale rainforest development in the mid-stratum in open forest, as advanced transition can prevent the reintroduction of planned burns, and transition

Figure 11. Advanced rainforest transition in Grey Gum forest in Round Mountain area. Hazard reduction burning would no longer be possible in this area.

may become irreversible. These areas should be considered a priority for burning before thickening progresses to a point where planned fire is no longer viable.

Rainforest species such as blueberry ash and many laurels can naturally coexist in the shrub layer of open forest with sclerophyll shrubs, grasses and sedges. However regular fire is required to maintain this balance - facilitating periodic regeneration of the sclerophyll species, while preventing rainforest species from dominating the community. Many rainforest species will resprout from bases and while fire will not kill them, it will keep them low in profile, so that other species can co-exist.

8.1.3 Maintaining diversity of age class & habitat structure

Achieving both fuel reduction and biodiversity objectives is best achieved if habitat areas are burnt in a variable mosaic (or patchwork) pattern. Each habitat area needs to be 'broken up' into a complex system of interlocking patches, each with a different fire history to promote maximum habitat diversity. These patches should provide variation in fire-interval (within biodiversity thresholds) within each vegetation community. To establish such a mosaic requires the use of natural as well as artificial fire control lines, taking advantage of suitable weather conditions (such as high soil moisture and dew), as well as considerable time and effort. Once established however, a mosaic is easier to manage because previously burnt patches act as barriers to assist with containment of each patch burn.

8.2 Indicators of healthy open forest

Key indicators of a healthy open forest (adapted from QPWS 2013)

- Well-developed grass, sedge, or heathy shrub-dominated understorey (or various mixtures);
- At least a few canopy species of variable sizes (to eventually replace the canopy).
- Lower and mid stratum trees are scattered (e.g. eucalypts, wattles, she oaks and ti-trees), but are not having any noticeable shading effects on ground stratum plants.
- In shrubby open forest, shrub layer is dominated by sclerophyllous (hard leaved) species (e.g. grass trees, banksia, and pea-flowers) with healthy foliage.
- In grassy or mixed open forest, grass clumps and/or sedges are well formed.

Swamp Sclerophyll Forest with a healthy ground layer of sedges and ferns. Mixed age classes of dominant canopy species. This area is now ready for a burn to ensure its ongoing health.

Swamp Sclerophyll Forest with a healthy ground layer of heathy shrubs, sedges and grasses. Mixed age classes of dominant canopy species. The area has not yet passed the minimum burn interval (7 years since last fire), so provides an example of understorey condition before the preferred burn window.

Open Sclerophyll Forest with a healthy ground layer of grasses, orchids, scramblers and other grass-like plants. The area has just passed the minimum burn interval (7 years since last fire), so provides an example of understorey condition at the earliest phase of the 18-year burn window.

Open Sclerophyll Forest with a healthy ground layer of heathy shrubs, ferns and grass-like plants. This area is now ready for a burn to ensure its ongoing health.

Open Sclerophyll Forest with a healthy ground layer of heathy shrubs, ferns and grass-like plants. This area is now ready for a burn to ensure its ongoing health.

8.3 Indicators of declining health in open forest

KEY INDICATORS OF DECLINING HEALTH IN OPEN FOREST

(observed across a broad area; adapted from QPWS 2013)

- Grasses overall appear sparse or clumps are poorly formed and collapsing. An accumulation of thatch (dead material) is present.
- There is limited recruitment of new heathy shrubs or young cohorts of canopy trees (lack of juvenile shrubs and trees).
- Many heathy shrubs have dead or dying branches, sparse crowns or beginning to die.
- Grass trees have dense brown skirts, or are dying in the shade.
- The diversity of mid/ground stratum species (grasses, herbs, sedges and shrubs) has declined from previous records or observations.
- In shrubby open forest, a loss or reduction of resprouters or obligate-seeders (shrub species that regenerate only from seed) has been observed and/or recorded over time.
- A broad-scale overabundance of rainforest species in the mid-stratum.

Some of the following may indicate that fire is required to maintain a melaleuca community:

- There is a dense accumulation of dead material (grasses/sedges/ferns) and grasses are beginning to collapse (no longer erect).
- Increasing density of monkey vine (*Parsonsia spp*.), in the mid stratum

Swamp Sclerophyll Forest with declining ground layer of sedges under developing rainforest midstorey. This area would be a high priority for a hazard reduction burn before the flammable ground layer is completely lost

Swamp Sclerophyll Forest where rainforest midstorey has shaded out the typical ground layer of sedges and ferns. A hazard reduction burn would no longer be possible or effective in this area. This area is likely to transition fully to rainforest without intervention.

Open Sclerophyll Forest with a declining ground layer of heathy shrubs, ferns and grass-like plants. Ground layer plants are smothered by leaf litter in some areas. Rainforest saplings are starting to suppress ground layer plants (e.g. Scentless Rosewood in lower right corner). This area would be a high priority for a hazard reduction burn before the flammable ground layer is completely lost.

Open Sclerophyll Forest where rainforest midstorey has completely shaded out the ground layer of shrubs, ferns and grass-like plants. While a low intensity burn may still be possible, it is unlikely to remove encroaching rainforest saplings.

8.4 Guidelines (Koala Habitat Maintenance)

Fire Interval	Burn within the parameters recommended for the fire vegetation group (**Table 1**).
Season	March to September to avoid koala breeding season (aim to vary the season of burn within this range) Try to carry out planned burns before significant seeding of rainforest pioneers occur.
FFDI	≤ 11
Soil moisture	Good soil moisture is critical to improve post-fire regeneration of both resprouters and germinating seedlings.
Fire Intensity	Where a burn area contains no koala risk areas, moderate-high intensity burns will achieve better habitat maintenance results, including increased heathy shrub germination, and suppression of rainforest saplings.
Burn Tactics	To simply maintain appropriate fire intervals, refer to the *Koala Protection Guidelines*. To maximise burn patchiness consider the following burn tactics: • Afternoon ignition and allowing the fire to burn into the night. • Progressive burning in the early part of the year after rain, with good humidity and moisture, to establish a patchy mosaic. Over the coming months repeat this exercise to establish a complex mosaic with highly variable season and flame characteristics. • Timing and moisture can be used tactically to burn adjoining vegetation with differing fire interval needs (e.g. lighting grassy open forest ridgelines early in the season with good soil moisture when adjoining shrubby open forest is too moist to burn). To remove or suppress rainforest saplings consider the following burn tactics: • **Line or strip ignition** is used to create a fire of higher intensity to remove rainforest saplings through scorching and to help fire carry through moist or inconsistent fuels under rainforest thickets. • A **running fire** travelling downwind or uphill may assist with inconsistent fuels and scorching of rainforest saplings. • A **follow-up burn** as fuel allows may be required to thin surviving saplings and any new seedlings. Wherever practicable / acceptable, burn areas should take advantage of natural fire control lines, strategically located tracks, and previously burnt vegetation to contain planned burns. Avoid lighting off road edges which can exacerbate weed invasion.
Landscape mosaic	Apply mosaic planned burns across the landscape at a range of frequencies to create varying stages of post-fire response (i.e. recently burnt through to the maximum time frame).

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