Department of National Parks,
Recreation, Sport and Racing

Planned Burn Guidelines

Wet Tropics Bioregion of Queensland

Queensland Government

Prepared by: Queensland Parks and Wildlife Service (QPWS) Enhanced Fire Management Team, Queensland Department of National Parks, Recreation, Sport and Racing (NPRSR).

First published May 2013
Published by the Department of National Parks, Recreation, Sport and Racing

National Library of Australia Cataloguing-in-Publication

Planned Burn Guidelines – Wet Tropics Bioregion of Queensland
First edition
Bibliography
ISBN 978-1-7423-0922
1. Planned Burn – Guideline 2. Fire Management 3. Bioregion – Queensland

Acknowledgements

The following people made substantial contributions to the intellectual content of these planned burn guidelines based on experience and/or expert knowledge with regard to fire management in the Wet Tropics bioregion. QPWS staff include: Mark Parsons, Neil Parker, Les Jackson, Rob Miller, Brendan Malone, Andrew Hedges, Andy Baker, Andrew Millerd, Geoff Smith, Mark Connell, Mike Ahmet, Ian Holloway, Peter Stanton (Peter Stanton Environmental Consultant Pty Ltd), Dr Paul Williams (Vegetation Management Science Pty Ltd) and Mick Blackman (Friendly Fire Ecological Consultants Pty Ltd).

This guideline has been developed and produced by the QPWS Enhanced Fire Management Team: Wayne Kington, David Shevill, Jenise Blaik, Kerensa McCallie, Troy Spinks and Justine Douglas; supported by David Clark, Caroline Grayson, Ellen Thyer and Tim Killen. Following a successful pilot project (QPWS South East Region Planned Burn Guidelines) initiated and developed by QPWS staff: Wayne Kington, David Kington and Mark Burnham.

Front cover photograph: Bishop's Peak, Mark Parsons, QPWS (2010).

Bp2007

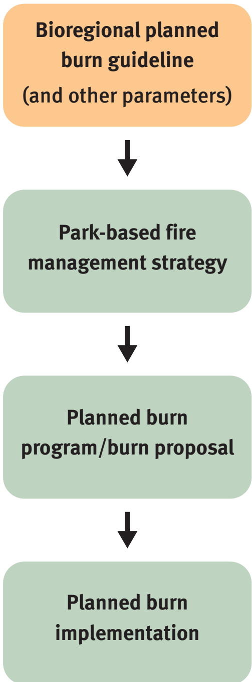
Foreword

With over 590 ecosystems, the Wet Tropics bioregion (refer to Figure 1) is complex and diverse for its relatively small size. Usually recognised for its world heritage rainforest values, the bioregion contains equally significant fire-tolerant and adapted species, communities and landscapes. While the science and practice of managing these ecosystems is complex and poses significant challenges for ecologists and practitioners an underlying concern is that the absence of fire from these systems causes a transition towards a closed forest of indeterminate value with extensive loss of biodiversity values.

These planned burn guidelines aim to provide direction towards understanding the role, ecology and practice of Wet Tropics fire management. Irrespective of the need to balance complex issues, competing viewpoints and priorities, what I hope emerges is an understanding of the importance of fire management to maintain the resilience and complexity of the wet tropics—and to inspire you to use and view fire as a conservation tool to halt further loss or weakening of the integrity of our lowland, highland and wetland fire-adapted communities.

Mark Parsons
Conservation Officer
Northern Region
Queensland Parks and Wildlife Service.

Table of contents



How the planned burn guideline fits into the QPWS Fire Management System.

Purpose of this guideline

This guideline was developed as part of the Department of National Parks, Recreation, Sport and Racing’s (NPRSR) Queensland Parks and Wildlife Service (QPWS) Fire Management System to support the formation of fire strategies, burn proposals and on-ground planned burn implementation (supported by the Planned Burn Guidelines: How to Assess if Your Burn is Ready to Go). They assist rangers and other land managers to:

- protect life and property
- maintain healthy ecosystems
- promote awareness of fire management issues in the field
- identify clear fire management objectives to address those issues; and how to assess objectives to assist in adaptive management
- identify suitable fire behaviour, burn tactics and weather conditions to achieve objectives
- provide information and tools to assist in implementing planned burns.

Please note that this planned burn guideline uses ‘fire vegetation groups’ provided in ParkInfo that assist their integration into maps and fire strategies. A fire vegetation group is a group of related ecosystems that share common fire management requirements.

Scope

- This guideline applies to the Wet Tropics bioregion (refer to Figure 1) and covers the following fire vegetation groups: lowland open forests; open forests of the foothills and ranges; tall open forests; grasslands, sedgelands and fern-lands; montane communities; fire-sheltered shrublands; melaleuca communities; riparian/fringing/dune communities; rainforests; and mangroves and saltmarshes (refer to Appendix 1 for regional ecosystems contained in each fire vegetation group).
- It covers the most common fire management issues arising in the Wet Tropics. In some cases, there will be a need to include issues in fire strategies or burn proposals beyond the scope of this guideline (e.g. highly specific species management issues).
- This guideline recognises and respects Traditional Owner traditional ecological knowledge and the importance of collaborative fire management. Consultation and involvement should be sought from local Traditional Owners in the preparation and implementation of planned burns and specific guidelines incorporated into fire strategies where relevant.
- Development of the guideline has been by literature review and a knowledge-capturing exercise, using both scientific and practical sources. It will be reviewed as new information becomes available.

Sylvia Millington, QPWS, Mt Coom (2010).

Figure 1: Map of the Wet Tropics bioregion of Queensland.

Fire and climate in the Wet Tropics bioregion

Depending on local climatic conditions there can be up to four seasons in the Wet Tropics bioregion (this will vary from moister to drier climatic areas): The **early burn period** following seasonal heavy rain—fire self-extinguishes overnight and will not burn through areas that were burnt the year before. **The secondary burn season**—fires will burn through the night and will extinguish within areas that were burnt the year before. **Falling leaf season**— a blanket of leaves often crosses natural water features during the dry season and fires will generally not go out (fires in dry conditions will often favour woody species over grasses). **Storm burning**—from December through to January (where climatic conditions allow) is a useful way to achieve intense, wind-supported fire where rain can be reliably expected to follow providing good conditions for regeneration.

Fire risk is linked to the occurrence of fire weather days or sequences of days (FDR very high+ / FDI 25+). In the Wet Tropics bioregion these days have an average temperature above 30˚C, low humidity (less than 50 per cent) and sustained winds of more than 35 km/hr (refer to Figure 2).

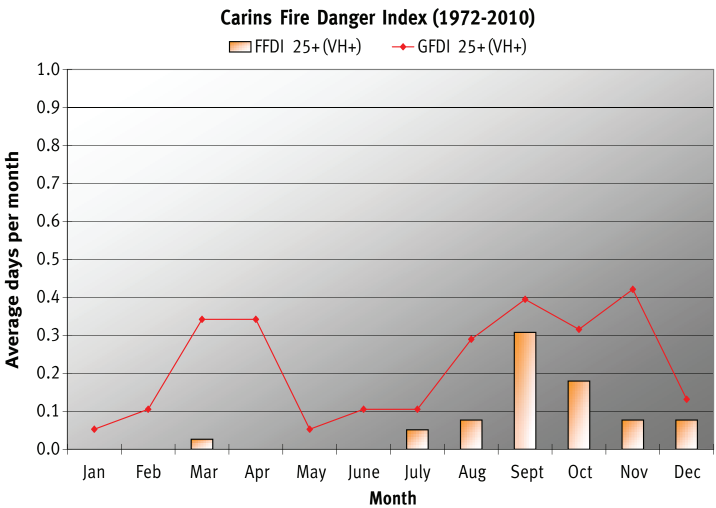


Figure 2: Fire weather risk in the Wet Tropics bioregion.

A fire weather day or sequence of days (FDI 25+) rarely occurs but is most likely at the end of the mid dry into the late dry season (approximately August to October). Data (Lucas 2010).

Further information can be found in the QPWS Planned Burn Guidelines: How to Assess if Your Burn is Ready to Go and on the Bureau of Meteorology website at <www.bom.gov.au>.

How to use this guideline

Step 1: Know your local fire strategy. This planned burn guideline works with and supports your local fire strategy. While the guideline should address the majority of issues in your area, it is essential you also review your fire strategy before completing your planned burn proposal to ensure all ecological issues are considered (e.g. zoning plan, threatened species, fire histories, *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* and other legislative requirements).

Step 2: Observe the country. It is essential to regularly observe the country that you manage (and the surrounding landscape). Familiarise yourself with this guideline so it becomes part of your observation of the environment as you go about your work. To assist you in observing the environment, undertake this simple exercise:

1. If a **canopy** is present (e.g. for open forests and woodlands) observe the following:
   a) Is tree branch foliage dying? Is there epicormic regrowth on branches? Are there any dead trees?
   b) Are there habitat trees (e.g. trees with hollows)?
   c) Are there rainforest, scrub or riparian ecosystems nearby?
2. For fire vegetation groups with a **mid-layer** (trees above the height of shrubs and grasses but not yet in the canopy) observe the following:
   a) What are the mid-layer trees (young canopy trees, wattles, casuarinas or rainforest species)? How open or dense is the mid-layer?
   b) Is there evidence of fire? What is the prevalence and height of blackened bark?
3. For fire vegetation groups with a **ground-layer** of grasses, sedges or shrubs, observe where relevant:
   a) The presence of grasses and grass clumps. Do the grasses look healthy and vigorous? Are there well-formed grass clumps?
   b) Is there a build-up of dead and decaying matter associated with grasses, shrubs, ferns or sedges?
   c) Are shrubs looking healthy and vigorous? Are there dying crowns on the shrubs?
   d) Does the ground-layer have a diversity of species or is it dominated by one or a few juvenile tree species? Are weeds dominating the understorey?

Step 3: Read the relevant chapters of this guideline and decide which issues apply to the area you are observing. It is common for burn proposals to address more than one issue—do not necessarily limit yourself to one issue per burn proposal.

Step 4: Consider your fire management priorities. Each chapter offers guidance for determining fire management priorities. The statements about priorities are based on a standard QPWS planned burn proposal prioritisation framework intended to guide both land managers and approval bodies.

Step 5: Choose measurable objectives. Each chapter of this guideline provides measurable objectives to include in your burn proposals (be guided also by the objectives in your fire strategy). Choose one or more objectives whilst observing the land. Do you need to adjust the objectives so they apply to your situation? Do you need to develop objectives not already included in these guidelines? If you find it difficult to identify your objectives, contact your natural resource management ranger or equivalent.

Step 6: Write a burn proposal. The **measurable objectives, fire behaviour, tactics** and **weather conditions** sections of each chapter can be copied directly into your burn proposals. Copy (ctrl+c) statements from a PDF version of this guideline and paste them (ctrl+v) into the burn proposal. Note that you may have to adjust the wording.

Step 7: Is your burn ready to go? Refer to the QPWS Planned Burn Guidelines: How to Assess if Your Burn is Ready to Go. Becoming familiar with the tools in this guideline will enable you to predict fire behaviour and achieve your burn proposal objectives.

Step 8: Review the measurable objectives in your burn proposal. After a fire, undertake the post-fire assessment recommended by this guideline (as defined in your burn proposal). This will indicate if you have achieved your planned burn objectives. This guideline provides information on how to report the results in your fire report.

Step 9: Review your fire management issue (re-apply this guideline to the burn area starting from Step 1). Return to the burn area after one year and then a few years after the original burn—once again applying this guideline. Many issues (such as weed control) are not resolved with a single burn and it is important to keep observing the land. If the results of fire management are unexpected or difficult to understand please seek further advice. If this process identifies shortfalls in your fire strategy, consider reviewing it. Step 9 can be implemented as part of a structured photo-monitoring process at various locations within the estate. Instructions can be obtained from the QPWS Fire Management System.

Chapter 1: Lowland open forest

This fire vegetation group contains a range of open eucalypt forest and woodland communities (from 12–30 metres in height) in the lowlands of the wet tropics bioregion, up to 200 metres in altitude. Depending on the frequency and severity of fire, the understorey may contain grasses, shrubs and small trees and/or rainforest pioneers. Most of these ecosystems have a biodiversity status of **endangered** or **of concern** due to extensive clearing of lowland areas (Queensland Herbarium 2011a). Tall open coastal communities (< 120 metres altitude), typically with a canopy of swamp mahogany, poplar gum and blue gum, provide critical habitat for the **endangered** mahogany glider (QPWS 2001).

Fire management issues

Where fire is common, the understorey is usually dominated by tall grasses, herbaceous plants, lilies, sedges, pandanus and in some areas grasstrees and other shrubs. Absence of fire can lead to overabundant saplings that create shading impacts on understorey diversity and degrades habitat for fauna including the mahogany glider. Planning fires needs to take account of cane harvesting and smoke impacts on urban settlements.

Issues:

1. Maintain healthy lowland open forest.
2. Reduce overabundant saplings and seedlings.
3. Manage high biomass exotic grasses.
4. Reduce *Lantana camara*.

Extent within bioregion: 65 354 hectares (ha), 3 per cent; **Regional ecosystems:** Refer to Appendix 1 for list.

Examples of this FVG: Girringun National Park, 9 488 ha; Hinchinbrook Island National Park, 5 709 ha; Girramay National Park, 5 680 ha; Paluma Range National Park, 2 530 ha; Monkhouse Timber Reserve, 2 264 ha; Daintree National Park, 1 650 ha; Tully Gorge National Park, 1 496 ha; Clemant State Forest, 1 333 ha; Mowbray National Park, 1 042 ha; Kuranda National Park, 941 ha; Cardwell State Forest, 819 ha; Abergowrie State Forest, 480 ha; Hull River National Park, 449 ha; Mount Mackay National Park, 341 ha; Kuranda State Forest, 333 ha; Wooroonooran National Park, 312 ha; Maria Creek National Park, 282 ha; Ella Bay National Park, 244 ha; Malbon Thompson Forest Reserve, 240 ha; Grey Peaks National Park, 219 ha; Murray Upper State Forest, 195 ha; Goldsborough Valley USL Lands, 182 ha; Russell River National Park, 172 ha; Dinden National Park, 154 ha; Family Islands National Park, 147 ha; Basilisk Forest Reserve, 136 ha; Annan River (Yuku Baja-Muliku) National Park, 133 ha; Japoon National Park, 129 ha; Trinity Forest Reserve, 125 ha; Mount Lewis National Park, 124 ha; Annan River (Yuku Baja-Muliku) Resources Reserve, 119 ha; Macalister Range National Park, 115 ha; Djiru National Park, 108 ha; Goold Island National Park, 84 ha; Gadgarra Forest Reserve, 81 ha; Koombooloomba Forest Reserve, 65 ha; Cedar Bay National Park, 63 ha.

Lowland open forest is home to the mahogany glider *Petaurus gracilis*, which is one of Australia's arboreal mammals. Its ability to glide, den hollows and food sources are threatened by open forest transitioning to a closed structure in the absence of fire (QPWS 2007).

Appropriate fire management is critical to the survival of this species.

Mark Parsons, QPWS, Jourama Falls (2001).

Issue 1: Maintain healthy lowland open forest

Maintain lowland forests and woodlands with mosaic burning.

Awareness of the environment

Indicators of healthy lowland open forests:

- Lowland open forests have a ground layer of tall grasses, legumes, lilies and sedges; with a few canopy species (enough to eventually replace the canopy), wattle, xanthorrhoea, pandanus, casuarinas or other small trees in the understorey; and a healthy canopy.
- Pockets of rainforest occur mainly along creeks and gullies, but thinning 25–40 metres away, where rainforest pioneers may be present but not in sufficient density to reduce the vigour and health of lower stratum grasses and shrubs or inhibit the movement of the mahogany glider.
- Presence of mature hollow-bearing live trees, typically poplar gum, swamp mahogany and bloodwood (essential for mahogany glider nesting) and an open structure in the mid stratum.
- Isolated or scattered distribution of cocky apple *Planchonia careya* and S*iris Albizia procera* (both mahogany glider food trees) and she-oaks or wattles (e.g. *Acacia crassicarpa* and *Acacia flavescens*).

Healthy lowland open forest. Note in the enlargement to the left, the diverse ground layer of grasses, sedges and legumes. *Dianella* spp. and *Lomandra* spp. are often present and blady grass is dominant near creeks.

Wayne Kington, QPWS, Yarrabah Girringun National Park (2010).

Healthy lowland open forest with *Xanthorrhoea* spp. and grasses present in understorey.
Mark Parsons, QPWS, Sunday Creek, Girringun National Park (2010).

Throughout lowland open forests, isolated pockets of rainforest are common along creek-lines and gullies but should thin out within 40 m of the creek or gully. Note the sharp boundary between the rainforest pocket and sclerophyll area.
Mark Parsons, QPWS, Little Stony Creek (2010).

Pandanus or cycads are often present as scattered plants or forming a grove in the mid stratum of healthy lowland open forests.

Mark Parsons, QPWS, Mullers Creek, Girringun National Park (2009).

The legume Cajanus *reticulatus* may be abundant in the ground layer after fire and thins in the third year. As it thins, it can be used to indicate when fire is becoming due.

Mark Parsons, QPWS, Lemon Tree Creek, Girringun National Park (2010).

In lowland open forests below 120 m in altitude, mahogany glider habitat emergent trees (live trees > 30 cm in diameter with hollows ≥ 10 cm), are important indicators of forest health.

Mark Parsons, QPWS, Mullers Creek, Girringun National Park (2010).

Signs of where fire is required to maintain healthy lowland open forest:

- Grasses thinning, collapsing or appearing matted with a build-up of dead material.
- Although pockets of rainforest are desirable, there is an abundance of rainforest pioneers colonising beyond these pockets into the forest in general. Rainforest pioneers such as *Melastoma* spp., *Chionanthus ramiflora, Mallotus philippensis, Alyxia spicata, Glochidion* spp. beginning to emerge above ground layer plants. As this advances (refer to Issue 2), shading from rainforest pioneers begins to impact on the vigour and health of understorey plants.
- An overabundance of acacia, she-oak or eucalypt species has germinated after fire and are beginning to shade out understorey plants.
- *Xanthorrhoea* spp. where present, are beginning to form brown skirts.
- Bracken fern may become dominant.

Rainforest pioneers are starting to dominate the understorey and will eventually shade-out ground layer diversity if left unburnt.

Mark Parsons, QPWS, Conn Creek, Girringun National Park (2010).

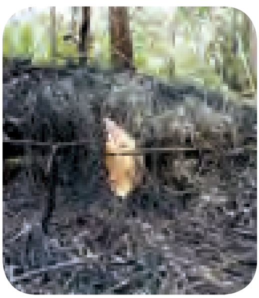
Brown skirts on *Xanthorrhoea* spp. provide habitat for invertebrates and skinks. However, as the skirts build up they indicate the need for fire management to maintain a forest with an open structure. Microhabitat such as this will develop over time. Although fire initially reduces them, it also maintains the forest that allows them to exist. In the absence of fire, such open forest habitat features would eventually perish. With appropriate planned burn conditions, unburnt patches and habitat features remain, in contrast to wildfires which burn extensive areas.

Kangaroo grass is starting to matt, die off at the base and accumulate dead material.

Dead and matting grasses are important habitat for invertebrates and skinks. However, they also indicate the forest requires fire to maintain grass health in general.

Low severity mosaic burns can help retain refuge areas as shown below; also, various fauna have strategies to survive fires.

All photos: Mark Parsons, QPWS, Mullers Creek, Girringun National Park (2010).



As rainforest pioneer shading advances, the ground layer begins to become sparse, grasses collapse, look less vigorous and build up dead material. However, shade tolerant sedges persist.

Mark Parsons, QPWS, Conn Creek, Girringun National Park (2010).

A high-severity fire in mahogany glider habitat caused a flush of wattles to germinate. These wattles will soon begin to shade-out the ground-layer and form a dense sub-canopy if a burn does not scorch them soon. Acacias are depicted, but equally, the overabundant seedlings could be she-oaks, eucalypts or rainforest pioneers.

Mark Parsons, QPWS, Mullers Creek, Girringun National Park (2010).

Discussion

- Most of the biodiversity in this fire vegetation group is within the ground layer. Regular fire plays an important role in maintaining the diversity of grasses, lilies, legumes, sedges and shrubs.
- Often, there are rainforests pioneers present in the ground layer. Fire keeps rainforest pioneers low in the profile. In the absence of fire, rainforests pioneers can grow into the mid stratum and begin to shade-out other ground layer species such as grasses, lilies, legumes, sedges and shrubs, impacting on diversity. Eventually it is difficult to reintroduce fire and the ecosystem is likely to transition to a closed forest. System change to closed forest is very rapid in this fire vegetation group (about 15 years).
- In the wet tropics, rainforests species tend to be able to quickly colonise in lowland open forests, irrespective of if they are near a rainforest margin.
- Where grazing occurs, it may be relevant to alleviate grazing pressure in the year prior to burning to allow accumulation of fuel.
- Transitioning/thickening threatens the habitat of the mahogany glider by reducing the efficiency of gliding, den hollows and food sources (QPWS 2001).

What is the priority for this issue?

Priority	Priority assessment
Very high	Planned burn required to maintain areas of **special conservation significance**.

Assessing outcomes

Formulating objectives for burn proposals

Every proposed burn area contains natural variations in topography, understorey or vegetation type. It is recommended that you select at least three locations that will be good indicators for the whole burn area. At these locations walk around and if visibility is good look about and average the results. Estimations can be improved by returning to the same locations before and after fire, and by using counts where relevant.

Select at least two of the following as most appropriate for the site:

Measurable objectives	How to be assessed	How to be reported (in fire report)
> 75 % of saplings < 2 metres are scorched to the tip.	Select one or more sites or walk one or more transects (taking into account the variability of landform and likely fire intensity), estimate the percentage of overabundant saplings (above ground components) scorched.	**Achieved:** > 75 %. **Partially Achieved:** 25–75 %. **Not Achieved:** < 25 %.
> 90 % of the grass clumps remain as stubble.	Select one or more sites or walk one or more transects (taking into account the variability of landform and likely fire intensity) and estimate grass stubble remaining after fire.	**Achieved:** > 90 % bases remain. **Partially Achieved:** 75–90 % bases remain. **Not Achieved:** < 75 % bases remain.
> 95 % of standing dead trees and standing live hollow-bearing trees (habitat trees) retained.	Select one or more sites or walk one or more transects (taking into account the variability of landform and likely fire intensity) and estimate number of habitat trees. Determine the percentage retained after fire.	**Achieved:** > 95 % retained. **Partially Achieved:** 90–95 % retained. **Not Achieved:** < 90 % retained.

25–60 % spatial mosaic of burnt patches.	Choose one of these options: a) Visual estimation of percentage of vegetation burnt—from one or more vantage points, or from the air. b) Map the boundaries of burnt areas with GPS, plot on GIS and thereby determine the percentage of area burnt. c) In three locations (that take account of the variability of landform and ecosystems within burn area), walk 300 or more metres through planned burn area estimating percentage of ground burnt within visual field.	**Achieved:** 25–60 % burnt. **Partially Achieved:** between 15–25 % or 60–75 % burnt. **Not Achieved:** < 15 % or > 75 % burnt.

If the above objectives are not suitable, refer to the compendium of planned burn objectives found in the monitoring section of the QPWS Fire Management System or consider formulating your own.

Monitoring the issue over time

Many issues are not resolved with a single planned burn and it is important to keep observing the land. To support this, it is recommended that observation points be established. Observation points are usually supported by photographs and by recording observations. Instructions for establishing observation points can be obtained from the monitoring section of the QPWS Fire Management System.

Fire parameters

What fire characteristics will help address this issue?

Fire severity

Low but vary with occasionally **moderate**-severity fire to ensure reduction of rainforest pioneers and to contribute to ground layer diversity, especially legumes. The occasional **high**-severity fire is required to stimulate the germination of mahogany glider food trees.

Fire severity class	Fire intensity (during the fire)		Fire severity (post-fire)	
	Fire intensity (kWm^{-1})	**Average flame height (m)**	**Average scorch height (m)**	**Description (loss of biomass)**
Low (L)	< 150	< 0.5	< 2.5	Significant patchiness. Litter retained but charred. Humus layer retained. Nearly all habitat trees, fallen logs and grass stubble retained. Some scorching of elevated fuels. Little or no canopy scorch.
Moderate (M)	150–500	0.5–1.5	2.5–7.5	Moderate patchiness. Some scorched litter remains. About half the humus layer and grass stubble remain. Most habitat trees and fallen logs retained. Some scorch of elevated fuels. Little or no canopy scorch.
High (H)	500–1000	1.5–3.0	7.5–15.0	Some patchiness. Some humus remains. Some habitat trees and fallen logs affected. At least some canopy scorch in moderate < 20m height canopy, mid stratum burnt completely (or nearly so).

Note: This table assumes good soil moisture and optimal planned burn conditions.

Fire frequency / interval (refer to Appendix 2 for a discussion)

- Fire frequency should primarily be determined through **on-ground assessment of vegetation health, fuel accumulation** and **previous fire patchiness** and adjusted for wildfire risk and drought cycles.
- 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 period). Consider a broad fire interval range of between two to five years.

Mosaic (area burnt within an individual planned burn)

- A mosaic is achieved with generally 25–60 per cent burnt.

Other considerations

- Ensure successive fires are somewhat variable in intensity, season, frequency (do not burn to a prescription of every 'x' years) and spatially (each fire creating a different mosaic of burnt and unburnt areas).

Low-severity fires created through spot ignition are desirable, and help in creating a mosaic of burnt and unburnt areas, retaining leaf mulch and (blackened) leaf litter on the ground and micro refuges for fauna.

Mark Parsons, QPWS, Fishers Creek, Girringun National Park (2010).

An occasional moderate-severity fire will help control overabundant saplings.
Mark Parsons, QPWS, Mullers Creek, Girringun, National Park (2010).

The occasional high-severity fire stimulates the germination of mahogany glider food trees such as *Albizia procera* (depicted centre). Once germinated however, return to lower-severity fires to allow these small trees to establish.
Mark Parsons, QPWS, Mullers Creek, Girringun National Park (2010).

Generally, it is very desirable to create a mosaic of burnt and unburnt areas. Unburnt areas are important fauna refuges and create a wider diversity of habitat.
Mark Parsons, QPWS, Blady Grass Creek, Girringun National Park (2010).

What weather conditions should I consider?

It is important to be aware of conditions prior to and following burns so that undesirable conditions and weather changes can be avoided, or to help with burn planning.

Season: Commence burning soon after the wet season (generally **April–May**) when a fire is likely to carry into the night, but not overnight. Avoid burning later in the dry season (**September–October**) unless for a specific purpose (e.g. managing thickening)

FFDI: < 12 and occasional up to 20 for higher severity fire

DI (KBDI): 100–150

Wind speed: < 15 km/hr.

What burn tactics should I consider?

Tactics will be site specific and different burn tactics may need to be employed at the same site (e.g. due to topographical variation). Also, during the burn, tactics should be reviewed and adjusted as required to achieve burn objectives. What is offered below is not prescriptive; rather it is a toolkit of suggested tactics that may assist in this issue.

- **Afternoon or evening ignition** generally creates milder burn conditions, promoting a low to moderate severity fire. Often this tactic will assist in creating a mosaic of burnt and unburnt patches and conditions where fire may self-extinguish overnight. This is particularly important if burning later in the dry season, or when burning adjacent to non-target communities and property.
- **Use of natural barriers.** The lowlands of the wet tropics have numerous natural barriers such as rock outcrops, creeks and rainforest gullies. Fire tends not to spread out extensively (except in very dry conditions). Natural barriers are useful in creating containment areas and landscape mosaics.
- **Consider adjacent primary production activities.** Often this fire vegetation group neighbours agricultural land uses such as sugarcane production. Planned burns in adjoining areas should be undertaken when the prevailing weather conditions (in particular wind direction) will direct the resulting fire, smoke and any airborne embers away from the sugar cane crop or mulch ('trash blanket') that follows harvesting. Line lighting the windward edge along the margin of the sugar cane is preferred when undertaking this type of burn so that a safe perimeter can be established. Establishing cooperative arrangements with cane farmers and rural fire brigades is essential in managing this issue.
- **Smoke issues.** Be aware of potential smoke impacts on urban settlements. Planned burns in adjoining areas should be undertaken when the prevailing weather conditions (in particular wind direction) will direct the resulting smoke away from settled areas.

Spot ignition in lowland open forest.

Justine Douglas, QPWS, Cape Sandwich, Hinchinbrook Island National Park (2004).

- **Spot ignition** is often used in lowland open forest, to alter the desired intensity of a fire and create the desired mosaic of burnt and unburnt areas. Spots closer together will result in a line of a greater intensity (as spots merge and create hot junction zones) while increased spacing between spots or alternatively a single spot ignition will result in a lower intensity fire with a greater mosaic of unburnt and burnt patches. The spacing of the spots may vary throughout the burn due to changes in weather conditions, topography and fuel loads.
- **A low intensity backing fire.** A slow moving, low intensity backing fire will generally result in a more complete coverage of an area and a better consumption of fuel. This tactic creates high residence time useful to reduce overabundant saplings, while ensuring fire intensity and rate of spread are kept to a minimum. Burning downhill can also create a low-intensity backing fire.
- **Progressive burning.** A number of burns of varying size and severity are lit in an area throughout the year when conditions allow. This creates a rich mosaic of burnt and unburnt patches and can be used to establish a safe perimeter allowing further planned burns to take place within secured areas. Refer to the glossary for a fuller discussion.
- **Aerial ignition.** Where access is difficult and limited. Used in tandem with good soil moisture and other landscape features such as drainage lines, moist gullies and vegetation communities including rainforests, this technique is an efficient means to create a landscape mosaic.

Landscape features such as this creek line help to control the movement of fire and create a landscape mosaic of burnt and unburnt areas.

Tim Devlin, QPWS, The Saddle, Paluma Range National Park (2004).

Issue 2: Reduce overabundant saplings and seedlings

In lowland open forests, overabundance of rainforest pioneers, she-oaks and acacias may reduce the health and diversity of the ground layer through competition and shading. If left unmanaged, the forest can transition from an open to a closed structure, in which fire becomes difficult to reintroduce.

Awareness of the environment

Key indicators:

- Mid-stratum is generally dominated by young trees including rainforest pioneers, she-oaks or acacias. Common rainforest examples are hard milkwood *Alstonia muelleriana*, northern guioa *Guioa acutifolia*, red kamala *Mallotus philippensis*, macaranga *Macaranga involucrata* and *Macaranga tanarius*.
- Understorey or mid-stratum is difficult to see through or walk through.
- Ground layer plants declining in health, diversity and abundance due to shading.
- Grasses thinning and sometimes being replaced by creeping shade grass *Oplismenus* spp.
- Vines starting to smother cycad fronds.
- Bracken, where present, is mostly dead.
- Presence of *Alyxia* spp. vine climbing into mid-stratum.

These mid-stratum rainforest pioneers are becoming dense – however, sparse grasses persist in ground-layer. Fire is needed here to prevent the pioneers shading out the grasses completely.

Mark Parsons, QPWS, Conn Creek, Girringun National Park (2010).

Mid-stratum overabundance has produced a screen that is difficult to see through. Ground layer grasses are thinning but will still carry fire easily.

Mark Parsons, QPWS, Little Stony Creek, Girringun National Park (2010).

She-oak overabundance in the mid-stratum. Understorey is less diverse. Grasses are very sparse. Bracken fern is dominant with numerous dead fronds.

Mike Ahmet, QPWS, Dinden National Park (2008).

Notice the presence of Alyxia vine. Shading of ground has progressed. Grasses are sparse and shaded leaf litter is becoming prominent. Fire will only carry in dry conditions.

Mark Parsons, QPWS, Conn Creek, Girringun National Park (2010).

In some areas it may be too late to try and restore open forest communities. However, where it is determined a conservation priority, several fires may be required (starting with a high-severity fire) to reduce the overabundance of rainforest pioneer species. The right conditions will be difficult to achieve. Notice the absence of grasses under *Polyscias australiana* and acacias, which have grown beyond the mid-stratum.

Mark Parsons, QPWS, Conn Creek, Girringun National Park (2010).

A sequence illustrating cycad decline in the absence of fire, followed by an image of recovery from a recent fire. The second photo in the series could be used as an indicator of when fire is overdue, and the third photo when fire is well overdue.

First three photos: Jenise Blaik, QPWS, Many Peaks Range (2010).

Post fire photo: Mark Parsons, QPWS, Broadwater (2009).

Discussion

- The speed of woody thickening (due to tree overabundance) in wet tropics lowland open forests is rapid due to higher rainfall and warmer temperatures.
- Fire keeps rainforest pioneers low in the profile in the ground layer. In the absence of fire, rainforests pioneers can grow into the mid-stratum and begin to shade out other species in the ground layer such as grasses, sedges, shrubs, and ferns; impacting on diversity. Eventually it is difficult to introduce fire into an area and the system is likely to transition to a closed forest (Williams et al. 2012). In the wet tropics, rainforests species can quickly colonise vegetation groups that are not necessarily near an existing rainforest margin.
- The open forest and woodlands of the coastal lowlands are quite susceptible to acacia and she-oak thickening. Certain acacias and she-oaks can germinate en masse. In the absence of fire, seed stock can build-up, this is likely to lead to a mass germination event after wildfire (which tends to be of a higher severity). Where this has occurred, it is likely that more than one fire will be required to control overabundance. Post fire observations are essential to monitor the kill rate and germination of acacias and she-oaks in order to ascertain the need of subsequent fires.
- It is important to ensure the recruitment of open forest and woodland canopy species. Although **moderate** to **high**-severity fires may be necessary to control mid-stratum sapling overabundance, it may also have an impact on canopy species recruitment. Therefore once mid stratum overabundance is controlled, it is important to return to a **low** to **moderate**-severity fire regime (refer to Issue 1).

What is the priority for this issue?

Priority	Priority assessment
High	Planned burns to **maintain ecosystems** in areas where **ecosystem health** is good.
Medium	Planned burn in areas where **ecosystem health** is **poor** but recoverable.
Low	Planned burn in areas where **ecosystem** structure and function has been **significantly disrupted**.

Assessing outcomes

Formulating objectives for burn proposals

Every proposed burn area contains natural variations in topography, understorey or vegetation type. It is recommended that you select at least three locations that will be good indicators for the whole burn area. At these locations walk around and if visibility is good look about and average the results. Estimations can be improved by returning to the same locations before and after fire, and by using counts where relevant.

Select at least two of the following as most appropriate for the site:

Measurable objectives	How to be assessed	How to be reported (in fire report)
> 75 % of mid stratum saplings are scorched to the tip.	Select one or more sites or walk one or more transects (taking into account the variability of landform and likely fire intensity), estimate the percentage of overabundant saplings (above ground components) scorched.	**Achieved:** > 75 %. **Partially Achieved:** 25–75 %. **Not Achieved:** < 25 %.
> 95 % of standing dead trees and standing live hollow-bearing trees (habitat trees) retained.	Select one or more sites or walk one or more transects (taking into account the variability of landform and likely fire intensity) and estimate number of habitat trees. Determine the percentage retained after fire.	**Achieved:** > 95 % retained. **Partially Achieved:** 90–95 %. retained. **Not Achieved:** < 90 % retained.
Restore cycad health (if cycads are present).	Select one or more sites or walk one or more transects (taking into account the variability of landform and likely fire intensity) and assess health of cycads.	***Achieved:** Cycads recovered. **Not Achieved:** Cycads did not recover. *cycads take several months to recover and may not have green material immediately after fire.
Alyxia spp. vine reduced to ground layer.	Select one or more sites or walk one or more transects (taking into account the variability of landform and likely fire intensity) and assess height of *Alyxia* spp. vine.	**Achieved:** *Alyxia* spp. vine reduced to ground layer. **Not Achieved:** *Alyxia* spp. vine still present in mid-stratum.

If the above objectives are not suitable, refer to the compendium of planned burn objectives found in the monitoring section of the QPWS Fire Management System or consider formulating your own.

Monitoring the issue over time

Many issues are not resolved with a single planned burn and it is important to keep observing the land. To support this, it is recommended that observation points be established. Observation points are usually supported by photographs and by recording observations. Instructions for establishing observation points can be obtained from the monitoring section of the QPWS Fire Management System.

Fire parameters

What fire characteristics will help address this issue?

Fire severity:

- **Moderate** for most situations where young trees are less than eight metres tall. Where young trees are taller than eight metres, a **high**-severity fire might be necessary. Use high-severity fire with caution, as there will be an impact on habitat trees and fallen logs (refer to table below), and the fire will be much harder to contain.
- Avoid lower severity burns, as this will exhaust fuel and reduce opportunities for subsequent higher severity burns.

Fire severity class	Fire intensity (during the fire)		Fire severity (post-fire)	
	Fire intensity (kWm^{-1})	Average flame height (m)	Average scorch height (m)	Description (loss of biomass)
Moderate (M)	150–500	0.5–1.5	2.5–7.5	Moderate patchiness. Some scorched litter remains. About half the humus layer and grass stubble remain. Most habitat trees and fallen logs retained. Some scorch of elevated fuels. Little or no canopy scorch.
High (H)	500–1000	1.5–3.0	7.5–15.0	Some patchiness. Some humus remains. Some habitat trees and fallen logs affected. At least some canopy scorch in moderate < 20 m height canopy, mid stratum burnt completely (or nearly so).

Note: This table assumes good soil moisture and optimal planned burn conditions.

Fire frequency / interval (refer to Appendix 2 for a discussion)

- More than one planned burn may be required to manage this issue. Monitor outcomes until overabundant saplings/seedlings are controlled.
- Once the area has recovered, the recommended regime for healthy lowland open forests and woodlands can be resumed (refer to Issue 1).

Mosaic (area burnt within an individual planned burn)

- As much of the area dominated by mid stratum saplings as possible burnt.

Other considerations

- Due to the landform of the coastal lowlands, there are greater opportunities to contain fire within natural barriers such as channels and waterways, and therefore a greater opportunity to carry out fires that address thickening issues. However, be aware of the presence of cane farms, settlements and roads.
- For acacia and she-oak thickening it is important to observe post fire germination and kill rates to ascertain the need for subsequent fires. If the initial fire triggers a flush of new acacia and she-oak seedlings, follow-up planned burn within two years with **moderate**-severity fire.
- It is likely that more than one planned burn will be required to manage this issue.
- If a fire has triggered a flush of eucalypt seedlings, do not burn for four to five years, the next burn should be of a **low**-severity to allow some of the seedlings to establish.

Depicting a desirable fire severity to control mid stratum overabundance.

Mark Parsons, QPWS, Mullers Creek, Girringun National Park (2010).

What weather conditions should I consider?

Season: Mid to late dry season as conditions allow. Progressive burning through the year in surrounding healthy areas, commencing soon after the wet season, will make it easier to manage late dry season burns

FFDI: 5–24

DI (KBDI): 120–180

Wind speed: < 23 km/hr

What burn tactics should I consider?

Tactics will be site specific and different burn tactics may need to be employed at the same site (e.g. due to topographical variation). Also, during the burn, tactics should be reviewed and adjusted as required to achieve burn objectives. What is offered below is not prescriptive; rather it is a toolkit of suggested tactics that may assist in this issue.

- While a moderate intensity fire is mostly recommended to address this issue this is largely dependant upon the height of the saplings. A **running fire** of a higher intensity may be required initially where there is a lack of surface and near-surface fuels due to shading-out or if the thicket is well developed. **Line or strip ignition** is used to create a fire of higher intensity or to help fire carry through moist or inconsistent fuels. This is also useful to reduce overabundant saplings/seedlings. In this instance a follow-up planned burn will be required in the two to three years post fire to kill surviving and new seedlings/saplings.
- **A backing fire with good residence time.** A slow moving backing fire (lit against the wind on the smoky edge or down-slope) will ensures the fire has a greater amount of residence time, while ensuring fire intensity and rate of spread are kept to a minimum. Greater residence time is useful in reducing overabundant seedlings/saplings.
- **Spot ignition**. Can be used effectively to alter the desired intensity of a fire particularly where there is an accumulation of volatile fuels. Spots closer together will result in a line of a greater intensity (as spots merge and create hot junction zones) while increased spacing between spots will result in a lower intensity fire.

Issue 3: Manage high biomass exotic grasses

Refer to Chapter 11 (Issue 3), regarding fire management guidelines.

It is important to be aware of the presence of high biomass grasses as they can dramatically increase fire severity and can be promoted by fire. Sometimes fire can be used to help in their control.

Basal reshooting of thatch grass. Fire is not effective in its control and too frequent fire promotes it.

Mark Parsons, QPWS, Princess Hill, Girringun National Park (2006).

As a taller grass, guinea grass can create dramatic flares of higher fire severity on the edge of a control line, increasing the risk of spot over and embers.

Mark Parsons, QPWS, Mullers Creek, Girringun National Park (2006).

Issue 4: Reduce *Lantana camara*

Refer to Chapter 11 (Issue 5), regarding fire management guidelines.

The presence of *Lantana camara* may require an altered approach to fire management or for well established infestations, integrated use of fire and herbicide.

The use of a broadleaf herbicide or splatter mix prior to planned burning can increase success rate of controlling thickets of lantana.

QPWS, Henrietta Creek, Girringun National Park

Dense infestations are often the source for lantana spread. Carried by small fruit eaters such as star finches, the seeds require gut passage to germinate. Using integrated control including fire helps discourage this seed spread.

Mark Parsons, QPWS, Black Bream Track, Girringun National Park (2008).

Chapter 2: Open forests of the foothills and ranges

This fire vegetation group contains open eucalypt forest and woodland communities with a grassy, shrubby and mixed grassy/shrubby understorey, found in the foothills and ranges of the Wet Tropics. Open forests of the foothills and ranges extend through much of the wet tropics, from moist to dry locations. It includes habitat for **endangered** flora and fauna.

Fire management issues

The main fire management issue is the maintenance of an open grassy, shrubby or mixed grassy/shrubby structure with regular mosaic burning, which will also help ensure habitat and food sources for the **endangered** northern bettong. An open structure can be threatened by overabundant saplings and weeds (usually caused by too infrequent burning or a too severe fire event). The presence of high-biomass grasses may unexpectedly increase severity of fires impacting on the health of ecosystems. Fire management in the coastal hill slopes requires special attention due to steep slopes and urban and rainforest interface issues.

Issues:

1. Maintain healthy open forests of the foothills and ranges.
2. Reduce overabundant saplings in the mid-stratum.
3. Fire management in the coastal hill slopes (including Cairns hill slopes).
4. Manage high biomass invasive grasses.
5. Reduce *Lantana camara*.

Extent within bioregion: 484 103 ha, 24 per cent; **Regional ecosystems:** Refer to Appendix 1 for complete list.

Examples of this FVG: Girringun National Park, 67 216 ha; Monkhouse Timber Reserve, 36 413 ha; Paluma Range National Park, 27 153 ha; Mount Windsor National Park, 15 988 ha; Daintree National Park, 15 517 ha; Dagmar Former State Forest, 9 379 ha; Mount Lewis National Park, 9 244 ha; Kuranda National Park, 8 868 ha; Hinchinbrook Island National Park, 7 192 ha; Kuranda State Forest, 4 650 ha; Dinden State Forest, 3 688 ha; Mount Fox State Forest, 3 544 ha; Wairuna Station (Proposed addition to Girringun National Park), 3 535 ha; Lannercost State Forest, 3 446 ha, Herberton Range State Forest, 3 428 ha, The Bluff State Forest, 3 149 ha, Abergowrie State Forest, 3 149 ha; Girramay National Park, 3 051 ha; Kirrama National Park, 2 761 ha; Clemant State Forest, 2 702 ha; Dinden National Park, 2,693 ha; Koombooloomba South Forest Reserve, 2 652 ha; Wooroonooran National Park, 2 585 ha; Little Mulgrave Forest Reserve, 2 505 ha; Macalister Range National Park, 2 498 ha; Goldsborough Valley USL Lands, 2 410 ha; Tumoulin State Forest, 2 071 ha; Paluma State Forest, 2 053 ha; Danbulla State Forest 2, 1 922 ha; Cardwell State Forest, 1 881 ha; Ravenshoe State Forest 1, 1 499 ha; Mowbray National Park, 1 411 ha; Upper Granite Normanby (under negotation with Aboriginal Land and NP), 1 374 ha; Ravenshoe State Forest 3, 1 367 ha; Formartine State Forest, 1 298 ha; Herberton Range National Park, 1 198 ha; Gadgarra Forest Reserve, 1 169 ha.

Issue 1: Maintain healthy open forests of the foothills and ranges

Maintain healthy open forest/woodland using mosaic burning.

Awareness of the environment

Indicators of healthy open forests of the foothills and ranges:

- Healthy open forest with a grassy, shrubby or mixed grassy/shrubby understorey with a few canopy species of variable sizes (to eventually replace the canopy) and a healthy canopy.
- Lower and mid stratum tree species are present, but **are not** having noticeable shading effects on ground layer plants.
- The forest is easy to walk through or see through.
- Rock outcrop and rock pavement areas that have grasses, leaf litter, and fire-sheltered refuges of sedges, ferns and fire-sensitive shrubs (see Chapter 6: Fire sheltered shrubland).

Woodland with a healthy grassy understorey.
Paul Williams, Vegetation Management Science Pty Ltd, Mt Bluff (2010).

Blue gum/iron bark open forest with a healthy grassy understorey. Because of the drier location, the grasses will naturally appear less green and vigorous. Note that tree recruitment is sparse, but sufficient to replace the canopy over time.

Paul Williams, Vegetation Management Science Pty Ltd (2010).

Open forest with a healthy grassy understorey. However, there is little tree recruitment. Consider introducing low-severity burns early in the dry season to encourage eucalypt regeneration.

Mark Parsons, QPWS, Rapid Creek, Girringun National Park (2005).

Note healthy understorey of cockatoo grass favoured by the northern bettong for food and shelter. Note casuarina showing signs of drought stress.

Ian Holloway, QPWS, Herberton Range.

Open forest with a healthy mixed grassy/shrubby understorey. Shrubby in this context refers to sclerophyllous (hard-leaved) shrubs such as the banksias depicted. There are also young trees present sufficient for canopy recruitment but not in such numbers that they would shade out the ground layer.

Paul Williams, Vegetation Management Science Pty Ltd, Mount Windsor (2006).

Pink bloodwood and turpentine open forest in a moist location with a mixed grassy/ shrubby understorey.

Paul Williams, Vegetation Management Science Pty Ltd (2009).

Burning in shrubby dominated open forest. Due to soils, some areas are naturally dominated by sclerophyllous shrubs with very little grass present.

Paul Williams, Vegetation Management Science Pty Ltd (2009).

Some areas of this fire vegetation group have rocky terrain and sheltered areas (refer to Chapter 6, fire-sheltered shrubland).
Mark Parsons, QPWS, Paluma Range (2007).

Areas of bare rock also occur.
Mark Parsons, QPWS, Paluma Range (2007).

The following may indicate that fire is required to maintain open forest with a grassy, shrubby or mixed grassy/shrubby understorey:

- Grasses becoming sparser or grass clumps are poorly formed.
- There is an accumulation of dead material and collapsing grasses.
- Shrubs with lower leaves and some branches dying.
- Accumulation of leaf litter.
- In drier areas, young she-oaks or acacias starting to become abundant in the ground stratum.
- Xanthorrhoea where present, have brown skirts.
- Cycads where present, are in poor health with fronds drooping or browning in large numbers, or vines starting to smother.
- In moister areas of the coastal foothills, rainforest pioneers starting to become abundant and beginning to emerge above the ground stratum. Rainforest pioneers commonly include: *Polyscias* spp., *Melicope* spp. (such as evodia), *Alstonia* spp. and *Alphitonia* spp.
- Where they are known to occur, reduction in the abundance of shrub species such as *Banksia spinulosa, Prostanthera* spp., *Cajanus* spp., *Grevillea parallela* and *Callitris macleayana*.

Mahogany/ ironbark open woodland with a grassy understorey. Note drooping, dead skirts accumulation on grass trees. Grass clumps are becoming poorly formed, although due to the dry location this is a difficult indicator to assess.

Mike Ahmet, QPWS, Dinden National Park.

Note build-up of dead material beneath grasses.
Paul Williams, Vegetation Management Science Pty Ltd, Herberton (2010).

Note the build up of dead grass material, fallen leaf litter and dead branches on shrubs.
Paul Williams, Vegetation Management Science Pty Ltd, Herberton (2010).

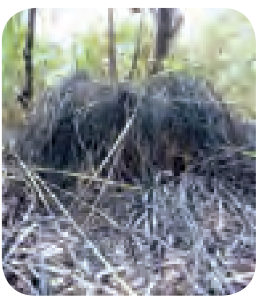
Brown skirts on *Xanthorrhoea* spp. provide habitat for invertebrates and skinks. However, as the skirts build up they indicate the need for fire management to maintain a forest with an open structure. Microhabitat such as this will develop over time. Although fire initially reduces them, it also maintains the forest that allows them to exist. In the absence of fire, such open forest habitat features would eventually perish. With appropriate planned burn conditions, unburnt patches and habitat features remain, in contrast to wildfires which burn extensive areas.

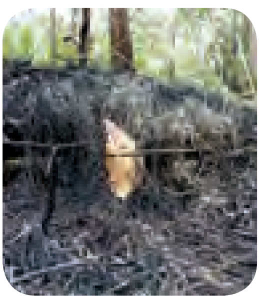
Kangaroo grass is starting to matt, die off at the base and accumulate dead material.

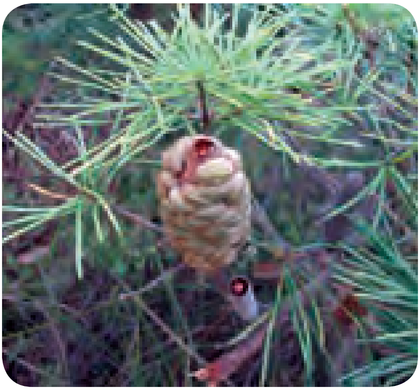
Dead and matting grasses are important habitat for invertebrates and skinks. However, they also indicate the forest requires fire to maintain grass health in general.

Low severity mosaic burns can help retain refuge areas as shown below; also, various fauna have strategies to survive fires.

All photos: Mark Parsons, QPWS, Mullers Creek, Girringun National Park (2010).







Where Banksia spinulosa is known to occur, as it begins to become less abundant, this is an indication that fire has been long absent.

Paul Williams, Vegetation Management Science Pty Ltd.

Where cycad fronds begin to brown-off in large numbers, this is an indication that fire has been long absent.

Paul Williams, Vegetation Management Science Pty Ltd, Crystal Cascade (2010).

Discussion

- It is important to distinguish 'shrubs' from juvenile trees or saplings. Shrubs remain small plants when mature and certain types of open forest are characterised by an abundance of shrubs in the lower stratum (e.g. *Banksia aquilonia, Dodonaea triquetra* and *Banksia spinulosa*). If an **abundance of juvenile trees or saplings** are present, without the intervention of fire, they will cause the system to transition to closed forest. Fire is required if the land manager intends to maintain an open forest with a grassy or shrubby understorey.
- The distribution of northern bettong appears to be limited by the availability of its main food source, truffles and other fire dependent species such as cockatoo grass, and lilies (Dennis 2001). Regular mosaic burning will promote growth of grasses and some species of truffle while maintaining the open forest structure which allows ease of movement for foraging. Kangaroo grass and xanthorrhoea also provide important refuges, as the bettongs build tunnel shaped 'nests' to shelter in.

- Be aware that signs of poor health can also be a result of drought. Implementing fire during drought conditions is not recommended as this could compound health problems. Also consider whether the area has naturally poor soil, and therefore grasses may always appear less vigorous.
- In moister areas, there may be rainforests species present in the ground layer. Fire keeps rainforest species low in the profile. In the absence of fire, rainforests species can grow into the mid stratum and begin to shade-out grasses and other species in the ground layer such as herbaceous plants, lilies and sedges, impacting on diversity (refer to Issue 2). Eventually it is difficult to introduce fire into an area and the system is likely to transition to a closed forest.

What is the priority for this issue?

Priority	Priority assessment
High	Planned burns to **maintain ecosystems** in areas where **ecosystem health** is **good**.

Assessing outcomes

Formulating objectives for burn proposals

Every proposed burn area contains natural variations in topography, understorey or vegetation type. It is recommended that you select at least three locations that will be good indicators for the whole burn area. At these locations walk around and if visibility is good look about and average the results. Estimations can be improved by returning to the same locations before and after fire, and by using counts where relevant.

Select at least two of the following as most appropriate for the site:

Measurable objectives	How to be assessed	How to be reported (in fire report)
> 75 % of saplings < 2 m are scorched to the tip.	Select one or more sites or walk one or more transects (taking into account the variability of landform and likely fire intensity), estimate the percentage of overabundant saplings (above ground components) scorched.	**Achieved:** > 75 %. **Partially Achieved:** 25–75 %. **Not Achieved:** < 25 %.
< 25 % of young eucalypt trees > 5 m tall are scorched to tip.	Select one or more sites or walk one or more transects (taking into account the variability of landform and likely fire intensity), estimate the number of scorched eucalypt trees > 5m tall.	**Achieved:** < 25 %. **Partially Achieved:** 25–50 %. **Not Achieved:** > 50 %.
> 90 % of the grass clumps remain as stubble.	Select one or more sites or walk one or more transects (taking into account the variability of landform and likely fire intensity) and estimate grass stubble remaining after fire.	**Achieved:** > 90 % bases remain. **Partially Achieved:** 75–90 % bases remain. **Not Achieved:** < 75 % bases remain.
50–70 % spatial mosaic of burnt patches.	Choose one of these options: • Visual estimation of percentage of vegetation burnt—from one or more vantage points, or from the air. • Map the boundaries of burnt areas with GPS, plot on GIS and thereby determine the % of area burnt. • In three locations (that take account of the variability of landform and ecosystems within burn area), walk 300 or more metres through planned burn area estimating percentage of ground burnt within visual field.	**Achieved:** 50–80 % burnt. **Partially Achieved:** between 25–50 % or 70–80 % burnt. **Not Achieved:** < 25 % or > 80 % burnt.

If the above objectives are not suitable, refer to the compendium of planned burn objectives found in the monitoring section of the QPWS Fire Management System or consider formulating your own.

Monitoring the issue over time

Many issues are not resolved with a single planned burn and it is important to keep observing the land. To support this, it is recommended that observation points be established. Observation points are usually supported by photographs and by recording observations. Instructions for establishing observation points can be obtained from the monitoring section of the QPWS Fire Management System.

Patchiness can be visually assessed via a walk-through over a burnt site. Ensure to take in features such as ridgelines and gullies, which as indicated in this photo, will influence patchiness.

QPWS, Herberton Range (2009).

Consider monitoring the suitability of fire management for maintaining northern bettong habitat by using quadrats to assess recruitment of grasses, sedges, lilies and food resources such as cockatoo grass following fire. Contact your local natural resource management staff for further information.

Andy Baker, QPWS, Davies Creek (2009).

Fire parameters

What fire characteristics will help address this issue?

Fire severity:

- **Low** to **moderate**.
- Repeated **low**-severity fires can contribute to an overabundance of saplings in the mid-stratum. An occasional moderate-severity fire may be needed to manage overabundant saplings.

Fire severity class	Fire intensity (during the fire)		Fire severity (post-fire)	
	Fire intensity (kWm^{-1})	Average flame height (m)	Average scorch height (m)	Description (loss of biomass)
Low (L)	< 150	< 0.5	< 2.5	Significant patchiness. Litter retained but charred. Humus layer retained. Nearly all habitat trees, fallen logs and grass stubble retained. Some scorch of elevated fuels. Little or no canopy scorch.
Moderate (M)	150–500	0.5–1.5	2.5–7.5	Moderate patchiness. Some scorched litter remains. About half the humus layer and grass stubble remain. Most habitat trees and fallen logs retained. Some scorch of elevated fuels. Little or no canopy scorch.

Note: This table assumes good soil moisture and optimal planned burn conditions.

Fire frequency / interval (refer to Appendix 2 for a discussion)

- Fire frequency should primarily be determined through on-ground assessment of vegetation health, fuel accumulation and previous fire patchiness, adjusting for wildfire risk and drought.
- 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 maximum time frame). Consider the following broad fire intervals:
- **Moist grassy open forest** (see GIS layer): two to five years.

- **Dry grassy open forest** (see GIS layer): two to five years.
- **Grassy to shrubby** (see GIS layer): six to ten years.

Mosaic (area burnt within an individual planned burn)

- A mosaic is achieved with generally 25–70 per cent burnt within the target communities.

Other considerations

- Across the landscape, burning some areas at shorter intervals and some at longer intervals will also add to diversity. Too frequent fire can eliminate shrubs, many of which require several years in order to mature and set seed prior to the next fire event.
- In grassy areas, at intervals greater than **three years**, mosaic burning becomes harder to achieve (as dry fuel becomes more continuous) and there is greater reliance on tactics, topography and choice of conditions to achieve a patchy burn.

What weather conditions should I consider?

It is important to be aware of conditions prior to and following burns so that undesirable conditions and weather changes can be avoided, or to help with burn planning.

Season: April-May to **September**

FFDI: < 12

DI (KBDI): 80–160

Wind speed: < 23 km/hr.

Chip lines can be useful to create temporary boundaries for mosaic burning. QPWS (2010).

What burn tactics should I consider?

Tactics will be site specific and different burn tactics may need to be employed at the same site (e.g. due to topographical variation). During the burn, regularly review and adjust tactics as required to achieve burn objectives. What is offered below is not prescriptive; rather it is a toolkit of suggested tactics that may assist in this issue.

- **A backing fire with good residence time.** A slow moving backing fire (lit against the wind on the smoky edge or lit from upslope) will generally result in a more complete coverage of an area and ensures fire has greater residence time, and minimises severity and rate of spread. Greater residence time reduces understorey density and results in greater consumption of fuel (which in some cases is desirable).
- **Using previously burnt grasses.** The first year after fire, regrowth grasses can be used as a fire line as they are green and will not carry fire **early in the year.** During the second year, there is a build up of dead grass material as the first year of grasses die-off. Fires will carry at this time, and especially during the third year when there is two years of dead grass build up.
- **Spot ignition.** Can be used to alter the desired intensity of a fire particularly where there is an accumulation of volatile fuels. Spots closer together will result in a line of a greater intensity (as spots merge and create hot junction zones) while increased spacing between spots will result in a lower-intensity fire. The spacing of the spots should regularly vary throughout the burn due to changes in weather conditions, topography and fuel loads.
- **Aerial ignition.** Where access is difficult, limited, or to cover extensive areas. Spot ignition and backing fires can be implemented with aerial ignition.
- **Progressive burning** is an approach to planned burning where ignition is carried out throughout much of the year as conditions allow. In the Wet Tropics, ignition can begin early in the year after heavy seasonal rain, with numerous small ignitions creating a fine-scale mosaic. These burnt areas can provide opportunistic barriers to fire for burning later in the year. They also provide fauna refuge areas. Progressive burning helps create a rich mosaic of intensities, burnt/unburnt areas, and seasonal variability. Be aware of how fire behaves differently in different seasons. Refer to the glossary for a fuller discussion.

Issue 2: Reduce overabundant saplings in the mid-stratum

Overabundance of rainforest pioneers, she-oaks, eucalypts and acacias may reduce the health of the ground layer through competition and shading.

Awareness of the environment

Key indicators:

- Mid-stratum is dominated by young eucalypts, rainforest pioneers, she-oaks or acacias.
- Understorey is difficult to see through or walk through.
- Grasses are scattered, poorly formed and collapsing. Other ground layer plants reduced in abundance and health.
- Cycads are in poor health or vines starting to smother cycad fronds.
- Accumulation of leaf litter, ribbons of bark suspended in shrubs and lower branches.
- Heavy fuels (> 6 mm) accumulate.
- Shrubs where present, are declining in diversity and abundance.

Where Banksia spinulosa is known to occur, as it begins to become less abundant, this is an indication that fire has been long absent.

Paul Williams, Vegetation Management Science Pty Ltd.

Where cycad fronds begin to brown-off in large numbers, this is an indication that fire has been long absent.

Paul Williams, Vegetation Management Science Pty Ltd, Crystal Cascade (2010).

A high-severity fire can cause a flush of *Acacia* spp. to germinate. If a second fire is not planned, these grow up to shade out ground layer diversity. *Acacia* spp. is used in the example; however the same is true for eucalypts and she-oaks.

Paul Williams, Vegetation Science Pty Ltd, Herberton (2010).

Overabundance of eucalypts in the understorey will eventually lead to too much shading.

Mike Ahmet, QPWS, Millstream National Park (2010).

Fire was used to scorch overabundant forest she-oaks. Forest she-oaks resprout from the base requiring follow up burns to avoid further overabundance.

Mark Parsons, QPWS, The Saddle, Paluma Range National Park (2011).

Scattered distribution or pockets of rainforest pioneers and taller she-oaks represent habitat diversity. However once these dominate it can be difficult to restore an open structure.

Mark Parsons, QPWS, Mt Zero, Taravale (2011).

Discussion

Why are saplings overabundant?

An overabundance of saplings in the understorey may be triggered in response to:

- a high severity fire event with no subsequent fire to thin the resulting flush of tree seedlings/saplings. If a fire triggers a flush of seedlings/saplings, it will be necessary to plan a subsequent burn
- repeated low severity, early season fires (not hot enough to scorch saplings)
- prolonged absence of fire
- certain acacias and she-oaks can germinate en masse. In the absence of fire, seed stock can build up, which is likely to lead to a mass germination event after wildfire (which tends to be a higher-severity fire). Where this has occurred, it is likely that more than one fire will be required to address the issue. Post fire observations are essential to monitor the kill rate and germination of acacias and she-oaks in order to ascertain the need of subsequent fires.

Potential impacts of overabundant saplings

- A thickening of trees may result in a lower diversity of plants within the understorey due to shading. This thickening threatens the health of the ecosystem leading to transition to a closed structure of indeterminate value, in which it is difficult to re-introduced planned fire.
- Too many saplings can change the structure from open to closed, and is one of the main threats to habitat for the endangered northern bettong found only in the wet tropics. Most importantly, it leads to a reduction of its main food sources and restricts movement for foraging.
- Canopy species in the understorey are necessary for ventual replacement of canopy; it is a question of how many and balancing this against shading of the understorey.

What is the priority for this issue?

Priority	Priority assessment
High	Planned burns to **maintain ecosystems** in areas where **ecosystem health** is **good**.
Medium	Planned burn in areas where **ecosystem health** is **poor** but recoverable.

Assessing outcomes

Formulating objectives for burn proposals

Every proposed burn area contains natural variations in topography, understorey or vegetation type. It is recommended that you select at least three locations that will be good indicators for the whole burn area. At these locations walk around and if visibility is good look about and average the results. Estimations can be improved by returning to the same locations before and after fire, and by using counts where relevant.

Select at least two of the following as most appropriate for the site:

Measurable objectives	How to be assessed	How to be reported (in fire report)
> 75 % of mid-stratum saplings are scorched to the tip.	Select one or more sites or walk one or more transects (taking into account the variability of landform and likely fire intensity), estimate the percentage of overabundant saplings (above ground components) scorched.	**Achieved:** > 75 %. **Partially Achieved:** 25–75 %. **Not Achieved:** < 25 %.
> 95 % of standing dead trees and standing live hollow-bearing trees (habitat trees) retained.	Select one or more sites or walk one or more transects (taking into account the variability of landform and likely fire intensity) and estimate number of habitat trees. Determine the percentage retained after fire.	**Achieved:** > 95 % retained. **Partially Achieved:** 90–95 % retained. **Not Achieved:** < 90 % retained.
Restore cycad health (if cycads are present).	Select one or more sites or walk one or more transects (taking into account the variability of landform and likely fire intensity) and assess health of cycads.	***Achieved:** Cycad recovered. **Not Achieved:** Cycad did not recover. *cycads will take several months to recover and may not have green material immediately after fire.

If the above objectives are not suitable, refer to the compendium of planned burn objectives found in the monitoring section of the QPWS Fire Management System or consider formulating your own.

Monitoring the issue over time

Many issues are not resolved with a single planned burn and it is important to keep observing the land. To support this, it is recommended that observation points be established. Observation points are usually supported by photographs and by recording observations. Instructions for establishing observation points can be obtained from the monitoring section of the QPWS Fire Management System.

Fire parameters

What fire characteristics will help address this issue?

Fire severity

- **Moderate** to **high**. Aim for scorch height sufficient to scorch to the tip of overabundant saplings (see table below). Although moderate to high-severity fire is recommended, low-severity fires on the advent of the wet season may produce scorch of pioneers in areas of good grass cover.

Fire severity class	Fire intensity (during the fire)		Fire severity (post-fire)	
	Fire intensity (kWm^{-1})	Average flame height (m)	Average scorch height (m)	Description (loss of biomass)
Moderate (M)	150–500	0.5–1.5	2.5–7.5	Moderate patchiness. Some scorched litter remains. About half the humus layer and grass stubble remain. Most habitat trees and fallen logs retained. Some scorch of elevated fuels. Little or no canopy scorch.
High (H)	500–1000	1.5–3.0	7.5–15.0	Some patchiness. Some humus remains. Some habitat trees and fallen logs affected. At least some canopy scorch in moderate < 20 m height canopy, mid stratum burnt completely (or nearly so).

Note: This table assumes good soil moisture and optimal planned burn conditions.

Fire extent

- Greater than 80 per cent of area dominated by understorey trees burnt.

Fire frequency / interval (refer to Appendix 2 for a discussion)

- Avoid low-severity fires in moist open forest at intervals of greater than five years, as this tends to create rainforest transition issues.

Repeated fires

- It is likely that more than one planned burn will be required to manage this issue. If the initial fire triggers a flush of new seedlings, follow-up planned burn within two years with **moderate**-severity fire.
- It is important to ensure the recruitment of open forest and woodland canopy species. Although **moderate** to **high**-severity fires may be necessary to control mid stratum sapling overabundance, it may also have an impact on canopy species recruitment. Therefore once mid stratum overabundance is controlled, it is important to return to a **low** to **moderate**-severity fire regime (refer to Issue 1).

An example of successful fire management of overabundant saplings. They are consistently scorched to the tip and yet grass stubble and unburnt fuels remain to promote a quick recovery of grasses.

Mark Parsons, QPWS, Wallaman Falls, Girringun National Park (2011).

What weather conditions should I consider?

It is important to be aware of conditions prior to and following burns so that undesirable conditions and weather changes can be avoided, or to help with burn planning.

Season: July to **November** (drier conditions)

FFDI: 8–18

Wind speed: < 23 km/hr. Winds greater than 15 km/hr can help carry fire into thickening areas.

What burn tactics should I consider?

Tactics will be site specific and different burn tactics may need to be employed at the same site (e.g. due to topographical variation). During the burn, regularly review and adjust tactics as required to achieve burn objectives. What is offered below is not prescriptive; rather it is a toolkit of suggested tactics that may assist in this issue.

- **Commence lighting on the leeward (smoky) edge.** This can be a useful way to create a containment edge for a higher severity fire ignited inside the burn area.
- **Backing fire with good residence time.** A slow moving backing fire (lit against the wind on the smoky edge or lit from upslope) will generally result in a more complete coverage of an area and ensures the fire has a greater amount of residence time, while ensuring fire intensity and rate of spread are kept to a minimum. Greater residence time is useful in reducing understorey density.
- While a moderate severity fire is often sufficient to address this issue, it is dependant upon the height of the saplings. A **running fire** of a higher intensity may be required initially where there is a lack of surface and near surface fuels due to shading or if the thicket is well developed. In this instance a follow-up planned burn will be required in the two to three years post burn to kill surviving saplings and any new seedlings.
- **Line or strip ignition** is used to create a fire of higher intensity or to help fire carry through moist or inconsistent fuels. This is also useful to reduce overabundant trees (through scorching).
- **Aerial ignition.** Where access is difficult and limited, or to cover extensive areas.

Issue 3: Fire management in the coastal hill slopes (including Cairns hill slopes)

The complex fire management issues of the coastal hill slopes require particular management approaches. Open forests and woodlands of the coastal hill slopes interface with urban areas, forestry, sugar cane and other crops. The land is steep, and dissected by sheltered rainforest gullies usually on an eastern aspect. There are complex land-use patterns such as walking tracks and easements for communication and power and some utilities at the top of the slopes. Also, there are various land tenures, especially in the lower slopes, that complicate management of fire.

Awareness of the environment

Key indicators to be aware of include the presence of:

- nearby urban areas or settlements
- nearby farms, sugar cane and other crops
- forestry areas including timber plantations
- walking track and communication easements
- infrastructure, especially if it is upslope (e.g. for power or communications)
- rainforests, especially if it is upslope
- areas of high fuel load or high biomass grasses that may dramatically increase fire severity.

Residences nestled into the open forests of the foothills are a common feature of the Cairns hill slopes.

Jonathan Roth, QPWS, Cairns (2008).

Burning near residences.

Mark Parsons, QPWS (2010).

Discussion

- Backing fire ignited from higher slopes with aerial ignition is the usual approach to fire management on the coastal hill slopes, though not exclusively. The fire is allowed to back down and extinguish along constructed fire lines or natural features. If necessary, the urban interface zones can be burnt away from after a sufficient period of backing fire from higher slopes.
- If forest structure is beginning to change from open to closed due to overabundant tree species, it might be necessary to light a fire from down slope to ensure sufficient penetration through these areas (refer to Issue 2). However, ensure containment and safety issues are addressed first.
- Urban interface areas introduce a range of additional challenges to planned burning, especially with regard to access behind properties, timber fences and dumped green waste. Be aware of these issues when planning burns.
- Inter-agency cooperation is usually required due to tenure and interface issues. Participation or cooperation from main roads, emergency services, traffic control, local government and others may have to be organised, especially emergency services and Cairns regional council.
- Planned burning on the Cairns hill slopes usually comes under media scrutiny. Media and neighbours need to be kept informed (e.g. through media releases and letterbox drops).
- Where high biomass grasses are present, they can dramatically increase the severity of fire. Be aware of the presence of these grasses (refer to Chapter 11, for fire management guidelines).
- In sugar cane areas, fire management often follows harvest time. Cane at harvest time is highly flammable, and caution is required.
- As the urban interface increases and development moves upslope, fire becomes increasingly difficult to manage. Fire managers must become increasingly strategic in these areas.

What is the priority for this issue?

Priority	Priority assessment
Highest	Planned burn required to **protect life** and/or **property**, usually within **protection zones**.
Very high	Planned burn required to **mitigate hazard** or **simplify vegetation structure**, usually within **wildfire mitigation zones**.

Assessing outcomes

Formulating objectives for burn proposals

Every proposed burn area contains natural variations in topography, understorey or vegetation type. It is recommended that you select at least three locations that will be good indicators for the whole burn area. At these locations walk around and if visibility is good look about and average the results. Estimations can be improved by returning to the same locations before and after fire, and by using counts where relevant.

Select at least two of the following as most appropriate for the site:

Measurable objectives	How to be assessed	How to be reported (in fire report)
Fuel reduced to less than 5 tonnes per hectare (t/ha).	Immediately or very soon after fire: fuel load assessed at several locations (taking into account variability in landform) using Step 5 of the QPWS Planned Burn Guidelines: How to Assess if Your Burn is Ready to Go.	**Achieved:** Fuel load reduced to < 5 t/ha across the fire association. **Partially Achieved:** Fuel load reduced to < 5 t/ha across the fire association but duff/humus layer removed. **Not Achieved:** Fuel load not reduced to < 5 t/ha.
Fuel reduced to overall low fuel hazard.	Immediately to very soon after fire: fuel load assessed at several locations (taking into account variability in landform) using the Overall Fuel Hazard Guide (Hines et al. 2010b).	**Achieved:** Overall fuel hazard reduced to low. **Partially Achieved:** Overall fuel hazard reduced to low or moderate. **Not Achieved:** Overall fuel hazard not reduced to low or moderate.

Fire extent or patchiness of: • 90–100 % burnt Protection Zones. • 60–80 % burnt Wildfire Mitigation zones. • 40–60 % burnt Conservation zones.	There are three options: 1. From one or more vantage points, estimate aerial extent of ground burnt. 2. In three locations (that take account of the variability of landform within burn area), walk 300 m through planned burn area estimating percentage of ground burnt within visual field. 3. Walk into one or more gully heads, and down one or more ridges and estimate percentage of ground burnt within visual field.	**Achieved:** • 90 % Protection zones. • 60–80 % Wildfire mitigation zones. **Partially Achieved:** • Mosaic or patchiness of 80–90 % for protection zones. • Mosaic or patchiness of 50 % to 80 % for wildfire mitigation zones. • The extent and rate of spread of any subsequent wildfire would still be limited. **Not Achieved:** • Mosaic or patchiness of < 80 % for protection zones. • Mosaic or patchiness of < 50 % for wildfire mitigation zones. • High proportion of patchiness, unburnt corridors extend across the area (the extent and rate of spread of any subsequent wildfire would not be limited).

If the above objectives are not suitable, refer to the compendium of planned burn objectives found in the monitoring section of the QPWS Fire Management System or consider formulating your own.

Monitoring the issue over time

Many issues are not resolved with a single planned burn and it is important to keep observing the land. To support this, it is recommended that observation points be established. Observation points are usually supported by photographs and by recording observations. Instructions for establishing observation points can be obtained from the monitoring section of the QPWS Fire Management System. In urban interface areas, consider ongoing monitoring of fuel load.

Backing fire from upslope areas. In this area, fire is allowed to travel down slope towards constructed fire lines. If necessary, once the fire has backed down most of the hill slope, the area behind the settlement can be line ignited to create a buffer.

Jonathan Roth, QPWS, Edmonton Spur (2010).

Fire parameters

What fire characteristics will help address this issue?

Fire severity

- **Low** to **moderate**.
- Repeated **low**-severity fires will contribute to an overabundance of saplings in the mid-stratum. Some moderate intensity fires should be planned where overabundant saplings are becoming a problem.

Fire severity class	Fire intensity (during the fire)		Fire severity (post-fire)	
	Fire intensity (kWm^{-1})	Average flame height (m)	Average scorch height (m)	Description (loss of biomass)
Low (L)	< 150	< 0.5	< 2.5	Significant patchiness. Litter retained but charred. Humus layer retained. Nearly all habitat trees, fallen logs and grass stubble retained. Some scorching of elevated fuels. Little or no canopy scorch.
Moderate (M)	150–500	0.5–1.5	2.5–7.5	Moderate patchiness. Some scorched litter remains. About half the humus layer and grass stubble remain. Most habitat trees and fallen logs retained. Some scorch of elevated fuels. Little or no canopy scorch.

Note: This table assumes good soil moisture and optimal planned burn conditions.

Fire frequency / interval (refer to Appendix 2 for a discussion)

- Consider a broad fire interval range of between two to five years for dry grassy open forest. For areas influenced by arson or areas with a poor coverage of previous fire, increase the fire frequency to one to two years where possible.

Mosaic (area burnt within an individual planned burn)

- Create a mosaic as appropriate to mitigate wildfire movement during the dry season. Generally:
  - 90–100 per cent burnt for protection zones
  - 60–80 per cent burnt for wildfire mitigation zones
  - 40–60 per cent burnt for conservation zones.

What weather conditions should I consider?

It is important to be aware of conditions prior to and following burns so that undesirable conditions and weather changes can be avoided, or to help with burn planning.

Season: April/May to **September**

FFDI: < 12

DI (KBDI): 80–160

Wind speed: < 23 km/hr

What burn tactics should I consider?

Tactics will be site specific and different burn tactics may need to be employed at the same site (e.g. due to topographical variation). During the burn, regularly review and adjust tactics as required to achieve burn objectives. What is offered below is not prescriptive; rather it is a toolkit of suggested tactics that may assist in this issue.

- **Backing fire ignited from higher slopes** with **aerial ignition** will create a slow moving backing fire which will generally result in a more complete coverage of an area and help to minimise fire intensity and rate of spread. Greater residence time will increase consumption of fuel. In the right conditions, where natural barriers or constructed fire lines are present, a backing fire should self-extinguish.
- At the urban interface zone, if necessary, **burn away from interface areas** after a sufficient period of backing fire from higher slopes. The backing fire should have descended downwards extensively prior to burning away from lower slope interface areas. If lower slope interface areas are ignited too early, this will create a running fire upslope, which is usually undesirable unless specifically planned in order to control overabundant trees.

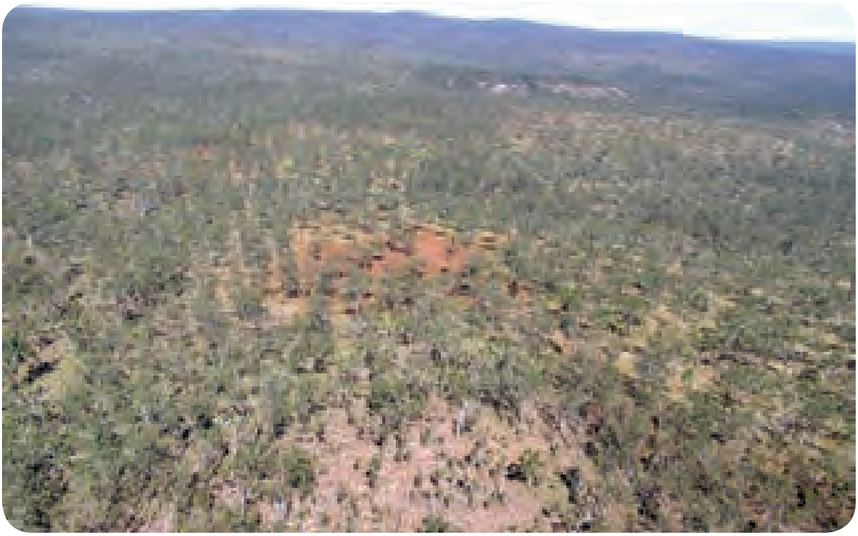
- **Consider adjacent primary production activities.** Often this fire vegetation group neighbours agricultural land uses such as sugar cane production. Planned burns in adjoining areas should be undertaken when the prevailing weather conditions (in particular wind direction) will direct the resulting fire, smoke and any airborne embers away from the sugar cane crop or mulch ('trash blanket') that follows harvesting. Line lighting the windward edge along the margin of the sugar cane is preferred so that a safe perimeter can be established. Establishing cooperative arrangements with cane farmers and rural fire brigades is essential in managing this issue.
- Rainforest gullies or areas can be used to **break up fires**, and as boundaries to contain fires within small sections. At the same time, it is important to protect rainforest margins by using appropriately moist conditions of burning, or by backing fire downhill and/or away from rainforest margins (refer to Chapter 11 [Issue 7], for fire management guidelines).
- These areas are highly prone to arson, and **progressive burning** is an important strategy. Burns early in the year create areas of low fuel helping to limit the extent and severity of later wildfires. Refer to the glossary for a fuller discussion.
- When planning burns, be aware of the need to choose conditions (especially wind direction) that will **minimise smoke impacts** on settlements. Be aware that inversion layers (when temperatures increase with altitude) prevent dispersion of smoke and therefore should be avoided. Consult weather forecasts.

In the foothills around Cairns, fire management often occurs in close proximity to residential areas.
Mark Parsons, QPWS, Toomulla (2010).

Issue 4: Manage high biomass invasive grasses

Refer to Chapter 11 (Issue 3), regarding fire management guidelines.

It is important to be aware of the presence of high biomass grasses as they can dramatically increase fire severity and can be promoted by fire. Sometimes fire can be used to help in their control.



Shown as rusty red in the foreground, grader grass outbreaks are easily spread by disturbance such as slashing fire trails. Often, exclusion of fire is necessary.
Shane O'Connor, DERM, Princess Hill, Girringun National Park (2006).

Issue 5: Reduce *Lantana camara*

Refer to Chapter 11 (Issue 4), regarding fire management guidelines.

The presence of *Lantana camara* may require an altered approach to fire management or for well established infestations, integrated use of fire and herbicide.

Monitoring weather conditions is useful in choosing the best time to push fire into lantana thickets.

Mark Parsons, QPWS, Mt Fox, Girringun National Park (2008).

Chapter 3: Tall open forest

This fire vegetation group includes tall (> 30 m) open eucalypt forests and woodlands within the moist uplands and highlands of the wet tropics. They are typically dominated by one or a mix of canopy species including rose gum Eucalyptus grandis, *Eucalyptus resinifera/Corymbia intermedia* (intermingled), *Eucalyptus tereticornis* (in belts adjacent to rainforests), *Eucalyptus pellita* (large areas north of Mossman and near Cairns), cadaghi *Corymbia torelliana* and turpentine *Syncarpia glomulifera*. The understorey or ground layer may be dominated by:

- grasses
- sedges and leaf litter
- sclerophyllous (hard leaf) shrubs
- rainforest/vine forest
- various combinations of the above.

Fire management issues

Fire plays a central role in these forests with longer fire frequencies leading to a transition from an open to a closed structure (Ash 1988; Stanton 1989; Harrington and Sanderson 1994; Williams and Tran 2009; Williams et al. 2010). Planned burning helps to maintain representative examples of this fire vegetation group (Smith 1993; Harrington et al. 2000), and especially grassy dominated ground layers, which have a propensity to transition from open grassy eucalypt forest to closed forest (Wet Tropics Management Authority 2004; Williams and Tran 2009). Transitioning is often irreversible and has caused many of these ecosystems to have an **endangered** biodiversity status (Queensland Herbarium 2011a). Loss of open structure threatens suitable habitat for species such as the **endangered** northern bettong and vulnerable yellow-bellied glider (Wet Tropics Management Authority 2004; Williams et al. 2010).

In managing these forests, it is important to understand the mechanism of transitioning. Most rainforest pioneers resprout after fire, however unlike eucalypts they must resprout from ground level. Therefore fire keeps them trapped near the ground where they co-exist with grasses, shrubs, ferns and other species. Fire can promote a pulse of rainforest germinates, and in the absence of fire for several years, rainforest germinates and saplings shade out ground layer plants, inhibit fire and create conditions favouring further rainforest recruitment and closed forest transition (Williams et al. 2006, 2012).

Because these forests are very moist, there are limited windows of opportunity to conduct planned burns. A high level of importance should be place on responding operationally to suitable weather conditions.

Fire management in tall open forest requires a carefully considered integrated approach. Beginning early in the year, surrounding fire-adapted communities should be burnt to create areas of low fuel that help contain higher-severity late-season fires. Late-season conditions are often required to allow tall open forests to dry sufficiently so that they can carry fire. The degree to which tall open forests can carry fire depends on understorey characteristics as influenced by the stage of transitioning to closed forest. The land manager should aim to keep representative examples of tall open forest as described below, where possible using fire to halt the transition to a denser state.

Issues:

1. Manage a grassy or shrubby tall open forest. These forests have an understorey that can carry fire much of the year after seasonal heavy rains.
2. Manage tall open forests where seedlings / saplings are abundant in the mid-stratum. Mid stratum tree overabundance has caused the ground layer to become sparser often characterised by sedges interspersed with leaf litter. Fire will carry in the right conditions, but using nearby grassy areas to help carry fire is useful.
3. Manage tall open forests at an advanced stage of transitioning. Trees have shaded-out the ground layer, which is now characterised by leaf litter and an absence of ground layer plants. It is probably necessary to use nearby grassy areas to carry fire into these areas. Windows of opportunity for fire are few.
4. Reduce *Lantana camara*.

Extent within bioregion: 93 352 ha, 5 per cent; **Regional ecosystems:** Refer to Appendix 1 for list.

Examples of this FVG: Girringun National Park, 11 219 ha; Paluma Range National Park, 7 352 ha; Daintree National Park, 5 310 ha; Monkhouse Timber Reserve, 5 149 ha; Koombooloomba Forest Reserve, 4 900 ha; Paluma State Forest, 3 823 ha; Mount Windsor National Park, 3 230 ha; Kirrama National Park, 3 103 ha; Herberton Range State Forest, 2 927 ha; Wooroonooran National Park, 2 848 ha; Mount Lewis National Park, 2 416 ha; Dinden National Park, 2 179 ha; Gadgarra Forest Reserve, 1 896 ha; Herberton Range National Park, 1 542 ha; Kuranda National Park, 1 193 ha; Tully Falls National Park, 1 131 ha; Goldsborough Valley USL Lands, 1 025 ha, Tumoulin State Forest 859 ha, Girramay National Park 857 ha, Danbulla National Park 849 ha, Abergowrie State Forest, 777 ha; Little Mulgrave Forest Reserve, 749 ha; Herberton Range Conservation Park, 574 ha; Ravenshoe State Forest 1, 560 ha; Macalister Range National Park, 466 ha.

Issue 1: Manage a grassy or shrubby tall open forest

Maintain tall open forests and woodlands that have a grassy or sclerophyllous (hard-leaved) shrubby dominated understorey.

Awareness of the environment

Key indicators of a tall open forest with a grassy understorey:

- Tall open forest ground layer is dominated by grasses (predominantly kangaroo grass and/or blady grass, and occasionally other native grass species) with occasional sedges; shrubs; bracken; legumes or any mix of these. Some young canopy species are present in the mid and lower stratums (enough to eventually replace the canopy).
- Lower and mid stratum tree species are present, but are not having noticeable shading effects on ground layer plants.
- The forest is easy to walk through or see through.

Tall open forest with a healthy grass layer. Mid stratum trees are in low numbers and do not impact on the ground layer.

Paul Williams,Vegetation Management Science Pty Ltd, Taravale, plot 6 (2005).

Tall open forest with a healthy grass layer. Although there are a number of rainforest and she-oak young trees, they are in insufficient numbers to impact on ground layer.

Mark Parsons, QPWS, Taravale, plot 6 (2006).

Northern bettong prefer habitat with grassy open ridges, shrubby influenced gullies and rock/ pavement outcrops. Notice rock outcrop.

Andy Baker, QPWS, Davies Creek (2010).

The following may indicate that fire is required to maintain the grassy structure:

- Rainforest, she-oak or acacia tree saplings or seedlings starting to become abundant and beginning to emerge above the ground stratum. Rainforest pioneers commonly include: *Polyscias* spp., *Melicope* spp. (such as evodia), *Alstonia* spp., and *Alphitonia* spp.
- Grasses becoming sparser or grass clumps poorly formed. An accumulation of dead material and collapsing grasses.
- Bracken fern, where present, is accumulating dead fronds.

Grass layer still healthy but an overabundance of rainforest pioneers are beginning to emerge above ground layer.
Mark Parsons, QPWS, Taravale, plot 10 (2004).

Although this area is due for fire, it is also important to allow recruitment of canopy species (e.g. rose gum). Manage the frequency and intensity of fire carefully to avoid scorching most of the recruiting rose gum.
Mark Parsons, QPWS, Mount Windsor (2010).

Left: Grass layer becoming sparse as a result of shading from rainforest and she-oak species.

Above: Enlarged detail of left photo highlighting collapsing grasses and an accumulation of dead grassy material.

Mark Parsons, QPWS, Taravale, plot 3 (2004).

Grass layer becoming sparser as a result of shading and competition from rainforest and she-oak species.

Mark Parsons, QPWS, Taravale, plot 4 (2006).

Near boulders or gullies, bracken fern shelters yellow-footed antechinus, rough scaled snakes and northern bettongs. With planned burn conditions, habitat features remain, in contrast to wildfires which burn extensive areas. However, as bracken fern declines in health, even these sheltered areas require fire. Fire should be patchy here.

Mark Parsons, QPWS, Deep Creek, Girramay National Park (2009).

A sequence illustrating clumping grass decline in the absence of fire. Sorghum is used as an example, but decline in *Themeda* spp. and other clumping species is similar. Dead and matting grasses (as illustrated in the bottom row) are important habitat for invertebrates and skinks. However, they also indicate the forest requires fire to maintain grass health in general. Lower severity fires and moist conditions help keep habitat refuges in place.

Wayne Kington, QPWS / David Kington, QPWS, Lamington National Park (2009).

Mark Parsons, QPWS, Mullers Creek (2010).

Key indicators for tall open forests with a shrubby understorey:

- Understorey is dominated by a diverse sclerophyllous (hard-leaved) shrub layer of continuous height. Scattered sedges, grasses and ferns may be present. Some young canopy species are present in the mid and lower stratums (enough to eventually replace the canopy).
- Lower and mid stratum tree species **are not** having noticeable shading effects on shrub or ground layer.

Some tall open forests have a sclerophyllous shrubby understorey. These have longer fire frequencies than grassy communities.

Yellow-bellied gliders live in *Eucalyptus grandis* (rosegum) and feed on *Eucalyptus resinifera*. This habitat is threatened by transitioning.

Andy Baker, QPWS, Daintree National Park (2009).

A shrubby understorey and good recruitment of canopy trees of various ages. The recruiting canopy trees are numerous, but do not shade out the understorey as rainforest pioneers would.

Mark Parsons, QPWS Mt Windsor (2010).

The following may indicate that fire is required to maintain shrubby types:

- Shrubs looking unhealthy, for example beginning to lose lower level leaves, spindly branches are present or some crowns (ends of branches) are dying. There is an accumulation of brown leaves on shrubs.
- Abundant rainforest, she-oak or acacia tree species are emerging among the shrubs. Rainforest colonists may include: *Polyscias* spp., *Melicope* spp. (such as evodia), *Alstonia* spp., and *Alphitonia* spp.
- Vines are starting to grow over some of the shrubs.
- *Lantana camara* is beginning to establish as thickets.
- Suspended litter and bark is perched in shrubs (e.g. rose gum bark ribbons).

Sedge and rainforest trees starting to emerge in a shrubby tall open forest. Notice the suspended ribbon bark.

Mark Parsons, QPWS, Mt Windsor (2010).

What is the priority for this issue?

Priority	Priority assessment
Very high	Planned burn required to maintain areas of **special conservation significance.**

Discussion

- It is important to distinguish 'shrubs' from juvenile trees or saplings. Shrubs remain small plants when mature and certain types of tall open forest are characterised by an abundance of shrubs in the lower stratum (e.g. *Banksia aquilonia, Dodonaea triquetra* and *Banksia spinulosa*). However, if an *abundance of juvenile* trees or *saplings* are present, without the intervention of fire they will usually cause the system to transition to closed forest. Therefore fire is required if the land manager intends to maintain a tall open forest with a grassy or shrubby understorey.
- In the wet tropics, there is a group of rainforest pioneers that tend to always be present in the ground layer of this fire vegetation group and can quickly grow into the mid stratum in the absence of fire.

Rainforest tree species resprouting after fire.

Paul Williams, Vegetation Science Pty Ltd, Paluma Range National Park (2004).

Where sufficient fuel accumulates, follow up burning can assist to suppress pioneer recruitment. Having conditions that enable a backing burn will promote a greater residence time, which may scorch the base of resprouting plants.

Mark Parsons, QPWS, Taravale (2009).

Assessing outcomes

Formulating objectives for burn proposals

Every proposed burn area contains natural variations in topography, understorey or vegetation type. It is recommended that you select at least three locations that will be good indicators for the whole burn area. At these locations walk around and if visibility is good look about and average the results. Estimations can be improved by returning to the same locations before and after fire, and by using counts where relevant.

Measurable objectives	How to be assessed	How to be reported (in fire report)
> 75 % of saplings < 2 m are scorched to the tip.	Select one or more sites or walk one or more transects (taking into account the variability of landform and likely fire severity), estimate the percentage of overabundant saplings (above ground components) scorched.	**Achieved:** > 75 %. **Partially Achieved:** 25–75 %. **Not Achieved:** < 25 %.
< 25 % of young eucalypt trees > 5m tall are scorched to the tip.	Select one or more sites or walk one or more transects (taking into account the variability of landform and likely fire intensity), estimate the number of scorched eucalypt trees > 5 m tall.	**Achieved:** < 25 %. **Partially Achieved:** 40–50 %. **Not Achieved:** > 50 %.
> 75 % fallen logs (with a diameter ≥ 10 cm) retained.	Select one or more sites or walk one or more transects (taking into account the variability of landform and likely fire intensity) and estimate number of fallen logs retained after fire.	**Achieved:** > 75 % retained. **Partially Achieved:** 50–75 % retained. **Not Achieved:** < 50 % retained.

If the above objectives are not suitable, refer to the compendium of planned burn objectives found in the monitoring section of the QPWS Fire Management System or consider formulating your own.

Monitoring the issue over time

Many issues are not resolved with a single planned burn and it is important to keep observing the land. To support this, it is recommended that observation points be established. Observation points are usually supported by photographs and by recording observations. Instructions for establishing observation points can be obtained from the monitoring section of the QPWS Fire Management System.

Objectives achieved as seen one week after fire. 100 per cent reduction of saplings and seedlings, while at the same time retention of all habitat trees, fallen logs and recovery of grasses.

Paul Williams, Vegetation Science Pty Ltd, Taravale, plot 1 (2004).

A low-severity fire has resulted in a patchy mosaic burn. Most but not all saplings and seedlings have been reduced across a broad area. This burn is still considered a success.

Paul Williams, Vegetation Science Pty Ltd, Taravale, plot 6 (2004).

Fire parameters

What fire characteristics will help address this issue?

Fire severity

- **Low**. With the occasional **moderate** severity fire (see table below, except that a good coverage of fire is desirable rather than a patchy fire). An occasional moderate-severity fire helps to ensure emerging overabundant trees are managed while low-severity fires help ensure enough canopy trees establish to replace the canopy. It is important to strike this balance between tree reduction and canopy tree recruitment.

Fire severity class	Fire intensity (during the fire)		Fire severity (post-fire)	
	Fire intensity (kWm^{-1})	Average flame height (m)	Average scorch height (m)	Description (loss of biomass)
Low (L)	< 150	< 0.5	< 2.5	Significant patchiness. Litter retained but charred. Humus layer retained. Nearly all habitat trees, fallen logs and grass stubble retained. Some scorching of elevated fuels. Little or no canopy scorch.
Moderate (M)	150–500	0.5–1.5	2.5–7.5	Moderate patchiness. Some scorched litter remains. About half the humus layer and grass stubble remain. Most habitat trees and fallen logs retained. Some scorch of elevated fuels. Little or no canopy scorch.

Note: This table assumes good soil moisture and optimal planned burn conditions.

Fire frequency / interval (refer to Appendix 2 for a discussion)

- Fire frequency should primarily be determined through **on-ground assessment of vegetation health, fuel accumulation** and **previous fire patchiness** and adjusted for wildfire risk and drought cycles.

- 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). Consider a broad fire interval range of between three to five years for **grassy** understorey and six to ten years for **shrubby** understorey.

Mosaic (area burnt within an individual planned burn)

- Because of a propensity for these systems to transition, aim to achieve a good coverage of fire. Despite this, in moister areas such as near gullies, unburnt areas tend to remain. This will help retain features such as ground epiphytes and denser pockets.

Landscape mosaic

- It is recommended that at least 30 per cent of wet tropics tall open forests with grassy or shrubby understoreys be burnt each year (refer to supporting GIS layer).

Other considerations

- When planning suitable fire severity and fire frequencies, take into account wildfires. Occasional wildfires are not an ecological concern in tall open forest, but do not allow a wildfire driven regime to dominate.

A low severity fire in northern bettong habitat.
Mark Parsons, QPWS, Zero Creek, Mt Zero (2007).

What weather conditions should I consider?

It is important to be aware of conditions prior to and following burns so that undesirable conditions and weather changes can be avoided, or to help with burn planning.

Season:

- Any time of the year **after the wet season** when rain can be reliably expected or good **soil moisture exists**.
- Be aware of the need to keep grassy areas unburnt where and if they are required during late-season burns to 'push' fire into adjacent areas that are transitioning to closed forest (refer to Issue 2 and Issue 3).

FFDI: < 12

DI (KBDI): 100–160

Wind speed: < 15 km/hr

Soil moisture: Good moisture conditions to protect grass bases, hollow-bearing trees and fallen logs.

What burn tactics should I consider?

Tactics will be site specific and different burn tactics may need to be employed at the same site (e.g. due to topographical variation). Also, during the burn, tactics should be reviewed and adjusted as required to achieve burn objectives. What is offered below is not prescriptive; rather it is a toolkit of suggested tactics that may assist in this issue.

- **Progressive burning.** Fires (of varying extents, severity and at various times) are lit in surrounding fire-adapted communities from early in the year when conditions allow. This progressively creates areas of low fuel acting as a buffer to undertake burns in tall open forests later in the year (after these forests have dried out sufficiently). Refer to the glossary for a fuller discussion.
- **Using previously burnt grasses.** The first year after fire, regrowth grasses are green and will not carry a fire **early in the year** and can be used as a fire line. During the second year, there is a build up of dead grass material as the first year of grasses die-off. Fires will carry at this time, and especially during the third year when there is two years of dead grass build up.
- **Commence lighting on the leeward (smoky) edge.** This can be a useful way to create a containment edge for a higher severity fire ignited inside the burn area.

- **Backing fire with good residence time.** A slow moving backing fire (lit against the wind on the smoky edge or lit from upslope) will generally result in a more complete coverage of an area and ensures the fire has a greater amount of residence time, while ensuring fire intensity and rate of spread are kept to a minimum. Greater residence time is useful in reducing understorey density.
- **Spot ignition.** Can be used to alter the desired intensity of a fire particularly where there is an accumulation of volatile fuels. Spots closer together will result in a line of a greater intensity (as spots merge and create hot junction zones) while increased spacing between spots will result in a lower intensity fire. The spacing of the spots will regularly vary throughout the burn due to changes in weather conditions, topography and fuel loads.
- **Aerial ignition.** Where access is difficult or limited, or to cover extensive areas. Spot ignition and backing fires can be implemented with aerial ignition.

Spot igniting from a ridge spur allowing fire to back downhill into tall open forest.

Tim Devlin, QPWS, Mt Kinduro (2006).

Spot ignition, such as lighting around the back of this very tall tree, creates small fingers of fire that gradually draw into a forest. This can be very useful in steep terrain in order to reduce fire severity.

Tim Devlin, QPWS, Attie Creek (2009).

Issue 2: Manage tall open forests where seedlings / saplings are abundant in the mid-stratum

Tall open forests and woodlands in which pioneer rainforest, she-oak or acacia saplings or seedlings are abundant in the mid-stratum creates a sparser ground layer often characterised by sedges interspersed with leaf litter. Fire is required in order to prevent further thickening and the creation of a ground layer of shaded leaf litter in which fire becomes difficult to reintroduce.

Awareness of the environment

Key indicators of mid stratum overabundance:

- Mid-stratum has an abundance of seedlings/saplings including rainforest pioneers, she-oaks or acacias.
- In areas that were once grassy, the ground layer is becoming dominated by sedges interspersed with leaf litter. Other scattered leafy plants may be present.
- Grasses, sedges, dianellas, ferns and/or shrubs are declining in health and abundance due to shading. Grasses collapsing and appearing very sparse.
- Mid or lower-stratum is difficult to see through or walk through.
- Ground layer or shrubs are smothered by leaf litter in some areas.
- For shrubby tall open forests, mature shrubs have sparse crowns or are beginning to die with little or no new recruitment of shrubs in the ground layer.
- An accumulation of fuels with a diameter > 6 mm.
- Ribbon bark and fine branch material perched in shrub and sapling foliage.
- Bracken fern smothering native grasses, and dead material building up around bracken fern.

Shading from rainforest and she-oaks has created a ground layer characterised by sedges interspersed with leaf litter. Grasses and other ground layer plants are sparse.
Mark Parsons, QPWS, Taravale, plot 4 (2004).

Shading due to she-oaks. She- oak needles can smother native grasses. Barb wire grass and lomandra tend to persist under she-oaks but not in great numbers.
Mark Parsons, QPWS, Taravale, plot 5 (2004).

Mid-stratum has an abundance of young rainforest trees. Mid and lower-stratum is difficult to see through. Fallen material suspended in foliage.

Mark Parsons, QPWS, Taravale, plot 7 (2004).

Notice bracken fern smothering grasses, and presence of dead bracken fronds.

Justine Douglas, QPWS, Hinchinbrook Island (2008).

Discussion

- In the wet tropics, there is a group of rainforest pioneers that tend to always be present in the ground layer of this fire vegetation group and can grow into the mid-stratum quickly in the absence of fire.
- Certain she-oaks, acacias and hopbush *Dodonaea* spp. can germinate en masse. Where this has occurred, it is likely that follow up fires will be required. Post fire observations are essential to monitor the kill rate and germination of acacias in order to ascertain the need for subsequent fires.
- It is important to ensure the recruitment of tall open forest and woodland canopy species. Although **high**-severity fires may be necessary to control mid-stratum sapling overabundance, it may also have an impact on canopy species recruitment. Therefore once overabundant mid-stratum trees are controlled, return to a **low** to **moderate**-severity regime (refer to Issue 1).

Hopbush overabundance can quickly emerge after fire.
QPWS.

What is the priority for this issue?

Priority	Priority assessment
High	Planned burns to **maintain ecosystems** in areas where **ecosystem health** is **good**.
Medium	Planned burn in areas where **ecosystem health** is **poor** but recoverable.

Assessing outcomes

Formulating objectives for burn proposals

Every proposed burn area contains natural variations in topography, understorey or vegetation type. It is recommended that you select at least three locations that will be good indicators for the whole burn area. At these locations walk around and if visibility is good look about and average the results. Estimations can be improved by returning to the same locations before and after fire, and by using counts where relevant.

Select at least two of the following as most appropriate for the site:

Measurable objectives	How to be assessed	How to be reported (in fire report)
> 75 % of saplings < 2 m are scorched to the tip.	Select one or more sites or walk one or more transects (taking into account the variability of landform and likely fire intensity), estimate the percentage of overabundant saplings scorched.	**Achieved:** > 75 %. **Partially Achieved:** 25–75 %. **Not Achieved:** < 25 %.
< 25 % of young eucalypt plants > 5 m tall are scorched to the tip.	Select one or more sites or walk one or more transects (taking into account the variability of landform and likely fire intensity), estimate the number of scorched saplings >5m tall.	**Achieved:** < 25 %. **Partially Achieved:** 40–50 %. **Not Achieved:** > 50 %.
> 75 % fallen logs (with a diameter ≥ 10 cm) retained.	Select one or more sites or walk one or more transects (taking into account the variability of landform and likely fire intensity) and estimate number of fallen logs retained after fire.	**Achieved:** > 75 % retained. **Partially Achieved:** 50–75 % retained. **Not Achieved:** < 50 % retained.

If the above objectives are not suitable, refer to the compendium of planned burn objectives found in the monitoring section of the QPWS Fire Management System or consider formulating your own.

Monitoring the issue over time

Many issues are not resolved with a single planned burn and it is important to keep observing the land. To support this, it is recommended that observation points be established. Observation points are usually supported by photographs and by recording observations. Instructions for establishing observation points can be obtained from the monitoring section of the QPWS Fire Management System.

In moist conditions, a moderate intensity fire should still allow retention of habitat trees and fallen logs, and promote grass recruitment.

Enlargement highlights grass recruitment.

Paul Williams, Vegetation Management Science Pty Ltd, Taravale, plot 5 (2004).

Fire parameters

What fire characteristics will help address this issue?

Fire severity

- **Moderate** to **high**. Aim to scorch to the top of mid-stratum saplings so that all the leaves of undesired saplings are brown after fire. The target scorch height should be as high as the tip of the mid-stratum trees that you wish to control. If using high-severity fire, be aware of the potential for impacts on mature trees and fallen logs, and that the fire will be harder to contain (see tactics section and address containment issues prior to burning). Once mid-stratum overabundance is controlled, return to a low to moderate-severity regime (refer to Issue 1).
- It is possible that **low** to **moderate**-severity backing fire, with a high residence time around the base of overabundant saplings would be sufficient to brown off the leaves and kill the above ground component of the plant. But more testing should be undertaken to confirm this.

Fire severity class	Fire intensity (during the fire)		Fire severity (post-fire)	
	Fire intensity (kWm^{-1})	Average flame height (m)	Average scorch height (m)	Description (loss of biomass)
Moderate (M)	150–500	0.5–1.5	2.5–7.5	Moderate patchiness. Some scorched litter remains. About half the humus layer and grass stubble remain. Most habitat trees and fallen logs retained. Some scorch of elevated fuels. Little or no canopy scorch.
High (H)	500–1000	1.5–3.0	7.5–15.0	Some patchiness. Some humus remains. Some habitat trees and fallen logs affected. At least some canopy scorch in moderate. < 20 m height canopy, mid stratum burnt completely (or nearly so).

Note: This table assumes good soil moisture and optimal planned burn conditions.

Fire frequency / interval (refer to Appendix 2 for a discussion)

- Increase frequency of fire until overabundance is controlled.

Mosaic (area burnt within an individual planned burn)

- As much of the area dominated by mid stratum trees as possible.

Other considerations

- If the initial fire triggers a flush of new she-oak, hopbush or acacia seedlings, plan a follow-up burn within three years. A backing fire will help reduce seedlings.

A moderate-severity backing fire. Scorching to the tip of the sapling helps to ensure the above ground component is reduced.

Mark Parsons, QPWS, Girringun National Park (2010).

What weather conditions should I consider?

It is important to be aware of conditions prior to and following burns so that undesirable conditions and weather changes can be avoided, or to help with burn planning.

Season: Dry season (October, November, December or sometimes-early January)

FFDI: < 18

DI (KBDI): 140–190

Wind speed: < 23 km/hr. A good wind speed 15–23 km/hr can help achieve the desired severity. Be aware of containment issues.

Other considerations: A key factor for this issue is being available to implement burns as the window of opportunity (suitable weather) arises.

What burn tactics should I consider?

Tactics will be site specific and different burn tactics may need to be employed at the same site (e.g. due to topographical variation). Also, during the burn, tactics should be reviewed and adjusted as required to achieve burn objectives. What is offered below is not prescriptive; rather it is a toolkit of suggested tactics that may assist in this issue.

- **Progressive burning.** Fires (of varying extents, severity and at various times) are lit in surrounding fire-adapted communities from early in the year when conditions allow. This progressively creates areas of low fuel acting as a buffer to undertake burns in tall open forests later in the year (after these forests have dried out sufficiently). Refer to glossary for a fuller discussion.
- **Commence lighting on the leeward (smoky) edge.** This can be a useful way to create a containment edge for a higher severity fire ignited inside the burn area.
- Using **grassy areas to push fire** into areas with less available fuel is a common method to help fire carry into areas of tall open forest that are transitioning and therefore have an understorey less likely to carry fire.
- **A backing fire with good residence time.** A slow moving backing fire (lit against the wind on the smoky edge or lit from upslope) will generally result in a more complete coverage of an area and ensures the fire has a greater amount of residence time, while ensuring fire intensity and rate of spread are kept to a minimum. Greater residence time is useful in reducing understorey density.
- Creating a **running** fire (through closely spaces spot ignition or line ignition with the wind or slope) may help fire carry into areas transitioning to closed forest. Be aware of the risk of undesirable impacts such as loss of habitat trees and fallen logs and the need to return to a lower-severity regime once issue is controlled.
- **Line or strip ignition** is used to create a fire of higher intensity or to help fire carry through moist or inconsistent fuels. This is also useful to reduce overabundant trees (through scorching).
- **Aerial ignition.** Where access is difficult and limited, or to cover extensive areas.

Issue 3: Manage tall open forests at an advanced stage of transitioning

Abundant rainforest, acacia, or she-oak trees have shaded out the ground layer, which is characterised by leaf litter and an absence of ground layer plants. The tall open forest is close to transitioning to a closed forest where planned burns can no longer be reliably introduced. It is often necessary to use nearby grassy areas to carry fire into these areas. Windows of opportunity for fire management are few. These tall open forests can occur as pockets inside rainforest areas.

Awareness of the environment

Key indicators of where fire management is required

- Abundant rainforest pioneers, she-oaks or acacias are reaching beyond the mid-stratum and forming an almost closed structure.
- Ground layer plants are almost absent, and the ground layer is dominated by leaf litter.
- Vines scramble onto mid-stratum saplings and lower-canopy branches.
- Presence of ferns on rocks and epiphytes in the lower or mid-stratum.
- Dead, dying, or rank sword sedge *Gahnia* spp.
- An accumulation of fuels with a diameter > 6 mm on the ground and suspended in foliage.
- Heavy build up of bark around bases of trees.

A mature stage of transitioning in a shrubby tall open forest. Notice the abundance of rainforest pioneers and a build up of heavy fuels on the ground and suspended in shrubs. It is still possible to introduce fire.

Mark Parsons, QPWS, Mount Windsor (2010).

A mature stage of transitioning. In the right conditions, it is still possible to introduce fire.
Mark Parsons, QPWS, Girringun National Park (2008).

An advanced stage of transitioning. It would be very difficult to introduced planned fire.
Paul Williams, Vegetation Management Science Pty Ltd, Mt Fox (2005).

Other indicators of long unburnt areas include the presence of ferns on rocks, epiphytes in the mid or lower-stratum and dead or dying Gahnia. These are also important features that add habitat diversity and refuge, so their loss in any one single fire event is not desirable.

Mark Parsons, QPWS, Mount Windsor (2010).

Discussion

- Certain she-oaks, acacias and hopbush *Dodonaea* spp., can germinate en masse. Where this has occurred, it is likely that follow up fires will be required. Post fire observations are essential to monitor the kill rate and germination of acacias in order to ascertain the need for subsequent fires.
- It is important to ensure the recruitment of tall open forest and woodland canopy species. Although **high**-severity fires may be necessary to control mid-stratum sapling overabundance, it may also have an impact on canopy species recruitment and therefore should be interspersed by **low**-severity fires.

What is the priority for this issue?

Priority	Priority assessment
Medium	Planned burn in areas where **ecosystem health is poor** but recoverable.
Low	Planned burn in areas where **ecosystem** structure and function has been **significantly disrupted**.

Assessing outcomes

Formulating objectives for burn proposals

Every proposed burn area contains natural variations in topography, understorey or vegetation type. It is recommended that you select at least three locations that will be good indicators for the whole burn area. At these locations walk around and if visibility is good look about and average the results. Estimations can be improved by returning to the same locations before and after fire, and by using counts where relevant.

Measurable objectives	How to be assessed	How to be reported (in fire report)
> 50 % of saplings scorched to the tip.	Select one or more sites or walk one or more transects (taking into account the variability of landform and likely fire intensity); estimate the percentage of overabundant saplings scorched by fire.	**Achieved:** > 50 %. **Partially Achieved:** 25–50 %. **Not Achieved:** < 25 %.
Regeneration of eucalypt species.	Select one or more sites or walk one or more transects (taking into account the variability of landform and likely fire intensity), estimate the number of live eucalypt saplings > 5 m tall.	**Achieved:** Abundant eucalypt regeneration observed. **Partially Achieved:** Some eucalypt regeneration observed. **Not Achieved:** Little or no eucalypt regeneration observed.

If the above objectives are not suitable, refer to the compendium of planned burn objectives found in the monitoring section of the QPWS Fire Management System or consider formulating your own.

Monitoring the issue over time

Many issues are not resolved with a single planned burn and it is important to keep observing the land. To support this, it is recommended that observation points be established. Observation points are usually supported by photographs and by recording observations. Instructions for establishing observation points can be obtained from the monitoring section of the QPWS Fire Management System.

An advanced stage of transitioning. Site not burnt for at least 15 years.

Mark Parsons, QPWS, Taravale, plot 7 (2009).

The same site eight months later. Post fire, the reduction of saplings to ground level is clearly visible.

Mark Parsons, QPWS, Taravale, plot 7 (2010).

Fire parameters

What fire characteristics will help address this issue?

Fire severity

High. And sometimes up to **very high** for highly-advanced transitioning, however it is not recommended to exceed an average **flame height** of **five metres**. Aim to scorch to the tip of overabundant trees so that all the leaves of undesired trees are browned after fire. Be aware that these higher-severity fires are recommended only to address this specific issue and need to be implemented with due caution and consideration of containment issues.

It is possible that **moderate**-severity backing fire, with a high residence time around the base of overabundant saplings would be sufficient to brown off the leaves and kill the above ground component of the plant. But more testing should be undertaken to confirm this.

Fire severity class	Fire intensity (during the fire)		Fire severity (post-fire)	
	Fire intensity (kWm^{-1})	Average flame height (m)	Average scorch height (m)	Description (loss of biomass)
High (H)	500–1000	1.5–3.0	7.5–15.0	Some patchiness. Some humus remains. Some habitat trees and fallen logs affected. At least some canopy scorch in moderate < 20 m height canopy, mid stratum burnt completely (or nearly so).
Very high (VH)	1000–3000	3.0–10.0	Extensive scorching	All understorey burnt to ash (or nearly so). Most habitat trees and fallen logs affected. Extensive crown scorch.

Note: This table assumes good soil moisture and optimal planned burn conditions.

Fire frequency / interval (refer to Appendix 2 for a discussion)

- This issue will not be resolved with one fire. Follow up burns are essential. Monitor fuel build-up and plant response and plan subsequent fires in the following years accordingly.

Mosaic (area burnt within an individual planned burn)

- Good burn coverage is required in areas dominated by overabundant seedlings or saplings.

Other considerations

- If the initial fire triggers a flush of new she-oak, hopbush or acacia seedlings, plan a follow-up burn within three years.

What weather conditions should I consider?

It is important to be aware of weather predictions prior to and following burns so that undesirable conditions and weather changes can be avoided.

Season: Dry season (October, November and December)

FFDI: 18–24

DI (KBDI): 150–200

Wind speed: 15–23 km/hr. Use wind to help carry fire into transitioning areas. Be aware of containment issues.

Other considerations: Be available to implement burns as a priority as windows of opportunity arise. Some cases of transitioning can only be addressed under rare weather conditions.

What burn tactics should I consider?

Tactics will be site specific and different burn tactics may need to be employed at the same site (e.g. due to topographical variation). Also, during the burn, tactics should be reviewed and adjusted as required to achieve burn objectives. What is offered below is not prescriptive; rather it is a toolkit of suggested tactics that may assist in this issue.

- **Progressive burning.** Fires (of varying extents, severity and at various times) are lit in surrounding fire-adapted communities from early in the year when conditions allow. This progressively creates areas of low fuel acting as a buffer to undertake burns in tall open forests later in the year (after these forests have dried out sufficiently). Refer to glossary for a fuller discussion.
- **Commence lighting on the leeward (smoky) edge.** This can be a useful way to create a containment edge for a higher severity fire ignited inside the burn area.
- Using **grassy areas to push fire** into areas with less available fuel is a common method to help fire carry into areas of tall open forest that are transitioning and therefore have an understorey less likely to carry fire.
- Creating a **running** fire (through closely spaces spot ignition or line ignition with the wind) may help fire carry into areas transitioning to closed forest. Be aware of the risk of undesirable impacts such as loss of habitat trees and fallen logs.
- **Line or strip ignition** is used to create a fire of higher intensity or to help fire carry through moist or inconsistent fuels. This is also useful to reduce overabundant trees (through scorching).
- **Aerial ignition.** Where access is difficult or limited.

Issue 4: Reduce *Lantana camara*

Refer to Chapter 11 (Issue 5), regarding fire management guidelines.

Lantana infestations in tall open forests can dominate the ground and mid-strata layers.

Mark Parsons, QPWS, Girringun National Park (2008).

The same site three months later following the integrated use of fire and herbicide (splatter mix), to remove lantana biomass from this endangered ecosystem. Grasses have begun to establish.

Mark Parsons, QPWS, Girringun National Park (2008).

Chapter 4: Grasslands, sedgelands and fernlands

This fire vegetation group is treeless and shrubless, dominated by one or two species of grass, sedge or fern, with other ground layer plants scattered. This group occurs in coastal, lowland and highland areas; in relatively small extents. It includes a range of ecosystems that are quite different in terms of their fire management needs as described below.

Coastal wetland grasslands, sedgelands and fernlands

In the wet tropics, grasslands, sedgelands and fernlands often occur within coastal wetland systems (such as Eubenangee Swamp) and are typically permanently or seasonally inundated.

Highland grasslands, sedgelands and fernlands

These communities are very restricted in distribution. Sedgelands and fernlands occur in moist highland on shallow soils usually on slopes with perpetual water available from clouds or seepage. Upland grasslands tend to occur in drier highland areas in the west of the wet tropics.

Grasslands of the coastal slopes

Grasslands dominated by kangaroo grass T*hemeda triandra* and *Themeda triandra* with blady grass *Imperata cylindrica* occur on steep coastal hill-slopes of coastal headlands and nearby islands, particularly Orpheus Island and the Palm Island group. These occur on shallow soils and readily dry-out under the influence of coastal breezes.

Fire management issues

A key conservation issue is loss of remaining examples of wetland grasslands, sedgelands and fernlands as they become dominated by melaleuca or rainforest pioneers in the absence of fire. These communities are ideally burnt when water is standing but has receded, exposing available fuel (wind may be required to fan flames). Because conditions with standing water but exposed fuel are scarce, burning with standing water is not always possible, but ensuring there is enough moisture to avoid peat fires is still important. Be aware of the need to avoid scorching coastal (littoral) rainforest edges, and to manage for the presence of high biomass grasses and pond apple. Sedgelands and fernlands have particularly high species diversity and local endemism (species evolved to that particular location) that poorly timed fire will impact on.

Grassy coastal headlands are rare, and their conservation is a high priority. Some of these communities have the potential to be threatened by invasive shrubs, especially acacia and lantana, in the absence of fire. The presence of lantana in some locations may also be associated with overgrazing of grassy headlands by goats and rabbits.

Planned burning under appropriate moisture conditions will assist in mitigating impacts of unplanned fire, allowing these communities to persist.

Issues:

1. Maintain wetland grasslands.
2. Maintain wetland sedgelands and fernlands.
3. Maintain upland grasslands, sedgelands and fernlands.
4. Reduce overabundant seedlings/saplings.
5. Manage high-biomass invasive grasses.
6. Maintain grasslands of the coastal slopes.
7. Limit fire encroachment into non-target communities.
8. Exclude fire from sedgeland of volcanic lakes.

Extent within bioregion: 4 812 ha, < 1 per cent; **Regional ecosystems:** Refer to Appendix 1 for complete list.

Examples of this FVG: Girringun National Park, 365 ha; Eubenangee Swamp National Park, 280ha; Russell River National Park, 143 ha; Orpheus Island National Park, 105 ha; Etty Bay Road Conservation Park, 98 ha; Wooroonooran National Park, 82 ha; Tully Gorge National Park, 72 ha; Annan River (Yuku Baja-Muliku) Resources Reserve, 60 ha; Daintree National Park, 57 ha; Monkhouse Timber Reserve 50ha, Herberton Range State Forest 27ha, Mount Mackay National Park 25ha, Hasties Swamp National Park, 18 ha; Cedar Bay National Park, 16 ha; Paluma Range National Park, 15 ha; Japoon National Park, 13 ha; Hinchinbrook Island National Park, 13 ha; Ella Bay National Park, 7 ha; Mount Windsor National Park, 5 ha; Danbulla National Park, 5 ha; Malbon Thompson Forest Reserve, 5 ha; Ingham State Forest, 2 ha; Koombooloomba South Forest Reserve, 2 ha; Hull River National Park, 1 ha; Kuranda National Park, 1 ha; Moresby Range National Park, 1 ha; Mowbray National Park, 1 ha.

Issue 1: Maintain wetland grasslands

Use fire to maintain inundated (permanent and seasonal) grasslands. See GIS layer and map label 'Gw'.

Awareness of the environment

Key indicators of healthy coastal wetland grasslands:

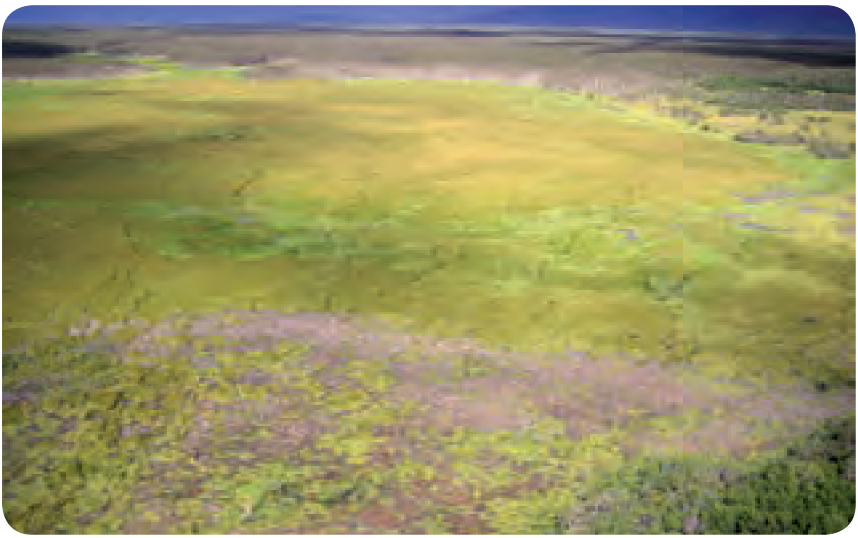
- A dense cover of native grass, usually dominated by one or two species, potentially with other ground layer plants scattered.
- No or only scattered sedges present.
- No trees or only scattered trees present.

Healthy wetland grassland. Notice grasses are erect and green. The amount of dead material is very limited.

Jeanette Kemp, Queensland Herbarium, Eubenangee Swamp National Park (2007).

Healthy wetland grassland. There are only scattered trees.

Les Jackson, QPWS, Eubenangee Swamp National Park (2010).



Bulkuru marine plain grassland.

Mark Parsons, QPWS, Bulkuru swamp, Warrina Plains, Girramay National Park (2010).

Early signs of where fire may be required to maintain coastal wetland grasslands:

- Build up of dead material around the base of grasses. Grasses are no longer erect—rather, they are beginning to collapse.
- Sedges and/or ferns becoming more than scattered.
- Seedlings of pond apple are present.
- Seedlings of melaleuca, she-oak or rainforest species are present.

Indicators of the need for fire. Notice the presence of sedge and the build up of dead material around the base of grasses. A number of grasses have collapsed.

Les Jackson, QPWS, Eubenangee Swamp National Park (2010).

The presence of melaleuca seedlings also indicates the need for fire.

Les Jackson,QPWS, Eubenangee Swamp National Park (2010).

Discussion

- Retaining remaining native wetland grasslands is a conservation priority. With inappropriate fire management they become dominated by sedges and melaleuca and/or rainforest trees. Regular fire is a key aspect to control the transition to forest.
- Peat fires should be avoided. However peat fires that are not extensive, down to about a metre in depth, might form a desirable aspect of wetland systems and restore channels of water movement within wetland landscapes. It is not necessary to plan to burn peat—it will burn occasionally due to minor fluctuations in topography and moisture.
- Fire is the most important tool for controlling pond apple in wetland environments where the understorey is dense enough to sustain fire. The fire must scorch to the living tip of pond apple. Fire also kills the seeds. Pond apple also occurs in permanently inundated areas or rainforest where it cannot be controlled with fire—in which case mechanical methods are used (CRC for Australian Weed Management 2003).
- High biomass invasive grasses increase fuel load, fire intensity and flame height (if present refer to Issue 5). In Eubenangee swamp, fire has been used to control the relative abundance of signal grass *Urochloa decumbens* and creeping signal grass Urochloa humidicola. Although these species recover from fire, it has been found that the recovery of native grasses is better, so fire gives native grasses a competitive advantage.
- Monitor after fire for the presence of melaleuca seedlings. If there is a flush of seedlings, plan a subsequent fire to control them.

Pond apple in wetland grassland.
Kylie Goodall, QPWS, Eubenangee Swamp National Park (2010).

What is the priority for this issue?

Priority	Priority assessment
Very high	Planned burn required to maintain areas of **special conservation significance**.

Assessing outcomes

Formulating objectives for burn proposals

Every proposed burn area contains natural variations in topography, understorey or vegetation type. It is recommended that you select at least three locations that will be good indicators for the whole burn area. At these locations walk around and if visibility is good look about and average the results. Estimations can be improved by returning to the same locations before and after fire, and by using counts where relevant.

Select from below as appropriate:

Measurable objectives	How to be assessed	How to be reported (in fire report)
> 75 % of saplings/ seedlings are scorched to the tip.	Select one or more sites or walk one or more transects (taking into account the variability of landform and likely fire severity), estimate the percentage of saplings/seedlings scorched.	**Achieved:** > 75 %. **Partially Achieved:** 25–75 %. **Not Achieved:** < 25 %.
> 95 % of grasses recover after fire.	Before and after fire, select three or more sites (taking into account the variability of landform and likely fire intensity) and estimate cover of grasses that recover one to three months after fire.	**Achieved:** > 95 % recover. **Partially Achieved:** 90–95 % recover. **Not Achieved:** < 90 % recover OR exotic grasses were promoted.

Significant reduction in pond apple.	Seek advice from resource staff and/or publications such as the Parks Victoria Pest Plant Mapping and Monitoring Protocol (Parks Victoria 1995). One option is given here. Before fire and after suitable germination and establishment conditions (taking into account the variability of landform and likely fire intensity), define the density of the infestation using the following criteria (from Parks Victoria Protocol [Parks Victoria 1995]): • Rare (0–4 % cover) = target weed plants very rare. • Light (5–24 % cover) = native species have much greater abundance than target weed. • Medium (25–75 % cover) = roughly equal proportions of target weed and native species. • Dense (> 75 %) = monoculture (or nearly so) of target weed.	**Achieved:** Weed infestation ‘drops’ two ‘density categories’ (e.g. goes from dense before the fire to light after the fire). **Partially Achieved:** Weed infestation ‘drops’ one ‘density category’ (e.g. goes from dense before the fire to medium after the fire). **Not Achieved:** No change in density category or weed density gets worse.

If the above objectives are not suitable, refer to the compendium of planned burn objectives found in the monitoring section of the QPWS Fire Management System or consider formulating your own.

Monitoring the issue over time

Many issues are not resolved with a single planned burn and it is important to keep observing the land. To support this, it is recommended that observation points be established. Observation points are usually supported by photographs and by recording observations. Instructions for establishing observation points can be obtained from the monitoring section of the QPWS Fire Management System.

Consider observing the abundance of sedge and melaleuca plants in relation to grasses over time.

Select from below as appropriate:

Fire parameters

What fire characteristics will help address this issue?

Fire severity

Moderate and sometimes high.

Fire severity class	Fire intensity (during the fire)		Fire severity (post-fire)	
	Fire intensity (kWm^{-1})	Average flame height (m)	Average scorch height (m)	Description (loss of biomass)
Moderate (M)	100–1500	0.5–1.5	Complete standing biomass removed	All surface and near surface fuels burnt. Stubble burnt to blackened remnants.
High (H)	1500–5300	1.5–4.0	Complete biomass removed	Ground burnt completely. Stubble burnt to ash.

Note: This table assumes good soil moisture and optimal planned burn conditions.

Fire frequency / interval (refer to Appendix 2 for a discussion)

- Fire frequency should primarily be determined through **on-ground assessment of vegetation health, fuel accumulation** and **previous fire patchiness** and adjusted for wildfire risk and drought cycles.
- 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). Consider a broad fire interval range of between three to five years.

Mosaic (area burnt within an individual planned burn)

- Because of the adjoining nature of fuel in these areas the entire planned burn area tends to burn with no internal mosaic. Mosaics are only possible if planned at a landscape level (by targeting different areas in different years).

Landscape mosaic

- At least 25 per cent of these communities in the wet tropics should be burnt in a year.

Other issues

- Grasslands and sedgelands have different fire regimes, but because they are often contiguous, applying the different regimes is difficult. Well thought out choice of weather conditions, wind direction and ignition strategies will help. Use of constructed breaks is discouraged because they introduce impacts such as weeds into these rare communities.
- These fires can produce a great deal of smoke. Be aware for the need to plan to minimise smoke impacts on urban settlements and roads.

If the above objectives are not suitable, refer to the compendium of planned burn objectives found in the monitoring section of the QPWS Fire Management System or consider formulating your own.

Dense smoke can be created when burning grasslands. Choosing conditions that carry smoke away from settled areas is desirable.

Mark Parsons, QPWS, Stony Creek, Girringun National Park (2010).

What weather conditions should I consider?

It is important to be aware of conditions prior to and following burns so that undesirable conditions and weather changes can be avoided, or to help with burn planning.

Season: Windows of opportunity to burn native grasslands are rare—take opportunities to introduce fire when conditions allow. Windows of opportunity in grassland areas usually occur **from the beginning of August until December.**

GFDI: < 20

DI (KBDI): 140–200

Wind speed: < 23 km/hr. Winds of 15–23 km/hr will help carry fire through moist areas.

Soil moisture: Standing water. If standing water is absent, grass bases should at least be water logged to avoid peat fires. Do not plan peat fires—occasional peat fires may be a natural part of these communities and can help restore channels of water movement.

Exposed grass fuels: Although the presence of water (to avoid peat fires) is important, the water must have receded enough to expose available grass fuels to enable the site to burn.

What burn tactics should I consider?

Tactics will be site specific and different burn tactics may need to be employed at the same site. Also, during the burn, tactics should be reviewed and adjusted as required to achieve burn objectives. What is offered below is not prescriptive; rather it is a toolkit of suggested tactics that may assist in this issue.

- **Commence lighting on the leeward (smoky) edge** to contain the fire and promote a low intensity backing fire. Depending on available fuels and the prevailing wind on the day this may require either spot or strip lighting or a combination of both.
- **Limit fire encroachment into non-target communities.** In some cases, mesophyll vine forest and coastal littoral rainforests occur adjacent to grasslands. These rainforests are highly endangered and can be damaged by fire. Use appropriate lighting patterns along the margin to promote a **backing fire** that burns away from the non target community (refer to Chapter 11).

- Creating a **running** fire (through closely spaced spot ignition or line ignition with the wind) may help carry fire into transitioning areas (sedge, melaleuca or rainforest).
- **Line or strip ignition** is used to create a fire of higher severity or to help fire carry through moist or inconsistent fuels. This is also useful to reduce overabundant trees (through scorching).
- **Staged burning.** Grassland and sedgeland are usually continuous and need to be burnt in association. Staging burning so that different areas are burnt at different times of the day or with different conditions can help differentiate the burning of grassland as opposed to sedgelands.
- **Burning-off cane headlands.** Uncultivated land adjacent to cane fields can be used as an edge to burn from. In these areas begin burning by securing the edge adjacent to cane areas.
- Fires, and especially peat fires, are very **difficult to extinguish** in wetland grasslands. It is essential that containment issues are carefully addressed at planning stage.

Evening ignition can be a successful tactic for lowland wetlands. It also favours a land breeze lowering risk of embers igniting cane trash or native forest.

Mark Parsons, QPWS, Yingalinda Girramay (2009).

Issue 2: Maintain wetland sedgelands and fernlands

Use fire to maintain coastal wetland sedgelands and fernlands.

Refer to GIS layer and map label Sfw.

Awareness of the environment

Key indicators of healthy wetland sedgelands and fernlands:

- A dense cover of sedges or ferns, which may be dominated by one or two species, but with a high diversity of mixed ground layer plants. Fernlands in particular can have a complex mix of flora and fauna.
- There are no trees or only scattered trees present.
- Sedgelands and fernlands often occur in standing water.
- Scattered pandanus may be present.

Sedges and grasses with standing water.

Paul Williams, Vegetation Management Science Pty Ltd, Dallachy Creek, Girramay National Park (1998).

The complex nature of fernlands. If left long unburnt, patchy fires become difficult to achieve.

Mark Parsons, QPWS, Maria Creek National Park (2010).

From foreground to background: grassland, sedgeland and *Melaleuca quinquenervia* open forest. Notice that the sedgeland ecotone can be very narrow and in the absence of fire, melaleuca will dominate.

Jeanette Kemp, Queensland Herbarium, Eubenangee Swamp National Park (2007).

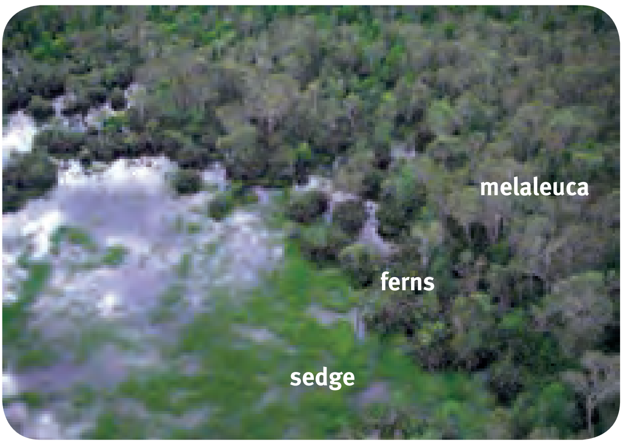


Image illustrating the ecotone between marine sedgeland, fernland and melaleuca dominated areas.

Hydrology is a key aspect in determining this ecotone, but fire will impact on the relative presence of melaleuca.

Mark Parsons, QPWS, Mount Coom, Hull River National Park (2010).

Signs of where fire may be required:

- Build-up of dead material around the bases of sedges. Sedges no longer erect, rather, they are beginning to collapse.
- Build-up of dead material around the bases of ferns.
- Fuel perched on sedges or ferns.
- Seedlings of pond apple are present.
- Seedlings of melaleuca, casuarinas or rainforest plants are present.

Depicting a build-up of dead material around the bases of ferns and sedges and high levels of perched fuel.

Mark Parsons, QPWS, Hull River National Park (2010).

Rainforest pioneers emerging in a fernland.

Mark Parsons, QPWS, Maria Creek National Park (2010).

A build-up of dead material around the base of gahnia.

Mark Parsons, QPWS, Hull River National Park (2010).

Discussion

- Retaining remaining native sedgelands and fernlands is a conservation priority. With inappropriate fire management they become dominated by melaleuca, casuarinas and/or rainforest trees.
- As illustrated in the photographs above, hydrology is a determining factor with lowland sedgelands and fernlands occupying narrow hydrological ecotones. Sedgelands and fernlands overtopped by melaleuca are natural ecosystems (refer to Chapter 6); however, without appropriate fire management, the melaleuca will increase in distribution.
- Sedgelands and fernlands have particularly high species diversity and local endemism (species evolved to that particular location) that poorly timed fire will impact on. In forest influenced lowland sedgelands and fernlands near creeks and rainforests, particularly where canegrass and pandanus is present, timing of fire is important due to the presence of the endangered crimson finch, the peppermint stick insect and related fauna. Fires late in the dry season can destroy habitat and animal refuges especially if fuel has built-up in the long absence of fire. Where this has occurred, try to introduce early-season fires or use evening ignition.
- Some lowland sedgelands will only burn under dry conditions and require longer periods of time than grassland to build-up sufficient fuel. Windows of opportunity to undertake burning with standing water present may only occur rarely so burning with soil moisture may be sufficient to avoid peat fire and protect the base of sedges in these areas.
- Lowland sedgelands and fernlands play an important role in maintaining landscape hydrological movement. In long unburnt areas, sedgelands can accumulate very high fuel loads that can impede hydrological flows and increase the risk of peat fire developing. Peat fires should be avoided. However peat fires that are not extensive, down to about a metre in depth, might form a desirable aspect of wetland systems and restore channels of water movement. It is not necessary to plan to burn peat; it will burn occasionally due to minor fluctuations in topography and moisture.
- Fire is the most important tool for controlling pond apple in wetland environments where the understorey is dense enough to sustain fire. The fire must scorch to the living tip of pond apple. Fire also kills the seeds. Pond apple also occurs in permanently inundated areas or rainforest where it cannot be controlled with fire; in which case mechanical methods are used. (CRC for Australian Weed Management 2003).

What is the priority for this issue?

Priority	Priority assessment
Very high	Planned burn required to maintain areas of **special conservation significance.**

Assessing outcomes

Formulating objectives for burn proposals

Every proposed burn area contains natural variations in topography, understorey or vegetation type. It is recommended that you select at least three locations that will be good indicators for the whole burn area. At these locations walk around and if visibility is good look about and average the results. Estimations can be improved by returning to the same locations before and after fire, and by using counts where relevant.

Select from the below as appropriate:

Measurable objectives	How to be assessed	How to be reported (in fire report)
> 75 % of saplings/ seedlings are scorched to the tip.	Select one or more sites or walk one or more transects (taking into account the variability of landform and likely fire severity); estimate the percentage of saplings/seedlings scorched.	**Achieved:** > 75 %. **Partially Achieved:** 25–75 %. **Not Achieved:** < 25 %.
> 95 % of sedges and ferns recover after fire.	Before and after fire, select three or more sites (taking into account the variability of landform and likely fire intensity) and estimate cover of sedges and ferns that recover one to three months after fire.	**Achieved:** > 95 % recover. **Partially Achieved:** 90–95 % recover. **Not Achieved:** < 90 % recover.
Significant reduction in pond apple.	Before fire and after suitable germination and establishment conditions (taking into account the variability of landform and likely fire intensity), define the density of the infestation using the following criteria (from Parks Victoria Protocol [Parks Victoria 1995]): • Rare (0–4 % cover) = target weed plants very rare. • Light (5–24 % cover) = native species have much greater abundance than target weed. • Medium (25–75 % cover) = roughly equal proportions of target weed and native species. • Dense (> 75 %) = monoculture (or nearly so) of target weed.	**Achieved:** Weed infestation ‘drops’ two ‘density categories’ (e.g. goes from dense before the fire to light after the fire). **Partially Achieved:** Weed infestation ‘drops’ one ‘density category’ (e.g. goes from dense before the fire to medium after the fire). **Not Achieved:** No change in density category or weed density gets worse.

If the above objectives are not suitable, refer to the compendium of planned burn objectives found in the monitoring section of the QPWS Fire Management System or consider formulating your own.

Monitoring the issue over time

Many issues are not resolved with a single planned burn and it is important to keep observing the land. To support this, it is recommended that observation points be established. Observation points are usually supported by photographs and by recording observations. Instructions for establishing observation points can be obtained from the monitoring section of the QPWS Fire Management System.

Consider monitoring for the presence and abundance of melaleuca seedlings. This will provide useful information in planning fires.

For wetlands, where possible, leave refuges either as unburnt mosaics or partially consumed fuels. This not only provides cover for invertebrates, skinks and amphibians but will also result in quicker recovery of gahnia sedges and *Lepironia* spp. ferns.

Left: Mark Parsons, QPWS, Whitfield Creek, Girramay National Park (2010).

Above: Marbled Frog, Russell Best, QPWS, Hull River National Park (2009).

Fire parameters

What fire characteristics will help address this issue?

Fire severity

Moderate in open sedgeland and fernland. In forest influenced sedgelands and fernlands near creeks and rainforests, particularly where canegrass and pandanus is present attempt to use **patchy** to **low** (unless overabundant sapling/seedlings is a problem).

Fire severity class	Fire intensity (during the fire)		Fire severity (post-fire)	
	Fire intensity (kWm^{-1})	Average flame height (m)	Average scorch height (m)	Description (loss of biomass)
Patchy (P)	< 50	< 0.3	≤ 1.5	High percentage of patchiness. Does not remove all the surface fuels (litter) and near surface fuels.
Low (L)	50–100	0.3–0.5	≤ 2.5	Some patchiness. Most of the surface and near surface fuels have burnt. Stubble still evident.
Moderate (M)	100–1500	0.5–1.5	Complete standing biomass removed	All surface and near surface fuels burnt. Stubble burnt to blackened remnants.

Note: This table assumes good soil moisture and optimal planned burn conditions.

Fire frequency / interval (refer to Appendix 2 for a discussion)

- Fire frequency should primarily be determined through **on-ground assessment of vegetation health, fuel accumulation** and **previous fire patchiness** and adjusted for wildfire risk and drought cycles.
- 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). Consider a broad fire interval range of between eight to twelve years for lowland sedgelands and fernlands.

Mosaic (patchiness of individual burns)

- Variation in topography and water logging will create a natural mosaic of burnt and unburnt areas.

Landscape mosaic

- Burn at least 25–30 per cent of these communities in the wet tropics in a year.

Other considerations

- High biomass invasive grasses increase fuel load, fire intensity and flame height (if present, refer to Issue 5).
- Monitor after fire for the presence of melaleuca seedlings. If there is a flush of seedlings, plan a subsequent fire to control them.

An early-season burn depicting very low smoke generation, a stable fire front and the retention of unconsumed fuels (that act as fauna refuges).

Mark Parsons, QPWS, Whitfield Creek, Girramay National Park (2010).

What weather conditions should I consider?

It is important to be aware of conditions prior to and following burns so that undesirable conditions and weather changes can be avoided, or to help with burn planning.

Season: Anywhere from **June to December.** Note that earlier burns (from **June**) will create patchier fires that are ideal for introducing fire into long unburnt areas (particularly areas with cane grass and pandanus). Burns in dry conditions (from **October to December**) create more extensive burns and are often required for wetland sites (be aware of the requirement for sufficient moisture—see below). Take opportunities to introduce fire when conditions are available—windows of opportunity to burn wetland sedgelands are rare.

GFDI: < 20

DI (KBDI): 100–200

Wind speed: < 23 km/hr. Winds > 15–23 km/hr help carry the fire into transitioning areas.

Soil moisture: Standing water—if standing water is absent sedge bases should be at least waterlogged to avoid peat fires. Do not plan peat fires—occasional peat fires may be a natural part of these communities and can help restore channels of water movement.

What burn tactics should I consider?

Tactics will be site specific and different burn tactics may need to be employed at the same site. Also, during the burn, tactics should be reviewed and adjusted as required to achieve burn objectives. What is offered below is not prescriptive; rather it is a toolkit of suggested tactics that may assist in this issue.

- **Commence lighting on the leeward (smoky) edge** to contain the fire and promote a low intensity backing fire. Depending on available fuels and the prevailing wind on the day this may require either spot or strip lighting or a combination of both.
- **Limit fire encroachment into non-target communities.** In many cases, mesophyll vine forest and coastal littoral rainforests occur adjacent to sedgelands and fernlands. These rainforests are highly endangered and can be damaged by fire. Use appropriate lighting patterns along the margin of the non-target community to promote a backing fire that burns away from the non-target community (refer to Chapter 11).
- Creating a **running** fire (through closely spaced spot ignition or line ignition with the wind) may help fire carry into transitioning areas.
- **Line ignition** is used to create a fire of higher severity or to help fire carry through moist or inconsistent fuels. This is also useful to reduce overabundant trees (through scorching).
- **Strip ignition to draw** fire away from non-target community edge. Using more than one line of ignition can create convective updrafts which draw fires together and away from non-target areas. It is important to have safe refuges when undertaking this type of burning (e.g. for lighting along a track the person furthest from the track should walk parallel to the track and at least 20 metres ahead of the person lighting nearer the track). This reduces the chance of the 'outer' person becoming cut off from the refuge area (the track).
- **Staged burning.** Grassland and sedgeland communities often need to be burnt in association. Staging burning so that different areas are burnt at different times of the day or with different conditions can help differentiate the burning of grassland as opposed to sedgelands.
- It is possible to target pockets from **June** under low wind conditions with a **backing fire**, to allow fire to trickle on the surface of perched fuel with standing or receding water or with high moisture content. This will create patchy fires.

Issue 3: Maintain upland grasslands, sedgelands and fernlands

Use fire to maintain grasslands, sedgelands and fernlands in upland locations. Refer to GIS layer and map labels 'Gu' for upland grassland and 'Sfu' for upland sedgeland/fernland.

Awareness of the environment

Key indicators of healthy upland grassland, sedgeland and fernland:

- A dense cover of grasses, sedges or ferns, which may be dominated by one or two species, but with other ground layer plants present. Fernlands in particular can have a complex mix of flora and fauna.
- There are no or only scattered trees or shrubs.

Upland grassland. Trees are beginning to encroach.
Mike Ahmet, QPWS, Towalla, Wooroonooran National Park (2000).

In planning fire management, do not overlook grasslands, sedgelands or fernlands that are completely surrounded by rainforest or open forest. These are especially vulnerable to being lost in the absence of fire.

Mike Ahmet, QPWS, Towalla, Wooroonooran National Park (2000).

An ephemeral sedgeland. Burn surrounding areas when standing water is present in the sedgeland.

Mark Parsons, QPWS, Henrietta Creek, Girringun National Park (2010).

Signs of where fire may be required:

- Build up of dead material around the bases of grasses and sedges. Grasses and sedges no longer erect, rather, they are beginning to collapse.
- Grass fuel becoming less continuous and grasses becoming scattered.
- Build up of dead material around the bases of ferns.
- Fuel perched on sedges or ferns.
- Seedlings of acacia, melaleuca, casuarinas or rainforest plants are present.

Notice the build up of dead material at the bases of grasses and sedge.

Also, acacia and casuarina seedlings are emerging.

Mike Ahmet, QPWS, Towalla, Wooroonooran National Park (2000).

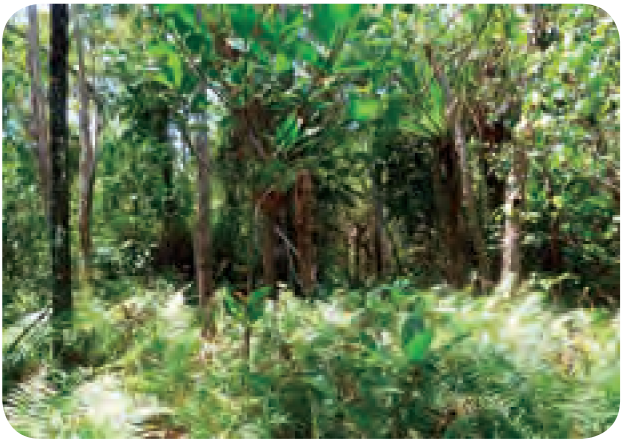
Notice that grass fuel is less continuous and grasses are becoming quite scattered.

This area is long unburnt.

Mike Ahmet, QPWS, Towalla, Wooroonooran National Park (2000).

Depicting a build-up of dead material around the bases of ferns and sedges and high levels of perched fuel.

Mark Parsons, QPWS, Hull River National Park (2010).



Rainforest pioneers emerging in a fernland.

Mark Parsons, QPWS, Maria Creek National Park (2010).

Discussion

- Retaining remaining grassland, sedgelands and fernlands is a conservation priority. With inappropriate fire management they become dominated by acacia, melaleuca, casuarinas and/or rainforest trees.
- Highland grassland tends to be managed in association with other montane communities (refer to Chapter 5), and as part of aerial ignition operations. Aim to burn grassland areas with a more frequent fire frequency than other montane communities.

What is the priority for this issue?

Priority	Priority assessment
Very high	Planned burn required to maintain areas of **special conservation significance.**

Assessing outcomes

Formulating objectives for burn proposals

Every proposed burn area contains natural variations in topography, understorey or vegetation type. It is recommended that you select at least three locations that will be good indicators for the whole burn area. At these locations walk around and if visibility is good look about and average the results. Estimations can be improved by returning to the same locations before and after fire, and by using counts where relevant.

Select from below as appropriate:

Measurable objectives	How to be assessed	How to be reported (in fire report)
> 75 % of saplings/ seedlings are scorched to the tip.	Select one or more sites or walk one or more transects (taking into account the variability of landform and likely fire severity); estimate the percentage of saplings / seedlings scorched.	**Achieved:** > 75 %. **Partially Achieved:** 25–75 %. **Not Achieved:** < 25 %.
> 95 % of grasses, sedges and ferns recover after fire.	Before and after fire, select three or more sites (taking into account the variability of landform and likely fire intensity) and estimate cover of sedges and ferns that recover one to three months after fire.	**Achieved:** > 95 % recover. **Partially Achieved:** 90–95 % recover. **Not Achieved:** < 90 % recover.

If the above objectives are not suitable, refer to the compendium of planned burn objectives found in the monitoring section of the QPWS Fire Management System or consider formulating your own.

Monitoring the issue over time

Many issues are not resolved with a single planned burn and it is important to keep observing the land. To support this, it is recommended that observation points be established. Observation points are usually supported by photographs and by recording observations. Instructions for establishing observation points can be obtained from the monitoring section of the QPWS Fire Management System.

Consider monitoring for the presence and abundance of casuarina and acacia seedlings. This will provide useful information in planning fires.

Fire parameters

What fire characteristics will help address this issue?

Fire severity

Any fire will be sufficient. The severity of fire will be heavily influenced by the available fuel.

Fire frequency / interval (refer to Appendix 2 for a discussion)

- Fire frequency is poorly understood, but the main issue is sufficient fire to avoid transition to rainforest or casuarina forest.
- Fire frequency should primarily be determined through **on-ground assessment of vegetation health, fuel accumulation** and **previous fire patchiness** and adjusted for wildfire risk and drought cycles.
- 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).
- **Upland grassland:** Consider a broad fire interval range of between two to five years.
- **Upland sedgeland and fernland:** Consider a broad fire interval range of between ten to twenty years.

Mosaic (area burnt within an individual planned burn)

- The entire area is likely to burn because of contiguous, evenly distributed fuel.

Landscape mosaic

- Burn at least 25–30 per cent of these communities in the Wet Tropics in a year.

What weather conditions should I consider?

It is important to be aware of conditions prior to and following burns so that undesirable conditions and weather changes can be avoided, or to help with burn planning.

Season: Anywhere from September to mid December

GFDI: < 18

DI (KBDI): 80–160

Wind speed: < 23 km/hr. Winds > 15–23 km/hr help carry fire into transitioning areas.

Soil moisture: Where possible for sedgelands, ensure standing water is present. If standing water is absent the sedge bases should at least be waterlogged to avoid the risk of a peat fire.

What burn tactics should I consider?

Tactics will be site specific and different burn tactics may need to be employed at the same site. Also, during the burn, tactics should be reviewed and adjusted as required to achieve burn objectives. What is offered below is not prescriptive; rather it is a toolkit of suggested tactics that may assist in this issue.

- **Aerial ignition.** Where access is difficult and limited. Used in tandem with good soil moisture and other landscape features such as drainage lines, moist gullies and vegetation communities including rainforests, this technique can further assist in achieving a landscape mosaic.
- **Spot ignition** is often used to alter the desired intensity of a fire and create the desired mosaic of burnt and unburnt areas. This can be achieved using a range of methods including drip torches, matches and incendiaries. Spots closer together will result in a line of a greater intensity (as spots merge and create hot junction zones) while increased spacing between spots or alternatively a single spot ignition will result in a lower intensity fire and a greatly varied mosaic of unburnt and burnt patches. The spacing of the spots may vary throughout the burn due to changes in weather conditions, topography and fuel loads.
- **A low intensity backing fire.** A slow moving, low intensity backing fire will generally result in a more complete coverage of an area and a better consumption of fuel. This tactic creates high residence time useful to reduce overabundant seedlings, while ensuring fire intensity and rate of spread are kept to a minimum.
- **Line or strip ignition** is used to create a fire of higher intensity or to help fire carry through moist or inconsistent fuels. This is also useful to reduce overabundant trees (through scorching).
- Creating a **running** fire (through closely spaced spot ignition or line ignition with the wind) may help fire carry into transitioning areas (casuarina, acacia, melaleuca or rainforest transition).
- **Progressive burning.** A number of burns of varying size and severity are lit in an area throughout the year when conditions allow. This creates a rich mosaic of burnt and unburnt patches and can be used to establish a safe perimeter allowing further planned burns to take place within secured areas. Refer to the glossary for a fuller discussion.

Issue 4: Reduce overabundant seedlings/saplings

Overabundant seedlings/saplings of melaleuca, acacia, casuarina and rainforest pioneers reduce the health and abundance of grasses, sedges and ferns and eventually lead to a transition to open or closed forest. This is a significant conservation issue because remaining grassland, sedgeland and fernland communities are rare.

Awareness of the environment

Key indicators of where fire can still be introduced:

- Melaleuca, acacia, casuarina or rainforest seedlings/saplings are beginning to colonise, emerging above the ground layer.
- Where there were previously grasses, sedges are beginning to become frequent (no longer just scattered).
- Ground layer is starting to become less continuous.
- Mid and lower stratum is difficult to see through or walk through.

Key indicators of areas that are difficult to recover with fire:

- Abundant melaleuca, acacia, casuarina and rainforest saplings have grown well above the ground layer affecting the continuity of fuel.
- Grasses, sedges or ferns are in isolated clumps and will not carry a fire.
- There is a visible blanket of leaf litter between areas of grass or sedge.

Rainforest pioneers have produced a mid-stratum screen that is difficult to see through. The ground layer is less continuous.

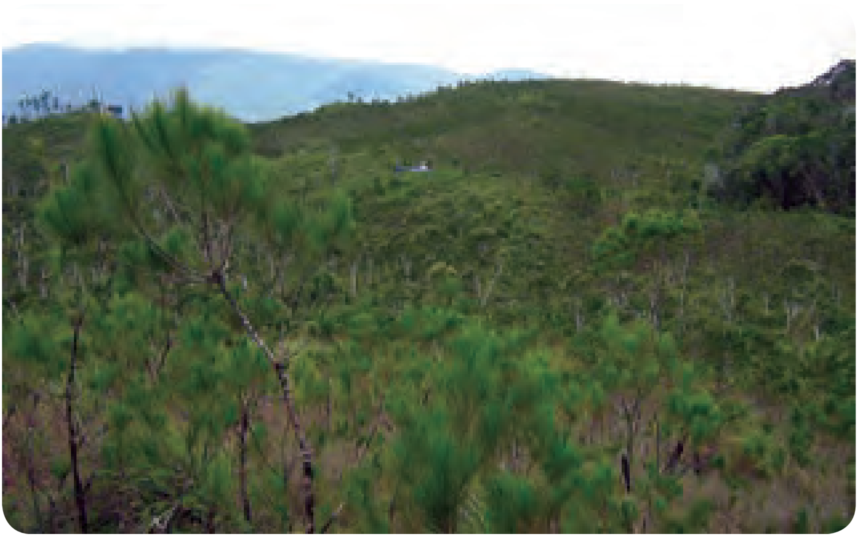
Mark Parsons, QPWS, Hull River National Park (2010).

Rainforest pioneer shading has advanced. The ground layer is broken-up with areas of leaf litter.

Mark Parsons, QPWS, Hull River National Park (2010).

Rainforest establishing in grassland areas. The grass cover is thinning and fuels are becoming less continuous. Fire can be 'pushed' into transitioning areas seen in the background.

Les Jackson, QPWS, Eubenangee swamp National Park (2010).



Casuarinas are dominating over large areas of this rare upland grassland. Fire has been long absent.

Mike Ahmet, QPWS, Towalla, Wooroonooran National Park (2000).

Discussion

- Where melaleuca and/or rainforest plants have begun to colonise lowland grasslands, sedgelands or fernlands, conditions need to be chosen carefully in order to push fire into these areas— otherwise fire intensity under melaleuca or rainforest saplings may decrease, causing a low-severity fire that will not necessarily address the issue, and at the same time consume fuel, making subsequent attempts difficult. In this way, grasslands or sedgelands may be permanently lost.
- Be aware that sometimes an intense fire can promote a flush of melaleuca seedlings, in which case, attempt a second fire as soon as possible (within about three years for grasslands; sedgelands are very difficult to recover once this has occurred). Once the issue has been addressed, return to the recommended fire frequency for grassland or sedgeland.
- Where access allows, using herbicide to kill melaleuca prior to burning will greatly increase the chance of success.
- It becomes difficult to introduce a high-severity fire where protection of rainforest edges and palm swamps is required. In some areas where high-severity fire cannot be introduced, transition to forest may be difficult to control if it has already become well advanced. In which case, remaining examples of grassland or sedgeland become a higher priority to conserve.

What is the priority for this issue?

Priority	Priority assessment
High	Planned burns to **maintain ecosystems** in areas where **ecosystem health** is **good**.
Medium	Planned burn in areas where **ecosystem health** is **poor** but recoverable.
Low	Planned burn in areas where **ecosystem** structure and function has been **significantly disrupted**.

Assessing outcomes

Formulating objectives for burn proposals

Every proposed burn area contains natural variations in topography, understorey or vegetation type. It is recommended that you select at least three locations that will be good indicators for the whole burn area. At these locations walk around and if visibility is good look about and average the results. Estimations can be improved by returning to the same locations before and after fire, and by using counts where relevant.

Select from below as appropriate:

Measurable objectives	How to be assessed	How to be reported (in fire report)
> 50 % of saplings/ seedlings are scorched to the tip.	Select one or more sites or walk one or more transects (taking into account the variability of landform and likely fire severity); estimate the percentage of saplings/seedlings scorched.	**Achieved:** > 50 %. **Partially Achieved:** 25–50 %. **Not Achieved:** < 25 %.
> 75 % of grasses recover after fire.	Before and after fire, select three or more sites (taking into account the variability of landform and likely fire intensity) and estimate cover of grasses that recover one to three months after fire.	**Achieved:** > 75 % recover. **Partially Achieved:** 50–75 % recover. **Not Achieved:** < 90 % recover.
> 75 % of sedges or ferns recover after fire.	Before and after fire, select three or more sites (taking into account the variability of landform and likely fire intensity) and estimate cover of sedges that recover one to three months after fire.	**Achieved:** > 75 % recover. **Partially Achieved:** 50–75 % recover. **Not Achieved:** < 50 % recover.

If the above objectives are not suitable, refer to the compendium of planned burn objectives found in the monitoring section of the QPWS Fire Management System or consider formulating your own.

Monitoring the issue over time

Many issues are not resolved with a single planned burn and it is important to keep observing the land. To support this, it is recommended that observation points be established. Observation points are usually supported by photographs and by recording observations. Instructions for establishing observation points can be obtained from the monitoring section of the QPWS Fire Management System.

Consider observing the predominance of acacia, casuarina, melaleuca or rainforest pioneers.

Fire parameters

What fire characteristics will help address this issue?

Fire severity

- **Moderate to high** depending on the height of the unwanted saplings— aim to scorch to the tip of the saplings (see table below).

Fire severity class	Fire intensity (during the fire)		Fire severity (post-fire)	
	Fire intensity (kWm^{-1})	Average flame height (m)	Average scorch height (m)	Description (loss of biomass)
Moderate (M)	150–500	0.5–1.5	2.5–7.5	Moderate patchiness. Some scorched litter remains. About half the humus layer and grass stubble remain. Some scorch of elevated fuels. Little or no canopy scorch.
High (H)	500–1000	1.5–3.0	7.5–15.0	Some patchiness. Some humus remains. At least some canopy scorch in moderate < 20m height canopy, mid stratum burnt completely (or nearly so).

Note: This table assumes good soil moisture and optimal planned burn conditions.

Fire frequency / interval (refer to Appendix 2 for a discussion)

- Ensure sufficient fuel has built up to carry a **moderate** to **high**-severity fire.

Mosaic (area burnt within an individual planned burn)

- Burn > 80 per cent of the area that is dominated by saplings.

What weather conditions should I consider?

It is important to be aware of weather predictions prior to and following burns so that undesirable conditions and weather changes can be avoided.

Season: September to November

GFDI: < 20

DI (KBDI): 160–200

Wind speed: < 23 km/hr. Careful planning of wind direction and with regard to neighbouring areas (such as sugarcane areas and residential areas) is required. Where it is necessary to push fires into transitioning areas, winds of > 20–23 km/hr may be desirable—but use with caution.

What burn tactics should I consider?

Tactics will be site specific and different burn tactics may need to be employed at the same site (e.g. due to topographical variation). Also, during the burn, tactics should be reviewed and adjusted as required to achieve burn objectives. What is offered below is not prescriptive; rather it is a toolkit of suggested tactics that may assist in this issue.

- **Progressive burning** of nearby areas earlier in the year can create areas of low fuel to help contain higher severity fires planned for later in the year.
- **Commence lighting on the leeward (smoky) edge** to contain the fire and promote a low-intensity backing fire, to create an edge to support a subsequent higher-severity fire internally. Depending on available fuels and the prevailing wind on the day, either spot or strip lighting may be required or a combination of both.
- Creating a **running** fire (through closely spaced spot ignition or line ignition with the wind) may help fire carry into transitioning areas (sedge, melaleuca or rainforest transitioning).
- **Line ignition** is used to create a fire of higher intensity or to help fire carry through moist or inconsistent fuels. This is also useful to reduce overabundant trees (through scorching).
- **Strip ignition** can be used to draw fire away from a non-target community edge. Using more than one line of ignition can create convective updrafts which draw fires together and away from non-target areas. It is important to have safe refuges when undertaking this type of burning (e.g. for lighting along a track the person furthest from the track should walk parallel to the track and at least 20 m ahead of the person lighting nearer the track). This reduces the chance of the 'outer' person becoming cut off from the refuge area (the track).
- **Limit fire encroachment into non-target communities.** In many cases, mesophyll vine forests and coastal littoral rainforests occur adjacent to this fire vegetation group. These rainforests are highly endangered and can be damaged by fire. Use appropriate lighting patterns along the margin of the non-target community to promote a backing fire that burns away from the non target community (refer to Chapter 11).

Issue 5: Manage high-biomass invasive grasses

Refer to Chapter 11 (Issue 3), regarding fire management guidelines.

In Eubenangee swamp, fire has been used to control the relative abundance of signal grass *Urochloa decumbens* and creeping signal grass *Urochloa humidicola*. Although these weed species recover from fire, it has been found that the recovery of native grasses is better, so fire gives native grasses a competitive advantage.

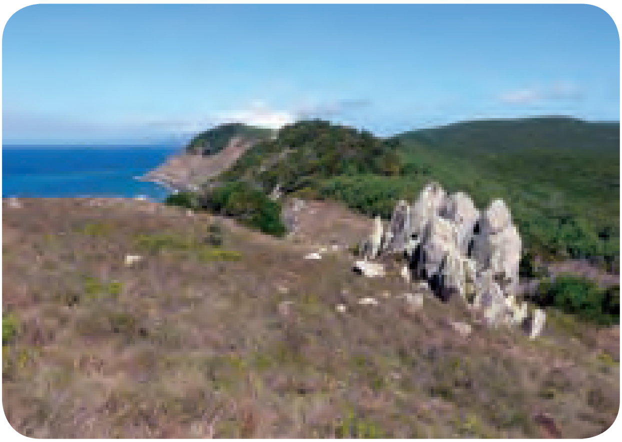
Issue 6: Maintain grasslands of the coastal slopes

Use fire to maintain grasslands of the coastal slopes, including managing invasive shrubs. Refer to GIS data, and map label 'Gcs'.

Awareness of the environment

Key indicators of healthy grasslands of the coastal slopes:

- Ground layer is dominated by kangaroo grass *Themeda triandra* and/or blady grass *Imperata cylindrica*, with other ground layer plants scattered.
- Grass cover usually appears dry (due to shallow soils or wind) however, is more or less continuous unless broken up by rocky areas.
- Acacia shrubs and lantana are either absent or scattered.



These grasslands naturally appear dry due to their location, wind or shallow soils. Shrubs, if present, are only scattered.

Justine Douglas, QPWS, Orpheus Island (2007).

There may be scattered ground layer plants amongst the grassy dominated ground layer. Ideally, the boundary between grasslands and neighbouring communities is well defined.

Justine Douglas, QPWS, Orpheus Island (2007).

Key indicators of areas where shrub invasion has become an issue:

- Shrubs are becoming frequent, and in some areas may form dense stands.
- The continuity of grass fuel has been broken-up by shrubs in some areas, making it increasingly difficult to introduce fire.
- The presence of goats and rabbits may be associated with lantana invasion making it increasingly difficult to introduce fire.

Shrubs are becoming more than scattered. They have colonised some locations forming stands.The boundary between ecosystems is blurred as shrubs encroach into grassland areas.

Justine Douglas, QPWS, Orpheus Island (2006).

Lantana is becoming frequent, breaking up the continuity of grass fuel.

Justine Douglas, QPWS, Orpheus Island (2009).

Discussion

- Because coastal headland grasslands are rare, their maintenance is important.
- Observations indicate that in the absence of fire, these grasslands transition to shrublands. Fire has been shown to halt or even push back the transition to shrubland if used frequently where shrubs are present, with at least a moderate severity.
- Storm burns, if achievable, improve regenerative conditions for grasses, in what are otherwise dry environments.

What is the priority for this issue?

Priority	Priority assessment
Very high	Planned burn required to maintain areas of **special conservation significance.**

Assessing outcomes

Formulating objectives for burn proposals

Every proposed burn area contains natural variations in topography, understorey or vegetation type. It is recommended that you select at least three locations that will be good indicators for the whole burn area. At these locations walk around and if visibility is good look about and average the results. Estimations can be improved by returning to the same locations before and after fire, and by using counts where relevant.

Choose from below as appropriate:

Measurable objectives	How to be assessed	How to be reported (in fire report)
> 75 % of shrubs reduced.	Before and after fire, select three or more sites (taking into account the variability of landform and likely fire intensity), and estimate the percentage of shrubs (above ground components) reduced by fire.	**Achieved:** > 75 % reduced. **Partially Achieved:** 50–75 % reduced. **Not Achieved:** < 50 % reduced.
Significant reduction in lantana.	**Before and after the burn** (after suitable germination/ establishment conditions and growing season): define the density of the infestation using the following criteria (from Parks Victoria Protocol [Parks Victoria 1995]): • Rare (0–4 % cover) = target weed plants very rare. • Light (5–24 % cover) = native species have much greater abundance than target weed. • Medium (25–75 % cover) = roughly equal proportions of target weed and native species. • Dense (> 75 %) = monoculture (or nearly so) of target weed.	**Achieved:** Weed infestation 'drops' two 'density categories' (e.g. goes from dense before the fire to light after the fire). **Partially Achieved:** Weed infestation 'drops' one 'density category' (e.g. goes from dense before the fire to medium after the fire). **Not Achieved:** No change in density category or weed density gets worse.
> 95 % of grasses recover after fire.	Before and after fire, select three or more sites (taking into account the variability of landform and likely fire intensity) and estimate cover of grasses that recover one to three months after fire.	**Achieved:** > 95 % recover. **Partially Achieved:** 90–95 % recover. **Not Achieved:** < 90 % recover.

If the above objectives are not suitable, refer to the compendium of planned burn objectives found in the monitoring section of the QPWS Fire Management System or consider formulating your own.

Monitoring the issue over time

Many issues are not resolved with a single planned burn and it is important to keep observing the land. To support this, it is recommended that observation points be established. Observation points are usually supported by photographs and by recording observations. Instructions for establishing observation points can be obtained from the monitoring section of the QPWS Fire Management System.

For this issue, consider recording the cover of shrubs or lantana.

Fire parameters

What fire characteristics will help address this issue?

Fire severity

- **In healthy grassland areas: Low** and occasionally **moderate**.
- **In areas with invasive shrubs: Moderate** where fire must be 'pushed' into areas dominated by shrubs or lantana. Ensure scorch height is sufficient to scorch to the tip of invading woody plants. Ensure fire does not encroach into nearby fire-sensitive communities such as coastal littoral rainforest.

Fire severity class	Fire intensity (during the fire)		Fire severity (post-fire)	
	Fire intensity (kWm^{-1})	Average flame height (m)	Average scorch height (m)	Description (loss of biomass)
Low (L)	50–100	0.3–0.5	≤ 2.5	Some patchiness. Most of the surface and near surface fuels have burnt. Stubble still evident.
Moderate (M)	100–1500	0.5–1.5	Complete standing biomass removed	All surface and near surface fuels burnt. Stubble burnt to blackened remnants.

Note: This table assumes good soil moisture and optimal planned burn conditions.

Fire frequency / interval (refer to Appendix 2 for a discussion)

- Fire frequency should primarily be determined through **on-ground assessment of vegetation health, fuel accumulation** and **previous fire patchiness**, adjusting for wildfire risk and drought cycles.

- 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). Consider a fire interval range of between two to three years.

Mosaic (area burnt within an individual planned burn)

- The rocky terrain will create a natural mosaic of burnt and unburnt areas.
- In grasslands that are transitioning aim to burn as much of the area containing invasive shrubs as possible.

What weather conditions should I consider?

It is important to be aware of weather predictions prior to and following burns so that undesirable conditions and weather changes can be avoided.

Season:

- Conduct early season burns from **April–June**.
- For areas with invading shrubs conducting **late year burns, prior to storms** will help achieve a higher fire severity. Moist conditions that follow will promote grass recruitment.

GFDI: 5–14

DI (KBDI): 80–150

Wind speed: < 23 km/hr. Winds > 15–23 km/hr are useful to carry fire through areas of discontinuous fuel or push fire into areas of shrub dominance.

Line ignition with wind can help the fire to carry in areas with rocky, broken terrain.
Justine Douglas, QPWS, Orpheus Island (2007).

What burn tactics should I consider?

Tactics will be site specific and different burn tactics may need to be employed at the same site (e.g. due to topographical variation). Also, during the burn, tactics should be reviewed and adjusted as required to achieve burn objectives. What is offered below is not prescriptive; rather it is a toolkit of suggested tactics that may assist in this issue.

- **Spot ignition.** Can be used to alter the desired intensity of a fire. Spots closer together will result in a line of a greater intensity (as spots merge and create hot junction zones) while increased spacing between spots will result in a lower intensity fire. This tactic can be used with ground or aerial ignition.
- **Line or strip ignition** is used to create a fire of higher intensity or to help fire carry through moist or inconsistent fuels. This is also useful to reduce overabundant shrubs (through scorching).
- Creating a **running** fire (through closely spaced spot ignition or line ignition with the wind) may help fire carry into shrub invaded areas.
- **Limit fire encroachment into fire-sensitive communities.** Use appropriate lighting patterns along the margin of the non-target community to promote a low-intensity backing fire that burns away from the non-target community (refer to Chapter 11).

Issue 7: Limit fire encroachment into non-target communities

Refer to Chapter 11 (Issue 7), regarding fire management guidelines.

Littoral Rainforest are vulnerable to scorching.

Mark Parsons, QPWS, Orpheus Island (2010).

Issue 8: Exclude fire from sedgeland of volcanic lakes

Sedgelands that occur in volcanic lakes contain a very deep peat layer and should not be burnt under any circumstances. Usually, they will not burn due to the presence of water. However, during planned burn operations, be aware of their presence and ensure fire is excluded.

Refer to GIS data and map label 'Sv'.

Chapter 5: Montane communities

In the Wet Tropics this fire vegetation group includes a complex of rock pavement, heathland, shrubland and low forest and woodland in upland locations in rocky areas and on poorer soils. They tend to occur on peaks and exposed ridges above surrounding fire-adapted or rainforest communities.

Fire management issues

Burning of montane communities is usually planned in association with the surrounding fire-adapted landscape. Implementation of mosaic burning in and around montane communities (with aerial ignition) helps achieve sufficient patchiness to mitigate against too much of the heath burning in a single fire event, emerging from the lower slopes.

Issue:

1. Maintain montane communities using fire.

Extent within bioregion: 43 350 ha, 2 per cent; **Regional ecosystems:** Refer to Appendix 1 for complete list.

Examples of this FVG: Hinchinbrook Island National Park, 12 150 ha; Girringun National Park, 10 520 ha; Paluma Range National Park, 3 388 ha; Goldsborough Valley USL Lands, 1 130 ha; Tully Gorge National Park, 1 025 ha; The Bluff State Forest, 1 009 ha; Girramay National Park, 775 ha; Wooroonooran National Park, 706 ha; Daintree National Park, 454 ha; Herberton Range State Forest, 360 ha; Mount Windsor National Park, 300 ha; Monkhouse Timber Reserve, 274 ha; Ravenshoe State Forest 3, 238 ha; Gadgarra Forest Reserve, 212 ha; Kirrama National Park, 169 ha; Mount Lewis National Park, 145 ha; Little Mulgrave Forest Reserve, 122 ha; Macalister Range National Park, 117 ha; Mount Cataract Forest Reserve, 109 ha; Paluma State Forest, 106 ha; Fitzroy Island National Park, 103 ha; Danbulla State Forest 2, 95 ha; Dinden National Park, 76 ha; Japoon National Park, 69 ha; Tully Falls National Park, 66 ha; Trinity Forest Reserve, 56 ha; Mowbray National Park, 42 ha; Malaan National Park, 40 ha; Annan River (Yuku Baja-Muliku) National Park, 40 ha; Herberton Range Conservation Park, 34 ha; Danbulla State Forest 1, 32 ha; Ravenshoe State Forest 1, 31 ha; Barron Gorge National Park, 28 ha; Annan River (Yuku Baja-Muliku) Resources Reserve, 25 ha; Cedar Bay National Park, 24 ha; Herberton Range National Park, 19 ha; Koombooloomba Forest Reserve, 14 ha; Mount Mackay National Park, 13 ha; Abergowrie State Forest, 12 ha; Bare Hill Conservation Park, 12 ha; Danbulla National Park, 10 ha; Goold Island National Park, 10 ha; Clemant State Forest, 10 ha.

Issue 1: Maintain montane communities using fire

Maintain montane communities by burning in association with the surrounding fire-adapted landscape.

Awareness of the environment

Key indicators of healthy montane communities:

- A high diversity of shrub species that appear green and vigorous and a high diversity of sedges, ferns and other plants in the ground layer. Shrub plants occur in dense stands or scattered among rocky areas interspersed with areas dominated by ground layer plants.
- There are no or only a few scattered trees. Or low trees occur in isolated groves.

Early signs of where fire management is required:

- Shrubs are beginning to lose lower-level leaves, or some crowns of shrubs are dying. Dead material accumulates on shrubs.
- There is a build up of dead sedge and fern material.
- Tree-high casuarinas are forming a canopy over large areas.
- Where *Banksia plagiocarpa* (vulnerable) is present (Hinchinbrook Island and Cardwell ranges), plants with several layers of fruit cones can be used to indicate that the area is ready for fire (because there is sufficient seed for post-fire regeneration).

The vulnerable *Banksia plagiocarpa* in flower.

Paul Williams, Vegetation Management Science Pty Ltd, Bishops Peak, Girringun National Park (2005).

Montane shrubland on Bishops Peak.

Mark Parsons, QPWS, Bishops Peak, Girringun National Park (2006).

Montane heath on Hinchinbrook Island. Notice that heath is usually dominated by a continuous layer of dense shrubs, unless broken up by rocky areas.

Justine Douglas, QPWS, Hinchinbrook Island National Park (2007).

Montane communities include stunted shrubs dispersed over broken rocky areas.
Paul Williams, Vegetation Management Science Pty Ltd, Mt Straloch (2008).

Fire has been long absent. Notice the build up of dead material.
Paul Williams, Vegetation Management Science Pty Ltd, Mt Straloch (2007).

Discussion

- The main concern is repeated fire events of short intervals that burn extensive areas of montane communities. These fires usually originate from forests and woodlands down slope and at drier times when natural barriers to fire are less reliable.
- The key fire management approach is aerial ignition early in the season. The moist conditions and natural barriers help control the spread of fire and create a natural mosaic of burnt and unburnt areas. This helps address the issue of unplanned fire repeatedly burning extensive areas in dry conditions, and therefore helps to maintain fire frequencies and species diversity.
- Because these areas are heavily broken with natural features such as rocky areas and creek lines, fire events (except in dry conditions) tend to be limited in extent—this helps to create a finer scale mosaic.
- Recently burnt heath generally has higher species richness than long unburnt heath. However, repeated fires at intervals of less than six years are too short for the replenishment of seed reserves and as such, the application of too frequent fire may affect species diversity (e.g. loss of *Banksia plagiocarpa*).

What is the priority for this issue?

Priority	Priority assessment
Very high	Planned burn required to maintain areas of **special conservation significance**.
High	Planned burns to **maintain ecosystems** in areas where **ecosystem health** is **good**.

Assessing outcomes

Formulating objectives for burn proposals

Every proposed burn area contains natural variations in topography, understorey or vegetation type. It is recommended that you select at least three locations that will be good indicators for the whole burn area. At these locations walk around and if visibility is good look about and average the results. Estimations can be improved by returning to the same locations before and after fire, and by using counts where relevant.

Measurable objectives	How to be assessed	How to be reported (in fire report)
A mosaic pattern of burnt and unburnt areas is achieved, within the aerial ignition footprint, reflecting topographical features that break up the burn.	Visual estimation of percentage of vegetation burnt—from one or more vantage points, or from the air.	**Achieved:** Mosaic achieved within aerial ignition footprint. **Not Achieved:** Fire extended beyond aerial ignition footprint.

If the above objectives are not suitable, refer to the compendium of planned burn objectives found in the monitoring section of the QPWS Fire Management System or consider formulating your own.

Monitoring the issue over time

Many issues are not resolved with a single planned burn and it is important to keep observing the land. To support this, it is recommended that observation points be established. Observation points are usually supported by photographs and by recording observations. Instructions for establishing observation points can be obtained from the monitoring section of the QPWS Fire Management System.

Consider monitoring the layers of fruit on *Banksia plagiocarpa* as an indicator of the minimum interval for fire management. Several years of cones should be present prior to burning to allow sufficient build up of seed. Also consider monitoring the presence of *Allocasuarina littoralis*. Where *Allocasuarina littoralis* trees begin to dominate, this indicates fire has been absent for too long.

Fire parameters

What fire characteristics will help address this issue?

Fire frequency / interval (refer to Appendix 2 for a discussion)

- Fire frequency should primarily be determined through **on-ground assessment of vegetation health, fuel accumulation** and **previous fire patchiness** and adjusted for wildfire risk and drought cycles.
- 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).
- On any particular peak, avoid two successive fires within six years that consume more than fifty per cent of the community. This will preserve the banksias, as they require about six years to replenish seed. Generally do not leave areas unburnt for more than ten years. Burn some areas at shorter intervals and some at longer intervals to aid diversity.

Landscape mosaic

- Usually planned burn areas are selected so that a landscape mosaic is created. This is achieved by targeting different sites in different years with aerial ignition. Also, how patchily areas have burnt will influence future target areas, so that the same area might be targeted for ignition again (even within six years) if previous fire was only very patchy.

Fire severity

- **Patchy/low** to **moderate/extreme**. Usually, moisture and topography influence severity. When trying to establish an area of low fuel to control fires emerging from lower areas, a too mild fire can be undesirable (as it will not break up fuel sufficiently).

Fire severity class	Fire intensity (during the fire)	Fire severity (post-fire)
	Average flame height (m)	Description (loss of biomass)
Patchy (P) to Low (L)	< 1	40–60 % vegetation burnt. Unburnt vegetation (green patches) in the ground and shrub layer. Does not remove all the surface fuels (litter) and near surface fuels. Can create distinct 'holes' in closed heath. Overall little canopy scorch. Some scorching of shrubs and small trees.
Moderate (M) to Extreme (E)	> 1	Greater than 60 % vegetation burnt. Understorey burnt to mineral earth. Extensive to total foliage burnt. Minimal evidence of green vegetation remaining. Skeletal frames of shrubs.

Note: This table assumes good soil moisture and optimal planned burn conditions.

What weather conditions should I consider?

It is important to be aware of conditions prior to and following burns so that undesirable conditions and weather changes can be avoided, or to help with burn planning.

Season: Although these areas are located at higher elevations and can receive regular moisture or rain, they are also exposed to coastal winds and can dry-out very quickly. Plan to avoid burning during dry conditions, as the fire will carry beyond the planned burn footprint. Suitable conditions generally arise from **April to July**. However, as these areas are heavily influenced by mountain-like weather conditions (e.g. drying and exposure), suitable planned burn conditions may arise as early as **March**.

FFDI: 5–12

DI (KBDI): 80–120

Wind speed: Stable or near-stable conditions for aerial ignition.

Relative humidity: Burning in high-humidity conditions (such as on the advent of rain, during low cloud cover or during the evening) is a useful tactic to limit the spread of fire and achieve the desired mosaic.

Soil moisture: Glistening features on rock pavements that are visible from the ground is a good indication that sufficient moisture is persisting. Plan burns to follow rain events, if conditions allow.

What burn tactics should I consider?

Tactics will be site specific and different burn tactics may need to be employed at the same site (e.g. due to topographical variation). Also, during the burn, tactics should be reviewed and adjusted as required to achieve burn objectives. What is offered below is not prescriptive; rather it is a toolkit of suggested tactics that may assist in this issue.

- **Burn in association with the surrounding landscape.** Montane communities have much longer fire frequencies than the sclerophyll communities that often surround them at lower elevation. Therefore burning of sclerophyll communities has to be planned with the montane communities in mind. Usually this is done by first burning from peaks, ridges and spurs to break up the fuel in and around the heath to control the spread of fire emerging from lower areas. This provides some level of control with regard to how much of the heath burns at one time, creating the required longer fire frequencies as well as a landscape mosaic. This also helps to protect against wildfire. Inappropriate fire usually occurs in dry conditions where wildfire will carry over landscape features that would usually prevent fire entering montane communities.
- **Aerial ignition.** Aerial ignition is used in tandem with good soil moisture and landscape features such as drainage lines, moist gullies and broken rocky areas to create a landscape mosaic. Aerial ignition should aim to reduce scorch and severity of fire on upper slopes, cater for varying needs of fire vegetation groups, create variability in fire severity and create rich mosaics. It is necessary to study and understand the topography and its likely effect on the fire, as part of planning for burns. Use of aerial photographs is recommended (stereoscopic images are particularly useful to gain an understanding of terrain). It is good practice to plot the incendiary drop path onto a map or aerial photograph. The usual strategy is lighting of peaks, ridges and spurs to create a backing fire downhill. Be careful not to create a hot junction zone around peaks with an ignition pattern that rings peaks from down-slope. Upland communities are ignited first allowing the fire to travel at least half way down slope, which could take more than a day. Following this, fires can be ignited from lowland areas. If lowland areas are ignited too soon, this can interfere with helicopter operations and negate the positive effects of avoiding too much of the heath being scorched.

- **Progressive burning.** Using a combination of techniques (ground and aerial ignition) this tactic can be used to good effect where smaller areas of communities are burnt over a period of time (usually starting early in the year after the wet season). This will create a varied landscape mosaic of available fuel that aims to limit the extent and severity of wildfires and gives land managers greater opportunity to implement planned burns later in the year when conditions are suitable. Exposed ridgelines can be targeted early after the wet season and are a good way to break up the country. Ground ignition in open forests and woodlands below peaks along firelines can be done in stages using natural barriers and pre-burnt areas to manage the spread of fire. Refer to the glossary for more information.
- **Use overnight conditions.** Progressive burning can utilise good soil moisture, cool nights, overnight dew and topographic features to control the spread of fire. Under the right conditions, fire will self-extinguish and be quite patchy.
- **Spot ignition.** Can be used effectively to alter the desired intensity. Due to the propensity of heath to burn with higher severities, incendiaries can be dropped closer together to create fires that join prior to becoming too large. Alternatively, under mild conditions, spots can be widely spaced, creating fires that will also have a low intensity.

Consider the incendiary drop pattern carefully.

Mark Parsons, QPWS, Bishops Peak, Girringun National Park (2010).

A single spot ignition, or very widely spaced spots, under the right conditions, can create a patchy/low-severity fire.

Mark Parsons QPWS, Bishops Peak, Girringun National Park (2010).

Closely spaced spots along ridges can cause fronts to join before building momentum, while the backing fire backs down slope. This will create a low-severity fire with a good coverage, useful to mitigate wildfire impacts.

Mark Parsons, QPWS, Bishops Peak, Girringun National Park (2010).

Chapter 6: Fire-sheltered shrubland

This fire vegetation group consists of isolated pockets supporting shrubland, heath, low woodland and low open forest in areas where fire rarely penetrates. Examples include rocky coastal headlands, exposed rocky slopes on foothills and ranges and moister sites on fire-sheltered dunes.

Many of the communities in this fire vegetation group are very restricted in distribution and have a biodiversity status of **endangered** or of **concern**.

Fire management issues

These communities may occasionally burn with surrounding fire-adapted vegetation, but should not be burnt intentionally.

In most cases fire sheltered shrublands occur as isolated stands surrounded by a mix of communities which may in some cases require fire (e.g. grasslands and open forests) and those that do not (e.g. estuarine and saltwater vegetation and coastal littoral rainforests). Occupying rocky or moist sites, fire-sheltered shrublands are mostly self-protecting.

Maintaining appropriate mosaic burning in surrounding fire-adapted areas is the best strategy to mitigate the spread of unplanned fire.

Extent within bioregion: 3 107 ha, < 1 per cent; **Regional ecosystems:** Refer to Appendix 1 for complete list.

Examples of this FVG: Hinchinbrook Island National Park, 771 ha; Paluma Range National Park, 375 ha; Daintree National Park, 186 ha; Orpheus Island National Park, 163 ha; Girringun National Park, 150 ha; Goldsborough Valley USL Lands, 113 ha; Monkhouse Timber Reserve, 88 ha; Wooroonooran National Park, 69 ha; Cedar Bay National Park, 55 ha; Barron Gorge National Park, 53 ha; Little Mulgrave Forest Reserve, 39 ha; Gadgarra Forest Reserve, 23 ha; Girramay National Park, 22 ha; Mount Cataract Forest Reserve, 20 ha; The Bluff State Forest, 16 ha; Family Islands National Park, 15 ha; Eubenangee Swamp National Park, 15 ha; Ravenshoe State Forest, 1 12 ha; Goold Island National Park, 10 ha; Proposed addition to Halifax Bay Wetlands National Park, 10 ha; Lannercost State Forest, 10 ha; Kuranda National Park, 9 ha; Maria Creek National Park, 7 ha; Ella Bay National Park, 6 ha; Tumoulin State Forest, 6 ha; Mount Lewis National Park, 6 ha; Fitzroy Island National Park, 4 ha; Trinity Forest Reserve, 4 ha; Macalister Range National Park, 4 ha; Hull River National Park, 3 ha; Russell River National Park, 2 ha; Dinden National Park, 2 ha; Bare Hill Conservation Park, 1 ha; Paluma State Forest, 1 ha; Mount Fox State Forest 1 ha.

Chapter 7: Melaleuca communities

This fire vegetation group includes various melaleuca communities with considerable differences in their understorey. Wetter sites support sedges, ferns, palms and pandanus; drier sites have a grassy or shrubby understorey including species such as xanthorrhoea and hakea. Melaleuca communities occur throughout the wet tropics, often in linear strips e.g. along waterways, or in isolated depressions. However, they also occur as open forest, woodland, shrubland and as part of swamp systems (Queensland Herbarium 2011a).

Fire management issues

Because there are considerable differences in how melaleuca communities occur in the landscape and considerable variation in understorey, different fire regimes are recommended (described in Issue 1). In some cases where they occur as isolated stands within a broader fire-adapted landscape, the focus will be on fire management in surrounding areas in appropriate conditions when the melaleuca is moist, this will help mitigate the spread of later-season fires into melaleuca communities and help achieve the longer fire frequencies. Where they occur as extensive forest, a more active approach to fire management within the melaleuca community will be required.

Issues:

1. Maintain healthy melaleuca communities.
2. Avoid peat fires.
3. Manage high biomass grasses.

Extent within bioregion: 41 929 ha, 2 per cent; **Regional ecosystems:** Refer to Appendix 1 for complete list.

Examples of this FVG: Girramay National Park, 4 192 ha; Girringun National Park, 1 182 ha; Hull River National Park, 1 045 ha; Eubenangee Swamp National Park, 963 ha; Russell River National Park, 889 ha; Hinchinbrook Island National Park, 815 ha; Clemant State Forest, 794 ha; Lannercost State Forest, 792 ha; Paluma Range National Park, 703 ha; Ella Bay National Park, 690 ha; Kurrimine Beach National Park, 557 ha; Proposed addition to Halifax Bay Wetlands National Park, 553 ha; Daintree National Park, 528 ha; Cardwell State Forest, 390 ha; Kuranda State Forest, 295 ha; Jalum Conservation Park, 196 ha; Halifax Bay Wetlands National Park, 190 ha; Mount Mackay National Park, 185 ha land acquired at Helens Hill, 168 ha; Dinden State Forest, 145 ha.

Issue 1: Maintain healthy melaleuca communities

Maintain healthy melaleuca communities with fire management.

Awareness of the environment

Key indicators of healthy melaleuca communities:

- Healthy melaleuca communities have grasses; sedges; ferns; shrubs or any mix of these in the understorey, with a few canopy species of variable sizes (to eventually replace the canopy); and a healthy canopy.
- Some wetter melaleuca communities have pandanus or palms present as understorey species and pockets of rainforest/vine forest along drainage lines or wetter sites.

Melaleuca woodland with a mixed understorey.

Paul Williams,Vegetation Management Science Pty Ltd, Clemant State Forest (2004).

Melaleuca with pandanus in the understorey and a fern dominated ground layer. This was recently burnt.

Paul Williams,Vegetation Management Science Pty Ltd, Hull River (2003).

A melaleuca community with an understory of ferns and sedge, with standing water present.

Sylvia Millington, QPWS, Mt Coom (2010).

Fire management in Melaleuca viridiflora open forest.
Mark Parsons, QPWS, Whitfield Creek (2010).

A melaleuca community with an understory of sedge.
Jeanette Kemp, Queensland Herbarium, Eubenangee Swamp National Park (2007).

Signs of areas requiring fire management:

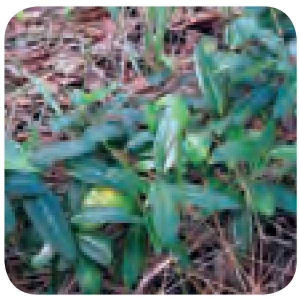
- Where grasses were evidently abundant, they are becoming sparse or grass clumps are poorly formed. There is an accumulation of dead material and grasses are beginning to collapse (no longer erect).
- Where *Xanthorrhoea* spp. or *Pandanus* spp. are present, they have formed extensive skirts of dead material.
- Within tall melaleuca communities, rainforest pioneers can extend beyond rainforest pockets into drier locations and colonise the understorey generally, shading-out native grasses, sedges, ferns or shrubs.
- There has been a flush of *Melaleuca viridiflora*, grevillea, she-oaks or pine wildling which have grown up and begun to shade-out the ground layer. Sometimes these form a whipstick stand of many closely-spaced narrow trees.
- Ground layer plants declining in health and abundance due to shading, and are becoming sparse.
- Where shrubs are present, they have a build up of dead leaves and some dead or dying branches.
- Alyxia vine *Alyxia spicata* has become common as an understory plant.
- Elevated fuels such as ribbons of bark are common.

In long unburnt areas, dead material builds up around the bases of sedges and grasses. Shrubs may have sparse, dead or dying branches.

Justine Douglas, QPWS (2007).

Pandanus skirts can be an indicator of time since fire. The image to the left shows a skirt that has formed 10 years since fire, and the one to the right 15 years since fire. The skirt to the left survived a low severity fire and therefore continues to provide shelter and refuge to fauna. Aim to retain pandanus skirts where possible. However, they will eventually burn.

Left: Mark Parsons, QPWS, Mullers Creek (2009) **Right:** Mark Parsons, QPWS, Mullers Creek (2010).



Where alyxia vine *Alyxia spicata* is common in the understorey, it is an indicator of shading impacts. Notice that understorey plants are becoming sparse.

Above is a close-up of alyxia vine.

Jenise Blaik, QPWS, Yarrabah (2010).

Discussion

- Melaleuca communities where a peat layer has formed are vulnerable to peat fire in the drier months and should always be burnt with standing water or when the peat layer is water logged (refer to Chapter 11 for guidelines about avoiding peat fire).
- Where canegrass and pandanus is present, timing of fire is important due to the presence of the endangered crimson finch, mannequins, the peppermint stick insect and related fauna. Pandanus skirts are important fauna habitat.
- Be aware that Siam weed can interweave amongst alyxia vine in sheltered locations. If Siam weed is present see Chapter 11 for control guidelines.
- Fire is the most important tool for controlling pond apple in wetland environments where the understorey is dense enough to sustain fire. The fire must scorch to the living tip of pond apple. Fire also kills the seeds. Pond apple also occurs in permanently inundated areas or rainforest where it cannot be controlled with fire; in which case mechanical methods are used (CRC for Australian Weed Management 2003).
- There are different types of melaleuca communities in the wet tropics, with considerably different understorey characteristics, levels of moisture and therefore different approaches to fire management. These are described below (and are indicated in the supporting GIS and maps).

Pond apple in wetland grassland.

Kylie Goodall, QPWS, Eubenangee Swamp National Park (2010).

Melaleuca gallery forests

- Melaleuca gallery forests fringe streams, are dominated by *Melaleuca fluviatilis* or *Melaleuca leucadendra* and may have rainforest/vine forest pockets present (near waterways drainage lines and wetter sites) that are particularly important habitats for invertebrates. These communities are **of concern** or **endangered**.

Submerged melaleuca/palm/vine forest swamps

- These are usually inundated areas dominated by *Melaleuca quinquenervia* with fan palm *Livistona* spp. and rainforest pockets present in the understorey. These communities are **endangered**.

Melaleuca on gley soils

- These melaleuca communities occur on poorly drained alluvial soils, often in broad low-lying areas, with a canopy of *Melaleuca viridiflora* mixed with other canopy trees. They are **endangered** communities.

Melaleuca forest/woodland

- Can be dominated by one, or a mix of melaleuca species with other canopy species also present. Understoreys may be dominated by grasses, shrubs, sedges, ferns or a mixture of plants that can vary depending on fire regime. Many of these communities are **endangered**.

What is the priority for this issue?

Priority	Priority assessment
Very high	Planned burn required to maintain areas of **special conservation significance**.
High	Planned burns to **maintain ecosystems** in areas where **ecosystem health** is **good**.

Use a low flame height where the ant plant *Myrmecodia beccarii* is present as its fire tolerance is unknown.

Mark Parsons, QPWS, Girramay National Park (2000).

Assessing outcomes

Formulating objectives for burn proposals

Every proposed burn area contains natural variations in topography, understorey or vegetation type. It is recommended that you select at least three locations that will be good indicators for the whole burn area. At these locations walk around and if visibility is good look about and average the results. Estimations can be improved by returning to the same locations before and after fire, and by using counts where relevant.

Select at least two of the following as most appropriate for the site:

Measurable objectives	How to be assessed	How to be reported (in fire report)
> 95 % of epiphytes and ant plants retained.	Select one or more sites or walk one or more transects (taking into account the variability of landform and likely fire intensity) and estimate number of epiphytes and ant plants remaining after fire.	**Achieved:** > 95 % retained. **Partially Achieved:** 90–95 % retained. **Not Achieved:** < 90 % retained.
> 50 % of pandanus skirts retained.	Select one or more sites or walk one or more transects (taking into account the variability of landform and likely fire intensity) and estimate number of pandanus skirts remaining after fire.	**Achieved:** > 50 % retained. **Partially Achieved:** 25–50 % retained. **Not Achieved:** < 25 % retained.
No scorch of the margin of rainforest/ vine forest pocket.	**After the burn** (immediately-very soon after): visual estimation of percentage of margins scorched – from one or more vantage points, or from the air. **Or** **After the burn** (immediately-very soon after): walk the margin of the pocket or representative sections (e.g. a 100m long section of the margin in three locations) and estimate the percentage of margin scorched.	**Achieved:** No scorch of the margin. **Partially Achieved:** < 5 % of margins scorched. **Not Achieved:** > 5 % or margins scorched.

> 75 % of saplings/ seedlings are scorched to the tip.	Select one or more sites or walk one or more transects (taking into account the variability of landform and likely fire severity); estimate the percentage of saplings / seedlings scorched.	**Achieved:** > 75 %. **Partially Achieved:** 25–75 %. **Not Achieved:** < 25 %.

If the above objectives are not suitable, refer to the compendium of planned burn objectives found in the monitoring section of the QPWS Fire Management System or consider formulating your own.

Monitoring the issue over time

Many issues are not resolved with a single planned burn and it is important to keep observing the land. To support this, it is recommended that observation points be established. Observation points are usually supported by photographs and by recording observations. Instructions for establishing observation points can be obtained from the monitoring section of the QPWS Fire Management System. In melaleuca communities, if a flush of *Melaleuca viridiflora* occurs after fire, it is recommended that photo points be established to monitor overabundant saplings/seedlings. Subsequent fires should be planned. Similarly, overabundant saplings such as acacias, grevilleas, she-oaks and pine wildings might be targeted for monitoring.

Where present, the persistence of button orchid on tree limbs is an indicator that the fire was of a sufficiently low severity and patchiness for melaleuca communities.

Notice edge of burnt area.

Mark Parsons, QPWS, Sunday Creek (2010).

Fire parameters

What fire characteristics will help address this issue?

Fire severity

- **Low** and occasionally **moderate**.

Fire severity class	Fire intensity (during the fire)		Fire severity (post-fire)	
	Fire intensity (kWm^{-1})	Average flame height (m)	Average scorch height (m)	Description (loss of biomass)
Low (L)	< 150	< 0.5	≤ 2.5 (up to 8 m on melaleuca trees)	Significant patchiness. Litter retained but charred. Humus layer retained. Nearly all habitat trees, fallen logs and grass stubble retained. Some scorching of elevated fuels. Little or no canopy scorch.
Moderate (M)	150–500	0.5–1.5	2.5–7.5 (up to 20 m on melaleuca trees)	Moderate patchiness. Some scorched litter remains. About half the humus layer and grass stubble remain. Most habitat trees and fallen logs retained. Some scorch of elevated fuels. Little or no canopy scorch.

Note: This table assumes good soil moisture and optimal planned burn conditions.

Other considerations

For melaleuca, acacia, grevillea, pine wilding and she-oak overabundance, it is particularly important to observe post-fire germination and kill rates to ascertain the need for subsequent fires. It is likely that more than one planned burn will be required to manage this issue. Although **moderate** severity fires may be necessary to control sapling overabundance, it may also have an impact on canopy species recruitment. Therefore once mid stratum overabundance is controlled, it is important to return to a predominantly **low** severity fire regime.

Planned burning in a melaleuca community where standing water is present.
Mark Parsons, QPWS, Sunday Creek (2010).

Depicting a desirable fire severity to control overabundant saplings.
Mark Parsons, QPWS, Sunday Creek (2010).

Specific guidelines for melaleuca communities

Melaleuca gallery forests and submerged melaleuca/palm/vine forest swamps:

- Burn surrounding areas in conditions that would limit fire encroachment. Occasional fire will play a role in maintaining the melaleuca component. Fire has a role in defining the ecotone; allow fire to carry into the edge of these communities so that the ecotone can be maintained.
- When using fire within these communities or when allowing fire to penetrate from surrounding areas, ensure moist conditions within the melaleuca community— where standing water is present or the peat is waterlogged (can squeeze water out of peat). This will avoid peat fires and protect fan palms and rainforest pockets.

Melaleuca on gley soils:

- Fire frequency of five to fifteen years. Shorter intervals if overabundant saplings are an issue.
- Burn the surrounding fire-adapted areas with a good awareness of moisture conditions within the melaleuca community. Fire penetration into melaleuca (from surrounding areas) can be planned to achieve the recommended fire frequency. If an area has not burnt for a long time, direct targeting of melaleuca areas with fire management may be required to achieve the fire frequencies.
- The vast majority of species in these communities occur in the very diverse ground layer, including rare and threatened ground orchids that are promoted by fire.
- The fire tolerance of ant plants *Myrmecodia beccarii* is unknown— where this species is present, use a low flame height.
- Weed invasion and overabundant saplings (sometimes forming whip stands of closely packed narrow trees) can be a problem and some moderate-severity fires may have to be planned to control these issues.

Melaleuca forest/woodland:

- Fire frequency of three to ten years— fire should not be planned at one location more frequently than three years or left longer than ten years.
- Fires that are too frequent and/or extensive will lead to lower species richness due to loss of fire-killed shrubs (these shrubs require several years between fire to mature and set seed prior to being burnt).
- High-severity fire may cause a flush of melaleuca, she-oak or grevillea, leading to a denser structure that will eventually shade out ground layer diversity— in which case plan subsequent fires to control sapling overabundance. High-severity fires will also damage fauna habitat.
- The fire tolerance of ant plants *Myrmecodia beccarii* is unknown— where this species is present, use a low flame height.
- Thatch and guinea grass is present in these communities and is promoted by fire. They also increase fire severity. Be aware of the presence of these grasses when planning fire. If present see chapter 11 of this guide.

What weather conditions should I consider?

It is important to be aware of conditions prior to and following burns so that undesirable conditions and weather changes can be avoided, or to help with burn planning.

Specific guidelines for melaleuca communities

Submerged melaleuca/palm/vine forest swamps, Melaleuca gallery forests and Melaleuca on gley soils:

- Burn **mid** to **late season** when fire can trickle but does not carry through to the palm and vine forest areas.

FFDI: < 18

DI (KBDI): 120–180

Wind speed: < 23 km/hr

Soil moisture: Prior to a planned burn ensure standing water is present or the ground feels sodden around palm or vine forest areas. Alternatively, peat is waterlogged (water can be squeezed from the peat).

Melaleuca forest/woodland:

- **June to mid dry season (August)** and sometimes up to September if rain periods are available. Choice of season is often site specific.
- Plan fires to coincide with forecast rain squall events in some locations e.g. Hinchinbrook Channel, to take advantage of higher winds. This approach creates a richer mosaic.
- Planned burns following rain will help protect melaleuca trees (due to moisture in bark) and reduce ember spotting. Burning following rain also increases patchiness of burns.
- Progressive burning is a useful tactic to create variation, mosaics and take advantage of different conditions.
- Progressive burning through the year as conditions allow in healthy areas will make it much easier to achieve burns later in the season that will help address overabundant saplings.

FFDI: < 12

DI (KBDI): 80–130 or up to 180 for overabundant saplings

Wind speed: < 23 km/hr

Soil moisture: Use good soil moisture.

What burn tactics should I consider?

Tactics will be site specific and different burn tactics may need to be employed at the same site (e.g. due to topographical variation). Also, during the burn, tactics should be reviewed and adjusted as required to achieve burn objectives. What is offered below is not prescriptive; rather it is a toolkit of suggested tactics that may assist in this issue.

- **Consider adjacent primary production activities.** Often this fire vegetation group neighbours agricultural land uses such as sugar cane production. Planned burns in adjoining areas should be undertaken when the prevailing weather conditions (in particular wind direction) will direct the resulting fire, smoke and any airborne embers away from the sugar cane crop or mulch (‘trash blanket’) that follows harvesting. Line lighting the windward edge along the margin of the sugar cane is preferred when undertaking this type of burn so that a safe perimeter can be established. Establishing cooperative arrangements with cane farmers and rural fire brigades is essential in managing this issue.
- **Spot ignition**. Can be used to alter the desired severity of a fire. Well spaced spot lighting adjacent to melaleuca stands is preferred to limit the chance of hot junction zones forming within this community.

- **Areas with standing water.** Can be used to create fires with a greater patchiness and at the same time protect fan palms and pandanus.
- Be aware that melaleuca **papery bark** is volatile and highly flammable and often described as a 'ladder fuel' causing fire to rapidly ascend from the base to the top of the tree. Be aware of wind conditions and embers spotting.
- **Commence lighting on the leeward (smoky) edge** to establish the initial fire-line, a safe perimeter and promote a low-severity backing fire. Depending on available fuels and the prevailing wind on the day this may require either spot or line lighting or a combination of both.
- **A backing fire with good residence time.** A slow moving backing fire (lit against the wind on the smoky edge or down-slope) will generally result in a more complete coverage of an area and ensures the fire has a greater amount of residence time, while ensuring fire intensity and rate of spread are kept to a minimum. Greater residence time is useful in reducing overabundant trees.
- **Line or strip ignition** is used to create a fire of higher intensity or to help fire carry through moist or inconsistent fuels. This is also useful to reduce overabundant trees (through scorching).
- **Storm burning.** When possible aim to conduct planned burns following sufficient rain to ensure good soil moisture throughout the site. Conditions where melaleuca bark is retaining water are optimal.
- **Limit fire encroachment into non-target communities.** When burning in surrounding fire-adapted areas (and to limit fire penetration into melaleuca), appropriate lighting patterns along the margin of the melaleuca community may assist in creating a low-intensity backing fire that burns away from the non-target area. Or, where the melaleuca is low-lying (e.g. drainage lines), utilise the surrounding topography to create a low intensity backing fire that travels down slope towards the melaleuca community. In both instances ensure good soil moisture is present within the melaleuca community.

Burning early in the season enables fires to self-extinguish due to moisture gradients.

Using anticipated rain squalls can aid in achieving a finer scale mosaic.

Mark Parsons, QPWS, Mullers Creek, Girringun National Park (2009).

Issue 2: Avoid peat fires

Please refer to Chapter 11 (Issue 6), for fire management guidelines.

Standing water will prevent peat fires and reduce likelihood of ignition during planned burning in adjacent communities.

Mark Parsons, QPWS, Sunday Creek, Girringun National Park (2010).

Issue 3: Manage high biomass grasses

Refer to Chapter 11 (Issue 3), regarding fire management guidelines.

It is important to be aware of the presence of high biomass grasses as they can dramatically increase fire severity and can be promoted by fire. Sometimes fire can be used to help in their control.

Chapter 8: Riparian, fringing and dune communities

This fire vegetation group includes coastal she-oak, shrubland on dunes, river she-oak open forest, riparian herbfield and other riparian vegetation (except for melaleuca dominated vegetation, refer to Chapter 7).

Fire management issues

Most of the species in these communities are fire sensitive. Do not intentionally burn. When burning adjacent fire-adapted communities, limit fire encroachment by using suitable conditions and/or by burning away from edges. In some cases fire may be introduced into these communities to control *Lantana camara*.

Issues:

1. Limit fire encroachment into riparian, fringing and dune communities
2. Reduce *Lantana camara*.

Extent within bioregion: 21 503 ha, 1 per cent; **Regional ecosystems:** Refer to Appendix 1 for complete list.

Examples of this FVG: Girringun National Park, 2 025 ha; Monkhouse Timber Reserve, 597 ha; Wooroonooran National Park, 522 ha; Paluma Range National Park, 510 ha; Abergowrie State Forest , 391 ha; Girramay National Park, 384 ha; Daintree National Park, 349 ha; Kuranda State Forest, 334 ha; Kuranda National Park, 271 ha; Tully Gorge National Park, 260 ha; Paluma State Forest, 139 ha; Mount Windsor National Park, 128 ha; Mount Lewis National Park, 103 ha; Goldsborough Valley USL Lands, 88 ha; Dinden State Forest, 67 ha; Koombooloomba Forest Reserve, 66 ha; Japoon National Park, 66 ha; Dagmar Former State Forest, 61 ha; Kurrimine Beach National Park, 58 ha; The Bluff State Forest, 55 ha; Barron Gorge National Park, 52 ha; Cardwell State Forest, 39 ha; Kamerunga Conservation Park, 28 ha; Little Mulgrave Forest Reserve, 26 ha; Clemant State Forest, 24 ha; Tumoulin State Forest, 23 ha; Millstream Falls National Park, 23ha; Bare Hill Conservation Park, 23 ha; Ella Bay National Park, 23 ha; Ravenshoe State Forest 3, 21 ha; Dinden National Park, 21 ha; Danbulla State Forest 2, 20 ha; Davies Creek National Park, 19 ha; Hull Gravel Reserve, 17 ha; Orpheus Island National Park, 17 ha; Hull River National Park, 16 ha; Gadgarra Forest Reserve, 16 ha; Halifax Bay Wetlands National Park, 15 ha; Hinchinbrook Island National Park, 10 ha; Herberton Range State Forest, 10 ha; Cedar Bay National Park, 9 ha; Macalister Range National Park, 8 ha; Russell River National Park, 8 ha; Trinity Forest Reserve, 6 ha; Ravenshoe State Forest 1, 6 ha.

Issue 1: Limit fire encroachment into riparian, fringing and dune communities

Refer to Chapter 11 (Issue 7), regarding fire management guidelines.

Many riparian communities contain a high proportion of fire-sensitive species and/or habitat trees. Too frequent and/or severe fire removes, or inhibits the development of structurally complex ground and mid strata and may open up the canopy. This in turn may increase the risk of weed invasion and soil erosion, and lead to greater production of fine fuel (mainly grass) and hence an increase in fire hazard. It is desirable to minimise the frequency and intensity of fire in many riparian communities in order to promote structurally complex ground and mid strata.

Coastal she-oaks are easily killed by fire and are an important food tree for the red-tailed black cockatoo. When burning adjacent fire-adapted communities, use appropriate conditions to avoid fire penetration. A bare earth buffer can easily be scratched with a rake-hoe through casuarina needles on sand to prevent fire trickling into these communities. Storm burning conditions may be useful to minimise impacts on mature she-oak. Be aware that dense Singapore daisy *Sphagneticola trilobata* and Mossman river grass *Cenchrus echinatus* infestations can draw fire into these communities.

Foredune she-oaks are killed by fire. Wildfire fuelled by tinder dry Singapore daisy carried flames against the wind back onto the base of these horse tailed she-oak trees. Singapore daisy resprouted soon after the fire.

Mark Parsons, QPWS, Yingalinda, Girramay National Park (2009).

Avoid fire penetrating into most riparian communities. This callistemon vegetation is fire sensitive.

Mark Parsons, QPWS, Stoney Creek, Girringun National Park (2008).

River she-oak community bordered by open woodland. Manage fire carefully to limit encroachment into river she-oak communities.

Mark Parsons, QPWS, Newly Creek, Girringun National Park (2007).

After a flood, flammable material may be stacked against trees and if ignited may damage or kill the tree. Avoid ignition and allow rot-down over time. Because this accumulated fuel is not continuous, it does not usually pose a wildfire hazard.

Peter Leeson, QPWS, Gympie (2011).

Issue 2: Reduce *Lantana camara*

Refer to Chapter 11 (Issue 4), regarding fire management guidelines.

Lantana often invades the edges of riparian, fringing and dune communities increasing fuel and drawing fire into these communities. Sometimes, if used carefully to avoid fire-sensitive areas, fire in these areas becomes a useful strategy to control lantana and aid recovery of native species.

Lantana thicket in fire-sensitive horsetail she-oak community.
Mark Parsons, QPWS (2005).

Chapter 9: Rainforest

Rainforest is the most extensive fire vegetation group in the Wet Tropics, and occurs from coastal lowlands to the uplands and tablelands of the Great Dividing Range. In the wet tropics bioregion this vegetation group includes mesophyll and notophyll rainforest, microphyll vine forest, beach scrubs and boulder fields with vine thickets.

Fire management issues

Typically rainforests will not burn due to moisture, microclimate conditions and a lack of flammable grasses (Bowman 2000). Scorching of rainforest edges may occur with the presence of high-biomass grasses or lantana particularly within the drier southern half of the wet tropics bioregion (refer to Chapter 11 regarding lantana and high-biomass grasses). Heavily disturbed rainforest (e.g. as a result of logging, cyclone or weed invasion) is potentially flammable in severe fire weather.

The main strategy is to maintain surrounding fire-adapted communities with mosaic burning to minimise the spread and severity of wildfire during very severe weather events. In certain situations, rainforests are more vulnerable to fire, e.g. coastal littoral rainforest, dry scrubs or where damaged rainforest is upslope from a planned burn area. In these instances, it may be necessary to employ specific tactics such as burning away from rainforest edges.

Occasionally, fire is used in rainforest areas for specific weed control and rehabilitation purposes.

Issue:

1. Limit fire encroachment into rainforest.

The southern cassowary is an iconic rainforest species of northern Queensland.
Photo: QPWS

Extent within bioregion: 706 822 ha, 35 per cent; **Regional ecosystems:** Refer to Appendix 1 for list.

Examples of this FVG: Wooroonooran National Park, 106 080 ha; Girringun National Park, 63 841 ha; Monkhouse Timber Reserve, 57 371 ha; Tully Gorge National Park, 56 271 ha; Daintree National Park, 51 460 ha; Paluma Range National Park, 27 633 ha; Japoon National Park, 24 332 ha; Koombooloomba Forest Reserve, 22 851 ha; Kuranda National Park, 15 437 ha; Tully Falls National Park, 15 366 ha; Girramay National Park, 15 291 ha; Dinden National Park, 14 920 ha; Mount Windsor National Park, 14 877 ha; Mount Lewis National Park, 12 743 ha; Kirrama National Park, 11 165 ha; Dagmar Former State Forest, 9 177 ha; Little Mulgrave Forest Reserve, 7 541 ha; Danbulla National Park, 6,477 ha; Proposed addition to Daintree National Park, 6 090 ha; Mowbray National Park, 5 765 ha; Malbon Thompson Forest Reserve, 5 575 ha; Cedar Bay National Park, 5 356 ha; Gadgarra Forest Reserve, 4 409 ha; Djiru National Park, 3 923 ha; Russell River National Park, 3 796 ha; Hinchinbrook Island National Park, 3 593 ha; Herberton Range National Park, 3 507 ha; Mount Mackay National Park, 3 077 ha; Ella Bay National Park, 2 668 ha; Malaan National Park, 2 423 ha; Macalister Range National Park, 2 201 ha; Barron Gorge National Park, 2 032 ha; Basilisk Forest Reserve, 2 017 ha; Herberton Range State Forest, 1 854 ha; Kuranda State Forest, 1 770 ha; Goldsborough Valley USL Lands, 1 639 ha; Danbulla State Forest 1, 1 503 ha; Wooroonooran National Park (Recovery), 1 148 ha.

Issue 1: Limit fire encroachment into rainforest

Refer to Chapter 11 (Issue 7), regarding fire management guidelines.

To protect rainforest edges from wildfire it is beneficial to mosaic burn surrounding fire-adapted communities. Rainforests edges are generally self-protecting during planned burning in appropriate conditions. Sometimes however, it may be necessary to burn back from rainforest edges.

The presence of weeds and a build up of dead material can draw fire into rainforests.

Paul Williams, Vegetation Management Science Pty Ltd, Curtain Fig National Park (2009).

The rainforest on this hillside was permanently lost due to the presence of high biomass grasses drawing fire into the rainforest during very dry weather.

Paul Williams, Vegetation Management Science Pty Ltd, Toogoora (2007).

Coastal littoral Rainforest is vulnerable to fire encroachment particularly when surrounded by fire-adapted ecosystems.

Mark Parsons, QPWS, Orpheus Island (2001).

Chapter 10: Mangroves and saltmarsh

Mangroves and saltmarsh are found near or within estuarine or brackish water. They are periodically inundated through tidal action and storms. Mangroves occur in stands (along tidal zones) as low trees or shrubs, with very little other vegetation present. Saltmarsh is dominated by salt adapted sedges or grasses with other plants sparse.

Fire management issues

Mangroves do not require fire and generally do not burn. Sometimes mangroves can be scorched in nearby planned burning operations or wildfire, but it is rare that any lasting damage is done.

However, care needs to be taken when burning around saltmarsh, as it is potentially flammable. The main strategy is to burn with king tides or recent rain with groundwater seepage protecting saltmarsh vegetation. Saltmarsh may occasionally burn, but plan to avoid burning.

Issue:

1. Limit fire encroachment into saltmarsh.

Extent within bioregion: 49 917 ha, 3 per cent; **Regional ecosystems:** refer to Appendix 1 for complete list.

Examples of this FVG: Hinchinbrook Island National Park, 8 068 ha; Girringun National Park, 4 856 ha; Girramay National Park, 3 142 ha; Hull River National Park, 1 380 ha; Proposed addition to Halifax Bay Wetlands National Park, 1 219 ha; Daintree National Park, 1 026 ha; Halifax Bay Wetlands National Park, 545 ha; Russell River National Park, 466 ha; Maria Creek National Park, 291 ha; Paluma Range National Park, 93 ha; Kurrimine Beach National Park, 89 ha; Monkhouse Timber Reserve, 70 ha; Ella Bay National Park, 54 ha; Clarkson Creek, 35 ha; Orpheus Island National Park, 35 ha; Smithfield Creek Reserve, 34 ha; Trinity Inlet - East Lands, 33 ha; Goold Island National Park, 9 ha; Annan River (Yuku Baja-Muliku) Resources Reserve, 8 ha; Cedar Bay National Park, 7 ha; Moresby Range National Park 4 ha; Carello Palm Swamp Conservation Park, 3 ha; Bloomfield River Conservation Park, 2 ha; Moresby Range Resources Reserve, 1 ha.

Issue 1: Limit fire encroachment into saltmarsh

Refer to Chapter 11 (Issue 7), regarding fire management guidelines.

The main strategy is to burn with king tide or recent rain with groundwater seepage protecting saltmarsh vegetation. Saltmarsh is most vulnerable to scorching if fire-promoting plants (especially flammable grasses) occur within or adjacent to them.

The ecotone between melaleuca, saltmarsh and mangrove communities. Slight differences in elevation and therefore inundation determine the distribution of these communities.
Mark Parsons, QPWS, Girringun National Park (2010).

Water seepage from recent rain along the ground surface of saltmarsh will help prevent fire encroaching into these communities.
Mark Parsons, QPWS, Girringun National Park (2010).

Flammable grasses can draw fire into saltmarsh communities.

Mark Parsons, QPWS, Girringun National Park (2010).

Surface water is used to control fire encroaching into saltmarsh.

Mark Parsons, QPWS, Girringun National Park (2010).

Saltmarsh will burn if care is not taken to ensure appropriate planned burning conditions. Saltmarsh does not require fire.

Mark Parsons, QPWS, Girringun National Park (2010).

Chapter 11: Common issues

In the Wet Tropics bioregion there are some issues where the fire management approach is similar irrespective of the fire vegetation group. Rather than repeating issues for each fire vegetation group, they are gathered in this chapter and cross-referenced where relevant in each fire vegetation group chapter.

Fire management issues

1. Hazard reduction (fuel management) burns.
2. Planned burning near sensitive cultural heritage sites.
3. Manage high-biomass invasive grasses.
4. Reduce *Lantana camara*.
5. Reduce Siam and sicklepod weed infestations.
6. Avoid peat fires.
7. Limit fire encroachment into non-target fire vegetation group.
8. Assess regrowth areas with regard to fire management.
9. Post-cyclone planned burning.

Issue 1: Hazard reduction (fuel management) burns

In many cases it is important to use fire to reduce fuels. In the QPWS Fire Management System, protection zones aim to create areas of simplified vegetation structure and reduced fuel levels around key infrastructure, property and natural and cultural resources that may be damaged by fire. Protection zones should be maintained in a relatively low fuel hazard state by planned burning as often as fuel levels allow. In wildfire mitigation zones the aim of planned burning is to simplify the structure and reduce the quantity of fuel (within the ecological regime for the community) to mitigate flame height, spread and intensity of subsequent wildfires; and therefore improve their controllability.

Awareness of the environment

Main indicators of where fire management is required

- The combined accumulation of all fuels (surface fuels, near-surface fuels, elevated fuels and bark hazard) exceeds a low to moderate overall fuel hazard as per the Overall Fuel Hazard Assessment Guide (Hines et al. 2010b). Note that this is the preferred assessment method.

Or

- The combined accumulation of all fuels (surface fuels, near-surface fuels, elevated fuels and bark hazard) exceeds five tonnes per hectare (see Step 5 of the supporting guideline: How to assess if your burn is ready to go, for a fuel load estimation technique).

Descriptive indicators of where fire management is required (Not all of these indicators will apply to every fire vegetation group)

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

Dead material build up around the base of grasses.
Kerensa McCallie, QPWS (2010).

Dead material builds up around the base of sedges.
Justine Douglas, QPWS, Hinchinbrook Island National Park (2007).

In long unburnt areas, there is a build up of bark, sticks and leaf litter smothering ground layer plants, as well as a build up of elevated fuel. Elevated fuels contribute significantly to fire severity.

Mark Parsons, QPWS, Mount Windsor (2010).

A recent fire created a low overall fuel hazard and fuel load of < 5 tonnes per hectare. Notice that the potential for elevated fuel build up has been addressed. Maintaining a simplified vertical fuel structure is an important aspect of fuel management.

Robert Miller, QPWS, Davies Creek (2008).

Discussion

- To estimate fuel hazard (recommended for use in open forests and woodlands) use the Overall Fuel Hazard Assessment Guide (Hines, et al. 2010b).
- To estimate fuel load, refer to Step 5 of the QPWS Planned Burn Guidelines: How to Assess if Your Burn is Ready to Go.
- The terms fuel load and fuel hazard are widely used to describe fuels, often interchangeably. While they are related, they do differ significantly (refer to Photos 1a and 1b) and can be defined as:

Fuel hazard – the "condition of the fuel taking into consideration such factors as quantity, arrangement, current or potential flammability and the difficulty of suppression if fuel should be ignited" (Wilson 1992).

Fuel load – "the dry weight of combustible materials per area, usually expressed as tonnes per hectare. A quantification of fuel load does not describe how the fuel is arranged nor its state or structure" (Hines et al. 2010a).

Demonstration of the difference between **fuel load** and **fuel hazard.**

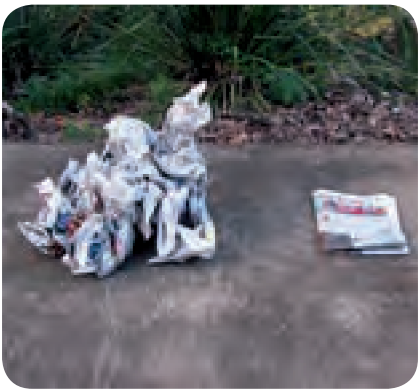


Photo 1a: The two samples above have the same **fuel load** (eighteen pages of newspaper) but a different fuel arrangement.

Troy Spinks, QPWS (2010).

Photo 1b: The fuel arrangement contributes to the difference in **fuel hazard.**

Troy Spinks, QPWS (2010).

- It is important to maintain a simplified vegetation fuel structure in protection zones and wildfire mitigation zones, which means addressing issues such as suspended and elevated fuel and overabundant saplings and seedlings.
- Fire management that favours grasses will assist in achieving an open structure suitable for wildfire management and mitigation. Moist conditions and low-severity burns that retain the bases of grasses will give them a competitive advantage over woody species.

- In wildfire mitigation zones it is essential to maintain ecosystem health. Ensure the use of appropriate conservation objectives for the fire vegetation group in addition to a fuel reduction objective (refer to fuel reduction objectives below).
- When establishing protection zones or wildfire mitigation zones favour fire vegetation groups that support a simplified vegetation fuel structure. Where possible avoid fire vegetation groups containing species that naturally produce high-severity fire during wildfire conditions (e.g. heath).
- It is not always possible to contain planned burns within the protected area due to the location of park boundaries (firelines may not exist along park boundaries as they are often in inaccessible areas and have continuous fuel levels. Cooperative fuel reduction burns with neighbours are often the only way to achieve the objectives of protection and wildfire mitigation zones. Refer to the QPWS Good neighbour policy and Notifying external parties of planned burn operations procedural guide.
- Planned burning often creates a smoke management issue particularly where burns are undertaken close to residential areas or commercial operations (e.g. agriculture, airports, major roads and high voltage power lines). Planning needs to consider factors such as fuel type, fuel hazard, temperature inversion and wind speed and direction all of which can have significant effects on the quantity of smoke generated and how it is distributed.

What is the priority for this issue?

Priority	Priority assessment
Highest	Planned burn required to **protect life** and/or **property,** usually within **protection zones.**
Very high	Planned burn required to **mitigate hazard** or **simplify vegetation structure,** usually within **wildfire mitigation zones**.

Assessing outcomes

Formulating objectives for burn proposals

Every proposed burn area contains natural variations in topography, understorey or vegetation type. It is recommended that you select at least three locations that will be good indicators for the whole burn area. At these locations walk around and if visibility is good look about and average the results. Estimations can be improved by returning to the same locations before and after fire, and by using counts where relevant.

Measurable objectives	How to be assessed	How to be reported (in fire report)
Reduce overall fuel hazard to low or moderate. **Or** Reduce fuel load to < 5 tonnes/ha.	**Post fire:** use the Overall Fuel Hazard Assessment Guide (Hines et al. 2010b) **Or** Step 5 of the QPWS Planned Burn Guidelines: How to Assess if Your Burn is Ready to Go, to visually assess the remaining fuel in at least three locations.	**Achieved:** Fuel hazard has been reduced to low or moderate **Or** fuel load has been reduced to < 5 tonnes/ha. **Not achieved:** Fuel hazard has not been reduced to low or moderate **Or** fuel load is > 5 tonnes/ha.
Burn 90 – 100 % (for protection zone) 60–80 % (for wildfire mitigation zone).	Choose one of these options: a) Visual estimation of percentage of vegetation burnt – from one or more vantage points, or from the air. b) Map the boundaries of burnt areas with GPS, plot on ParkInfo and thereby determine the percentage of area burnt. c) In three locations (that take account of the variability of landform and ecosystems within burn area), walk 300 or more metres through planned burn area estimating the percentage of ground burnt within visual field.	**Protection zone** **Achieved:** > 90 % burnt. **Partially achieved:** 80–90 % burnt, the extent and rate of spread of any subsequent wildfire would still be limited. **Not achieved:** < 80 % burnt. High proportion of unburnt corridors extend across the area (the extent and rate of spread of any subsequent wildfire would not be sufficiently limited). **Wildfire mitigation zone** **Achieved:** 60–80 % burnt. **Partially achieved:** 50–60 % burnt. **Not achieved:** < 50 % burnt. High proportion of unburnt corridors extend across the area (the extent and rate of spread of any subsequent wildfire would not be sufficiently limited).

If the above objectives are not suitable, refer to the compendium of planned burn objectives found in the monitoring section of the QPWS Fire Management System or consider formulating your own.

Fire parameters

What fire characteristics will help address this issue?

Fire severity

- **Low** and occasionally **moderate**. Where there is a high fuel load or elevated fuels (e.g. when first establishing a protection zone) the initial fire may result in a **moderate** to **high** severity. Following this initial burn, aim to reinstate a regime that will promote **low** severity planned burns. Severity should be sufficient to reduce elevated fuels and bark hazard (i.e. allow fire to run up trunks).

Fire frequency / interval (refer to Appendix 2 for a discussion)

- **Protection zones:** Fuel management planned burns within protection zones are carried out as soon as possible after they can carry a fire in order to maintain a relatively low fuel hazard.
- **Wildfire mitigation zones:** Planned burns within wildfire mitigation zones are undertaken within the fire frequency recommended for the fire vegetation group but generally towards the lower end of that range.

Mosaic (area burnt within an individual planned burn)

- **Protection zones:** 90 per cent burnt.
- **Wildfire mitigation zones:** 60–80 per cent burnt.

What weather conditions should I consider?

It is important to be aware of conditions prior to and following burns so that undesirable conditions and weather changes can be avoided, or to help with burn planning.

Season: January–August
Later burning can occur in protection zones if they are well established and have no containment hazards. For wildfire mitigation zones, avoid periods of increasing fire danger when relights are more likely.

FFDI: < 11

DI (KBDI): < 160

Wind speed: < 15 km/hr

Soil moisture: While the aim of hazard reduction burning is to reduce the amount of fuel, good soil moisture is desirable to:

- reduce scorch height and limit leaf drop post fire
- reduce the likelihood of a thicket of woody species developing post fire
- favour grasses over woody species as woody species will create undesirable fuel conditions.

What burn tactics should I consider?

Tactics will be site-specific and different burn tactics may need to be employed at the same location (e.g. due to topographical variation). During the burn, tactics should be reviewed and adjusted as required to achieve the burn objectives. What is offered below is not prescriptive, rather a toolkit of suggested tactics.

- **Spot ignition** can be used effectively to alter the desired intensity of a fire particularly where there is a high accumulation of available and volatile fuels. Spots closer together will result in a line of a greater intensity (as spots merge and create hot junction zones) while increased spacing between spots will result in a lower intensity fire. The spacing of the spots will generally vary throughout the burn due to changes in weather conditions, topography and fuel loads.
- **Commence lighting on the leeward (smoky) edge** to contain the fire and promote a low intensity backing fire. Depending on available fuels and the prevailing wind on the day, use either spot or strip lighting or a combination of both.
- **A low intensity backing fire** is usually slow moving, and will generally result in a more complete coverage of an area and a better consumption in continuous fuel. This tactic ensures the fire has a greater amount of residence time and reduction of available fuels, particularly fine fuels (grasses, leaf litter, twigs etc), while minimising fire severity and rate of spread.
- While a low intensity backing fire is recommended, a **running fire** of a higher intensity may be required in discontinuous or elevated fuel. Use with caution and be aware of environmental impacts that may result. To create higher intensity, contain the smoky side first, then **spot light the windward (clear) edge.** If the planned burn area is narrow, use caution when lighting the windward edge as the fire intensity may increase when the fire converges with the previously lit backing fire creating higher-intensity junction zones and the potential of fire escaping through a spot-over.

Issue 2: Planned burning near sensitive cultural heritage sites

It is important to have knowledge of the location of significant cultural heritage sites, items and places of Indigenous or European heritage when planning fire management. The local fire strategy should identify these locations (it is important to note that some locations will be culturally sensitive and therefore their location will not be specifically identified in text or on maps). Consulting Traditional Owners, the Department of Aboriginal and Torres Strait Islander and Multicultural Affairs (DATSIMA) Indigenous cultural heritage branch and the Department of Environment and Heritage Protection (EHP) European cultural heritage branch during fire strategy preparation will help to identify these places, items and issues.

Awareness of the environment

Key indicators of Indigenous cultural heritage sites:

- Raised mounds (especially with visible shell debris) or the presence of scattered shell debris can indicate the presence of shell middens.
- The presence of rock shelters, especially if they have rock paintings, stone tools, artefact bundles, wrapped material or bones inside.
- 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. a scar in the shape of a canoe).

Indigenous people scarred trees in order to make canoes, containers or temporary shelters. These trees are potentially vulnerable to fire if fuel builds up around their bases.

David Cameron, DNRM (2004).

This rock art site is potentially vulnerable to radiant heat and smoke impacts.

QPWS, Carnarvon Gorge.

Caves such as this may contain cultural material vulnerable to smoke impacts.

David Cameron, DNRM, Unspecified location.

Rocks on the ground that appear to have been purposefully arranged are likely to have cultural heritage significance.

David Cameron, DNRM, Atherton (2002).

Shell material strewn across the ground or visible in a mound structure usually indicates the presence of a midden. Middens are potentially vulnerable from radiant heat, fire line construction or vehicle or machinery operations.

David Cameron, DNRM, Bribie Island (2005).

Key indicators of European cultural heritage sites:

- Ruined buildings, corrugated iron shacks, wooden house stumps, old fence posts, old stockyards, tombstones, wells, graves, bottle dumps, old machinery and iron debris may all indicate the presence of a significant site.
- The presence of quarries and old mines sites (often seen as deep holes covered with corrugated iron or wood).
- Plane wreckages.
- The presence of forestry artefacts including marked trees (shield trees), springboard trees (stumps or trees with axe notches cut into it to support boards) and old machinery such as winders (timber tramways) and timber jinkers (timber lifting wagon).

Sometimes early European explorers left marks, plaques, and paint on trees. These may be vulnerable to fire especially if fuel has built up around the base of the tree.

David Cameron, DNRM, Dogwood Creek (2005).

In bushland areas, forestry and timber getting operations left a number of items that are now of cultural heritage significance including from the top left: shield trees (this one marks an apiary site), road signs (and other signs), timber getting equipment such as this timber winch, springboard trees, campsite remains (and other ruins from huts and fire towers).

Because of their location in forested areas, these are often vulnerable to fire, and need to be protected from wildfire through appropriate planned burning or mechanical fuel reduction.

When planning burns, consider if particular mild weather conditions, tactics, chipped lines or mechanical fuel reduction (e.g. raking) is required prior to implementing the burn.

David Cameron, DNRM, various locations.

Discussion

- **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 cultural heritage coordination units of DATSIMA (for Indigenous sites) or EHP (for European sites). Also refer to the Duty of Care Guidelines provided in the *Aboriginal Cultural Heritage Act 2003* (Queensland Government 2004).
- When planning burns in and adjacent to sensitive cultural heritage places there is a duty of care to ensure appropriate people are involved. Appropriate people may include Traditional Owners, indigenous rangers, historical societies and cultural heritage experts. If you are unsure who the appropriate people are, refer to the DATSIMA and/or EHP cultural heritage coordination units.
- Be aware of QPWS policy and procedures Management of cultural heritage places on NPRSR estate (DERM 2010a, 2010b) which recommends fire management of a heritage place involve burning only the area surrounding the place that does not contain objects or areas related to the cultural heritage place (e.g. fences or gravestones).
- Large-scale wildfires are known to damage cultural heritage values. A landscape proactively managed with mosaic burning will limit the spread and severity of wildfires giving better protection to cultural heritage artefacts and sites.
- The key risks to cultural heritage sites and artefacts from fire are direct contact with flames, radiant heat and smoke (e.g. radiant heat can exfoliate the surface of rock art sites, flame can crack or burn items and smoke can damage paintings).
- To manage impacts from flame and radiant heat, consider reducing fuel levels though manual, mechanical, or herbicide means or a combination of these. If it is not necessary to reduce fuel it is preferable to leave the site completely undisturbed.
- For larger culturally significant sites it may be necessary to create a secure burnt edge by backing fire away from these locations. Use this tactic prior to broader-scale planned burns.
- For sites that may be impacted by smoke (e.g. rock paintings and rock shelters) use wind to direct smoke away from the site.

What is the priority for this issue?

Priority	Priority assessment
Very high	Planned burn required to maintain areas of **special conservation significance**.

Assessing outcomes

Formulating objectives for burn proposals

As required choose three or more locations that will be good indicators for the whole burn area. Return to the same locations before and after fire.

Measurable objectives	How to be assessed	How to be reported (in fire report)
No impact on item or site of cultural heritage significance.	Visual inspection of site or items taking photographs before and after fire.	**Achieved:** No impact on site or item. **Not Achieved:** There was some impact on site or item.

If the above objectives are not suitable, refer to the compendium of planned burn objectives found in the monitoring section of the QPWS Fire Management System or consider formulating your own.

Fire parameters

What fire characteristics will help address this issue?

Fire severity

- Burn within the parameters recommended for the fire vegetation group. **Low**-severity fires will be less likely to impact on cultural heritage sites.

Fire frequency / interval (refer to Appendix 2 for a discussion)

- Be guided by the fire zoning plan and the recommendations within it for the fire vegetation group within the planned burn area.

Mosaic (area burnt within an individual planned burn)

- Where possible create a patchy fire to give greater overall protection to cultural heritage sites and items (unless burning in adjacent areas where the object is to reduce fuel—in which case a good coverage of fire is recommended).

Landscape mosaic

- A landscape that is proactively managed using mosaic burning will help reduce fuel hazard and thereby limit the spread and severity of wildfires, giving better protection to cultural heritage artefacts and sites.

What weather conditions should I consider?

When planning a burn it is important to be aware of weather predictions prior to and following burns so that undesirable conditions and weather changes can be avoided.

Season: Favour early season burning and moist conditions.

FFDI: < 7

DI (KBDI): < 160

Wind speed: < 15 km/hr

Wind Direction: Closely monitor the wind direction to avoid smoke, flame and/or radiant heat being exposed to sensitive cultural heritage sites.

Soil moisture: Ensure good soil moisture.

Using spot ignition and still conditions kept smoke away from this rock art site.
Mark Parsons, QPWS, Fishers Creek (2010).

What burn tactics should I consider?

Tactics will be site specific and often different tactics will need to be implemented at the same site due to changes in the topography, the weather and variations in the vegetation. During the burn, regularly review and adjust tactics as required to achieve burn objectives. What is offered below is not prescriptive; rather it is a toolkit of suggested tactics that may assist in this issue.

- **Spot ignition.** This tactic is used to alter the desired intensity of a fire particularly where there is an accumulation of available and volatile fuels next to a site of interest. Widely spaced spots is preferred in this instance as it will promote a slow moving and manageable low-severity fire and limits the chances of high-severity junction zones developing.
- **A low-severity backing fire.** A slow moving backing fire will help minimise fire severity and rate of spread, and may reduce smoke particulates.
- Depending upon conditions on the day, **spot light the windward (clear) edge** to direct the active fire line and smoke away from the site of interest. It may be necessary to secure the edge closest to the cultural heritage site with a chipped line or wet line.
- **Manual fuel management.** Usually, burning in appropriate conditions should be sufficient to protect cultural heritage items. However, prior to undertaking planned burns near sites of cultural significance (e.g. scar trees and rock art sites), assess the need for manual reduction of fuel. This may include the raking, clearing (e.g. rake-hoe line), trimming or leaf blowing of surface fuels away from the site to limit potential impacts from smoke, flame and heat radiation. Only undertake manual fuel management if required, otherwise it is preferable to leave the site completely undisturbed.

Issue 3: Manage high-biomass invasive grasses

High-biomass exotic grasses are capable of outcompeting native species to form dominant stands. High-biomass grasses of concern in the Wet Tropics are guinea, molasses, grader, para, thatch, gamba, olive hymenachne and giant rat's tail grass. Mission and aleman grass are emerging threats. They are generally much taller and produce significantly more dry matter than native species; increasing fuel loads, fire intensity, spotting and flame height which leads to increased fire severity and spread. This results in greater tree death and loss of habitat features with flow on effects to species. Fire can be used as part of control for some high-biomass exotic grasses. At the same time, high-biomass grasses both promote fire and many are promoted by fire. They tend to occur as a result of disturbance and spread along fire lines and utility easements. It is important to be aware of the presence of high biomass grasses during planned burn operations.

Awareness of the environment

Key indicators:

Note: be on the look out for newly forming stands; control is much easier if their presence is detected early.

- The presence of high biomass grasses, usually occurring in a dense infestation (see photographs below).
- High biomass grasses generally form single species dominated stands.
- Generally taller than native species.
- High-biomass grasses have a lot of mass and/or dead material.

Guinea grass infestation.

John Clarkson, QPWS, Mereeba (2007).

Close up of Guinea grass.

Paul Williams, Vegetation Management Science Pty Ltd, near Patterson's Gorge (2005).

The height, mass and structure of guinea grass infestations increases flame height and severity, contributing to tree death.

Mark Parsons, QPWS, Mullers Creek (2010).

In this photo, increased fire severity caused by gamba grass has resulted in tree death.
Paul Williams, Vegetation Management Science Pty Ltd, Bachelor Northern Territory (2007).

Gamba grass infestation.
John Clarkson, QPWS, Batchelor, Northern Territory (2004).

Grader grass infestation.
John Clarkson, QPWS, Mareeba (2007).

Thatch grass infestation.
John Clarkson, QPWS, Mareeba (2007).

Molasses grass infestation.

John Clarkson, QPWS, Mareeba (2007).

Molasses grass flowering.

Paul Williams,Vegetation Management Science Pty Ltd, near Patterson's Gorge.

Para grass infestation.
John Clarkson, QPWS, Julatten (2007).

Fruiting para grass.
Paul Williams, Vegetation Management Science Pty Ltd (2007).

Discussion

- During planned burn operations, where these grasses are present, the potential to either promote them or control them and their effect on fire severity must be considered. Be aware that fire will usually promote these grasses unless used in very specific ways mentioned below.
- Exotic grasses are highly invasive and thrive on disturbance. They can establish where the cover of native grasses has been reduced, however some species such as gamba and molasses grass can outcompete even a dense cover of native grasses.
- There is a relationship between fire timing, frequency and severity and the ability of these grasses to invade which is still poorly understood. You are encouraged to record observations regarding these species' response to fire.
- Be aware of weed hygiene issues when planned burning in areas with high-biomass grasses. Fire vehicles and machinery can aid seed spread along fire lines and should be washed down after exposure.
- In many cases it is desirable to avoid burning high-biomass invasive grasses, due to the likely increase in fire severity and the potential to promote them. However, the risk of wildfire later producing an even higher-severity fire must be considered. In some situations, burning high biomass grasses under mild conditions with planned fire is more desirable than allowing them to burn with wildfire.
- For some species, application or exclusion of fire is known to be an important aspect of control. Specific information is offered below:

Molasses grass

- Molasses grass has become quite extensive in the Wet Tropics, even in remote areas, but particularly around the edges of rainforests where it can contribute to rainforest scorching (by increasing fire severity and spread). It can spread by runners and smother native grasses even if the native grass cover is reasonably healthy. Molasses grass is easily killed by fire; however follow up burning or chemical control is essential to manage post fire recruitment. Fire is most effective if applied prior to seed production (mid May), particularly for follow up burns.

Grader grass

- Grader grass is an annual (life cycle occurs within a year) and the viability of seed in the soil has been observed to drop off after four or five years. Fire should be excluded for four or five years, because if fire is applied while the seed is still viable, grader grass will be promoted.
- If using fire, attempt to time fire at the end of the wet season prior to seed set which is typically in March.
- When fire is reapplied in these infestations ensure good soil moisture to aid the re-establishment of native grass species.
- Too frequent or severe fire promotes the spread of grader grass.
- New infestations of grader grass can be controlled by hand removal before they set seed (March-May).

Guinea and thatch grass

- Fire is not known to be an effective tool to manage guinea and thatch grass. However, frequent fire (every one to two years) promotes their spread through disturbance mechanisms and possibly through reducing canopy cover.
- Post-fire herbicide control has been effective but needs to be ongoing.
- If guinea and thatch grass must be burnt, timing is a critical factor. Avoid burning late in the season for a variety of reasons including the risk of creating high-severity fire and encroachment into riparian zones.

Para grass

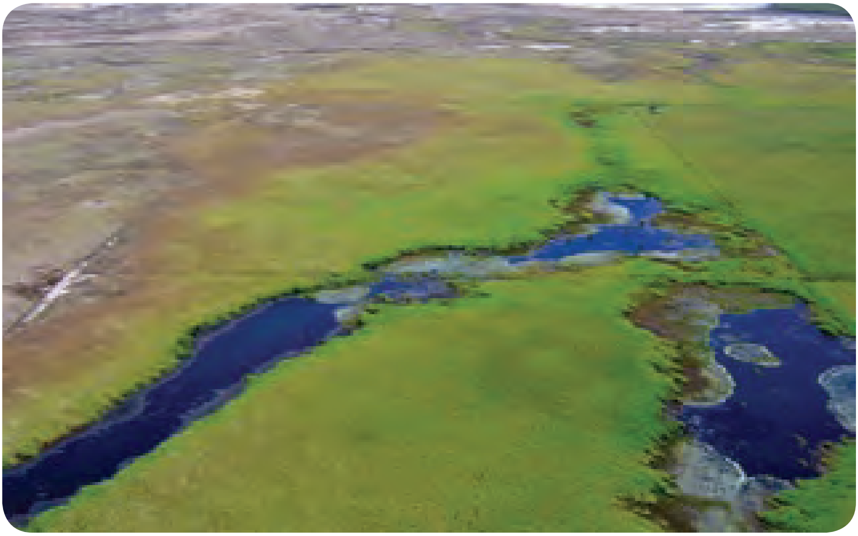
- Fire can be used with partial success for the management of para grass where it occurs in swamps and drainage lines. Fire is more effective where the para grass is within ephemeral swales which have dried out (which occur with limited windows of opportunity in the late season). Burning has been found to be more effective if used later in the year or in combination with chemical control.

Other high-biomass grasses

- Successful fire management techniques for other species of high-biomass grasses in the Wet Tropics are not yet established and will require experimentation. The examples above might be useful as a starting point.

What is the priority for this issue?

Priority	Priority assessment
High	It is important to be **aware of the presence** of high biomass grasses so that their negative effects can be managed and the potential of control can be considered.



Fire has been found to be effective in burning para grass where it exists in ephemeral wetland depressions. This can open channels of water flow previously clogged by grass invasion.

Paul Williams, Vegetation Management Science Pty Ltd, Townsville Town Common (2007).

Assessing outcomes

Formulating objectives for burn proposals

Every proposed burn area contains natural variations in topography, understorey or vegetation type. It is recommended that you select at least three locations that will be good indicators for the whole burn area. At these locations walk around and if visibility is good look about and average the results. Estimations can be improved by returning to the same locations before and after fire, and by using counts where relevant.

Choose from below as appropriate:

Measurable objectives	How to be assessed	How to be reported (in fire report)
Protect high-biomass grass infestation from unplanned fire, by burning adjacent areas.	Inspection of infestation at the end of the fire year.	**Achieved:** At the end of the fire year, infestation remains unburnt. **Partially Achieved:** At the end of the fire year, infestation partially burnt. **Not Achieved:** At the end of the fire year, infestation burnt.

*Significant reduction in density of invasive grasses.	**Before and after the burn** (after suitable germination/establishment conditions and growing season): define the density of the infestation using the following criteria (from Parks Victoria Protocol [Parks Victoria 1995]): • Rare (0–4 % cover) = target weed plants very rare. • Light (5–24 % cover) = native species have much greater abundance than target weed. • Medium (25–75 % cover) = roughly equal proportions of target weed and native species. • Dense (> 75 %) = monoculture (or nearly so) of target weed.	**Achieved:** Weed infestation 'drops' two 'density categories' (e.g. goes from dense before the fire to light after the fire). **Partially Achieved:** Weed infestation 'drops' one 'density category' (e.g. goes from dense before the fire to medium after the fire). **Not Achieved:** No change in density category or weed density gets worse. *note that some of these species quickly recover even after they have been reduced. Ongoing monitoring is recommended.

If the above objectives are not suitable, refer to the compendium of planned burn objectives found in the monitoring section of the QPWS Fire Management System or consider formulating your own.

Monitoring the issue over time

Many issues are not resolved with a single planned burn and it is important to keep observing the land. To support this, it is recommended that observation points be established. Observation points are usually supported by photographs and by recording observations. Instructions for establishing observation points can be obtained from the monitoring section of the QPWS Fire Management System. When using fire to reduce the density of high biomass grasses, it is important to monitor the potential for these grasses to re-establish.

As highly invasive weeds, high-biomass grasses such as this single guinea grass plant can quickly establish and spread. The maintenance of a healthy native grass cover is vital to exclude high biomass exotic grasses. Fire has an important role in maintaining healthy grass cover.

Mark Parsons, QPWS, Princess Hill, Girringun National Park (2007).

Fire parameters

Varies depending on species, see discussion earlier in this Issue.

What burn tactics should I consider?

Tactics will be site specific and often different tactics will need to be implemented at the same site due to changes in the topography, the weather and variations in the vegetation. During the burn, regularly review and adjust tactics as required to achieve burn objectives. What is offered below is not prescriptive; rather it is a toolkit of suggested tactics that may assist in this issue.

- **As part of a control program.** The initial spraying of high biomass grasses (e.g. guinea grass) with herbicide, followed a month later by a low to moderate intensity planned burn has been shown to be very effective as a control method. The successful treatment of these grasses will require continued monitoring and follow up, either by fire or herbicide, of any remaining plants and new seedlings.
- **Spot ignition.** Can be used effectively to alter the desired severity of a fire particularly where there is a high-biomass grass infestation. Increased spacing between spots will result in a lower intensity. The spacing of the spots may vary throughout the burn due to changes in weather conditions, topography and fuel loads.
- **A low intensity backing fire.** A slow moving, low intensity backing fire (against the wind or down slope) will generally result in a more complete coverage of an area and a better consumption of available fuels. This tactic ensures the fire has a greater amount of residence time, while ensuring fire severity and rate of spread is kept to a minimum.
- **Running fire.** For many high biomass grasses it is recommended to burn early in the season. Conditions which favour a running fire will help carry the fire though the infestation if weather conditions are too mild or grasses are not sufficiently cured. This can be achieved by shortening the spacing of lit spots or alternatively using line or strip ignition.

Issue 4: Reduce *Lantana camara*

Lantana occurs throughout most fire vegetation groups favouring disturbed areas, rich soils, clearings, drainage lines, gullies, road verges and wet riparian pockets. The growing habit of lantana shades out regeneration of native species and in particular grasses, which in turn inhibits low-severity planned burns, but at the same time carries wildfire (Tran et al. 2008). Where it occurs along rainforest edges, it increases the severity of fire, impacting on fire-sensitive ecosystems. Lantana is a class three declared pest plant under Queensland legislation and a Weed of National Significance (WONS).

Awareness of the environment

Key indicators of *Lantana camara* where it has a scattered distribution:

- *Lantana camara* occurs as a scattered understorey plant.
- Grass fuels are still continuous despite the occurrence of lantana.

Lantana occurring as a scattered understorey plant. Notice that grass fuels are still continuous and therefore the standard fire regime for the fire vegetation group could be applied to help control lantana.

Mark Parsons, QPWS (2010).

Key indicators of *Lantana camara* where it is a dense infestation:

- *Lantana camara* occurs as a dense infestation.
- The absence of grass or fine fuels.

Lantana / guinea grass infestation.
Jenise Blaik, QPWS, Smithfield Conservation Park (2010).

Discussion

- A series of fires (with increased fire frequency) can be used to reduce the abundance and density of lantana, or reduce the size of individual plants so that native ground covers can compete. Where lantana is widespread this may be the only practical method of control. Implementing the recommended regime for the fire vegetation group may be effective in the management of the density and occurrence of lantana where it is scattered as an understorey plant. In areas where lantana is not widespread, herbicide application becomes more practical and may be the preferred approach. A balance must be struck in terms of resourcing.
- In areas where lantana density is high but where some native grasses remain beneath it, the introduction of a low to moderate-severity fire may be sufficient to control lantana and favour the native grasses. In areas where lantana has become a dense infestation of a limited size, an approach combining fire and herbicide becomes more practical, though fire or herbicide on its own may prove sufficient.
- Use of fire in inappropriate conditions may promote lantana or scorching of fire-sensitive communities particularly where lantana occurs along rainforest margins. If lantana has been promoted, a follow up low to moderate-severity backing fire in moist conditions may be required to favour the recruitment of native grasses and to kill lantana.

What is the priority for this issue?

Priority	Priority assessment
High	Planned burns to **maintain ecosystems** in areas where **ecosystem health** is **good**.
Medium	Planned burn in areas where **ecosystem health** is poor but recoverable.
Low	Planned burn in areas where **ecosystem** structure and function has been **significantly disrupted**.

Assessing outcomes

Formulating objectives for burn proposals

Every proposed burn area contains natural variations in topography, understorey or vegetation type. It is recommended that you select at least three locations that will be good indicators for the whole burn area. At these locations walk around and if visibility is good look about and average the results. Estimations can be improved by returning to the same locations before and after fire, and by using counts where relevant.

Choose from below as appropriate:

Measurable objectives	How to be assessed	How to be reported (in fire report)
Significant reduction in abundance of lantana.	**Before and after the burn** (after suitable germination/ establishment conditions, and if using cover – a growing season): define the density of the infestation using the following criteria (from Parks Victoria Protocol [Parks Victoria 1995]): • Rare (0–4 % cover) = target weed plants very rare. • Light (5–24 % cover) = native species have much greater abundance than target weed. • Medium (25–75 % cover) = roughly equal proportions of target weed and native species. • Dense (> 75 %) = monoculture (or nearly so) of target weed.	**Achieved:** Weed infestation ‘drops’ two ‘density categories’ (e.g. goes from dense before the fire to light after the fire). **Partially Achieved:** Weed infestation ‘drops’ one ‘density category’ (e.g. goes from dense before the fire to medium after the fire). **Not Achieved:** No change in density category or weed density gets worse.

Majority of lantana clumps burnt back to the extent that regrowth is by basal resprouting (and hence follow-up spraying more efficient and effective).	**After the burn** (preferably after rain): visual estimation (by traversing the burn area on foot) of the percentage of clumps that are reduced to basal resprouting.	**Achieved:** ≥ 60 % of clumps reduced to basal resprouting. **Partially Achieved:** 25–59 % of clumps reduced to basal resprouting. **Not Achieved:** < 25 % of clumps reduced to basal resprouting.

If the above objectives are not suitable, refer to the compendium of planned burn objectives found in the monitoring section of the QPWS Fire Management System or consider formulating your own.

Monitoring the issue over time

Many issues are not resolved with a single planned burn and it is important to keep observing the land. To support this, it is recommended that observation points be established. Observation points are usually supported by photographs and by recording observations. Instructions for establishing observation points can be obtained from the monitoring section of the QPWS Fire Management System.

Fire parameters

What fire characteristics will help address this issue?

Key factors

- The principal factor in successful control is repetitive fire.

Fire frequency / interval (refer to Appendix 2 for a discussion)

- Apply successive fires frequently (within three years of each other) until observations indicate that the issue is under control. After this, re-instate the recommended fire regime for the fire vegetation group. Continue Monitoring the issue over time.
- Where lantana is a scattered understorey plant, apply the recommended fire frequency for the fire vegetation group in which it occurs. In any case, increasing fire frequency for a period will assist control. Monitor the issue over time.

Mosaic (area burnt within an individual planned burn)

- 90 per cent where lantana has become a dense infestation; or
- Increase coverage of fire to 50–70 per cent where lantana is a scattered understorey plant.

Fire severity

- **Low** to **moderate**. Best results have been achieved using a slow moving backing fire with good residence time at the base of the plant in combination with high soil moisture. Fire severity should generally remain within the recommendations for the fire vegetation group in which the lantana occurs.
- For a dense infestation, **moderate** to **high**-severity fire may initially be required. A sequence of fires in dry conditions has been used to reduce the biomass of high density infestations. Be aware of potential damage to ecosystems and be cautious when using this method adjacent to fire-sensitive vegetation and along creek lines.

Lantana and fire management.
Mark Parsons, QPWS, Flaggy Creek (2005).

What weather conditions should I consider?

It is important to be aware of conditions prior to and following burns so that undesirable conditions and weather changes can be avoided, or to help with burn planning.

Season: Different approaches (such as burning early in the year with good moisture or progressive burning to secure a late season burn under dry conditions) are possible. In the Wet Tropics bioregion the control of lantana by fire has been very successful when implemented as a storm burn with high relative humidity and temperatures, impending rain and good soil moisture.

FFDI: < 12 and sometimes 18 for higher severity fires

DI (KBDI): 100–180

Wind speed: < 23 km/hr. Variable depending on the objective and density of the lantana infestation (denser infestations may require some fanning by the wind so that the fire will carry).

What burn tactics should I consider?

Tactics will be site specific and often different tactics will need to be implemented at the same site due to changes in the topography, the weather and variations in the vegetation. During the burn, regularly review and adjust tactics as required to achieve burn objectives. What is offered below is not prescriptive; rather it is a toolkit of suggested tactics that may assist in this issue.

- **Line or strip ignition:** Used when the objective is to implement a fire of higher severity generally due to factors such as moist fuels, mild weather conditions and inconsistent fuels. May be required where the lantana infestation is of such a density that spot ignition will not be sufficient or there are minimal surface fuels available (e.g. grasses).
- **A low to moderate severity backing fire.** Where lantana is scattered in the understorey, a slow moving, low to moderate-severity backing fire with good soil moisture (and presence of sufficient surface fuels) ensures a greater residence time at ground level and has proven to be successful in killing both seedlings and mature lantana plants.
- **Subdividing lantana infestations.** Dividing an infestation into sections by hand or with heavy equipment can improve access, aeration and allow the infestation to be burnt in sections in order to manage fire severity and behaviour.
- **As part of a control program.** The initial over-spraying of lantana with herbicide (e.g. splatter gun), knocking down the lantana frames a month or so post herbicide treatment and then implementing a low to moderate-severity burn into the remaining material has been shown to be very effective as a control method and is particularly useful along rainforest margins. Alternatively, it is possible to knock down the lantana first, prior to herbicide control. The successful treatment of lantana will require monitoring the site and follow up treatments either by fire or herbicide treatment of any remaining plants and new seedlings.
- **Progressive burning.** A tactic that has been used to good effect in the wet tropics where lantana is present as a dense infestation has been the implementation of low-severity, early-season burns (e.g. April onwards) to create a safe perimeter around the lantana infestation, followed by a burn in November-December of a **moderate** to **high**-severity targeting the lantana infestation.

Monitoring weather aids in choosing the right conditions to push fire into dense lantana thickets.

Mark Parsons, QPWS, Mt Fox, Girringun National Park (2008).

The lantana depicted was treated with herbicide; its frames knocked down and then burnt. This has proved an effective method of control while reducing the risk of scorching when lantana is adjacent to fire-sensitive communities.

Mark Parsons, QPWS, Henrietta Creek, Girringun National Park (2008).

Issue 5: Reduce Siam and sicklepod weed infestations

Within the wet tropics bioregion Siam weed or sicklepod can form dense stands in disturbed areas, clearings, drainage lines, gullies, road verges and wet riparian pockets. These weeds particularly invade within and along the edge of lowland open forests, rainforests and creek lines. The dense growing habit of both Siam weed and sicklepod shades regeneration of native species and in particular grasses, which in turn inhibits low severity planned burns. Where Siam weed occurs along rainforest edges and creek lines, it can cause higher-severity fires that impact on fire-sensitive vegetation. Siam weed is a class one declared pest and sicklepod is a class two declared pest in Queensland.

Awareness of the environment

Key indicators:

- Siam weed and/or sicklepod occurring as scattered understorey plants.
- Siam weed and/or sicklepod occurring as dense infestations.
- Siam weed and sicklepod can occur together or separately.

A dense infestation of Siam weed on a hill slope.
Paul Williams, Vegetation Management Science Pty Ltd, Java, Indonesia (2007).

Moderately dense infestations of Siam weed.
Paul Williams, Vegetation Management Science Pty Ltd, Badjabulla (2004).

Siam weed in flower.
Paul Williams, Vegetation Management Science Pty Ltd, Badjabulla (2004).

This dense infestation of sicklepod occurred within an endangered ecosystem and covered 40 hectares. Integrated control with fire and herbicide restored grassy open forest.
Mark Parsons, QPWS, Stony Creek, Girringun National Park (2008).

Discussion

Siam weed

- Often Siam weed occurs in fire vegetation groups where use of fire may be inappropriate. However, it has also been found with guinea grass on the edge of such fire vegetation groups, in which case fire can be used to reduce the biomass of invasive grasses, improve access and detectability of Siam weed (obscured by guinea grass) and help in its control.
- Fire has been shown to kill small Siam weed plants, however, the remaining plants will coppice and follow up herbicide control is required. Fire is most effective prior to August when Siam weed produces seed (Williams et al. 2008).
- Inappropriate fire can promote the spread of Siam weed by creating a disturbance (Williams et al. 2008).
- Planned burning can be used as the second stage of integrated control. The initial over-spraying of Siam weed with herbicide, followed by a moderate severity fire in the remaining material has been shown to be effective as a control method. Follow-up control is still required.

Sicklepod

- The key strategy is to use fire to stimulate mass germination of sicklepod seedlings, followed by herbicide control on the alfalfa-like growth. Stimulating mass germination is an efficient means to exhaust the seed bank and concentrate herbicide efforts.
- Use of fire in moist conditions followed by broad-leaved herbicides is recommended, as this will provide native grasses with a significant advantage. Once grass cover is established, it will be much harder for sicklepod to re-establish.

What is the priority for this issue?

Priority	Priority assessment
High	Planned burns to **maintain ecosystems** in areas where **ecosystem health** is **good**.
Medium	Planned burn in areas where **ecosystem health** is **poor** but recoverable.
Low	Planned burn in areas where **ecosystem** structure and function has been **significantly disrupted**.

After fire, sicklepod seedlings were observed to germinate at ten times the rate of unburnt sites. This alfalfa-like growth is ready for application of broad-leaved herbicide.

Mark Parsons, QPWS, Stony Creek (2004).

Following a wildfire in 2004, herbicide was applied. The image on the left (October 2007) is immediately after herbicide treatment. There was a dramatic recovery of blady grass as shown in the image below in November 2009.

Mark Parsons, QPWS, plot No. 5, Stony Creek, Girringun National Park.

(2007) left and (2009) below.

Assessing outcomes

Formulating objectives for burn proposals

Every proposed burn area contains natural variations in topography, understorey or vegetation type. It is recommended that you select at least three locations that will be good indicators for the whole burn area. At these locations walk around and if visibility is good look about and average the results. Estimations can be improved by returning to the same locations before and after fire, and by using counts where relevant.

Choose from below as appropriate:

Measurable objectives	How to be assessed	How to be reported (in fire report)
Significant reduction in abundance of weed.	**Before and after the burn** (after suitable germination/ establishment conditions, and a growing season): define the density of the infestation using the following criteria (from Parks Victoria Protocol [Parks Victoria 1995]): • Rare (0–4 % cover) = target weed plants very rare. • Light (5–24 % cover) = native species have much greater abundance than target weed. • Medium (25–75 % cover) = roughly equal proportions of target weed and native species. • Dense (> 75 %) = monoculture (or nearly so) of target weed.	**Achieved:** Weed infestation ‘drops’ two ‘density categories’ (e.g. goes from dense before the fire to light after the fire). **Partially Achieved:** Weed infestation ‘drops’ one ‘density category’ (e.g. goes from dense before the fire to medium after the fire). **Not Achieved:** No change in density category or weed density gets worse.

Majority of weed burnt back and germination or regrowth stimulated (and hence follow-up spraying more efficient and effective).	**After the burn** (preferably after rain): visual estimation (by traversing the burn area on foot) of the percentage of plants that are reduced and the amount of regrowth stimulated.	**Achieved:** ≥ 60 % of mature weed burnt. Significant cover of weed regrowth. **Partially Achieved:** 25– 59 % of weed reduced. Some weed regrowth. **Not Achieved:** < 25 % of weed reduced.

If the above objectives are not suitable, refer to the compendium of planned burn objectives found in the monitoring section of the QPWS Fire Management System or consider formulating your own.

Monitoring the issue over time

Many issues are not resolved with a single planned burn and it is important to keep observing the land. To support this, it is recommended that observation points be established. Observation points are usually supported by photographs and by recording observations. Instructions for establishing observation points can be obtained from the monitoring section of the QPWS Fire Management System.

Fire parameters

What fire characteristics will help address this issue?

Mosaic (area burnt within an individual planned burn)

- 90 per cent where Siam weed and/or sicklepod has become a dense infestation; or
- Between 50–70 per cent where Siam weed and/or sicklepod is scattered amongst the understorey.

Fire severity

- **Low**-severity trickling fire.
- Sometimes high severity fire may be required to improve access into an infestation or if guinea grass is present. Otherwise low-severity fire should be sufficient.
- Planned burning when Siam weed is healthy, flowering and actively growing has been shown to be somewhat successful in the mortality of juvenile plants and seedlings less than one metre tall (Williams et al. 2008). Follow up herbicide control is required as fire will not kill all plants and many will coppice vigorously after fire.

What weather conditions should I consider?

Siam weed

Season: November to December or whenever sites dry-out sufficiently to carry a fire prior to August (when Siam weed sets seed).

FFDI: < 12

DI (KBDI): Siam weed: 120–200

Wind speed: < 23 km/hr.

Sicklepod

Season: August to September. Aim for ground moisture that is sufficient to support germination and native grasses. High humidity (to encourage a trickle fire) and recent rain (for soil moisture) is desirable.

FFDI: < 12

DI (KBDI): 100–170

Wind speed: < 23 km/hr.

What burn tactics should I consider?

Tactics will be site specific and often different tactics will need to be implemented at the same site due to changes in the topography, the weather and variations in the vegetation. During the burn, regularly review and adjust tactics as required to achieve burn objectives. What is offered below is not prescriptive; rather it is a toolkit of suggested tactics that may assist in this issue.

- **Line or strip ignition:** Used when the objective is to implement a running fire to carry through moist fuels or inconsistent fuels, or when the weather is very mild. This tactic may be required where the Siam weed or sicklepod infestation is of such a density that spot ignition will not sufficiently carry, or there are minimal surface fuels available (e.g. grasses).
- **As part of a control program.** The initial over-spraying of Siam weed or sicklepod with selective herbicide, followed by implementing a moderate intensity burn into the remaining material has been shown to be effective as a control method. The successful treatment of Siam weed and sicklepod requires monitoring and follow up herbicide treatment of remaining plants and any seedlings to ensure the infestation does not worsen post fire due to the greater availability of light resulting from reduced forest canopy cover and increased available soil nutrients (Williams et al. 2008).
- **A gas heat wand** can be used for follow up control of small weeds (below approximately 20 cm). It can also be used to kill Siam weed seed heads so as to avoid spreading the seed by mechanical removal.

Low severity trickle fires are sufficient to reduce sicklepod or Siam weed, and at the same time, aid in the recovery of grasses by leaving grass bases in place.

Mark Parsons, QPWS, Stony Creek, Girringun National Park (2010).

Issue 6: Avoid peat fires

Often low lying communities (including wetlands and melaleuca communities) gradually accumulate partially decayed, densely packed vegetation known as peat. In the absence of good soil moisture the peat is easily ignited resulting in a peat fire. Peat fires can burn for months, and can have very negative impacts on ecosystems. Peat takes many years to re-form.

Awareness of the environment

Key indicators of suitable conditions to avoid peat fires:

- Standing water: visible water on surface or surface water that covers the bases of sedges and grasses.
- In the absence of standing water, the peat should be water logged (it is possible to squeeze water out of it).

Melaleuca community with an understorey of ferns and sedges with standing water.
Sylvia Millington, QPWS, Mt Coom (2010).

Post fire in a melaleuca community with standing water.
Mark Parsons, QPWS, Sunday Creek, Girringun National Park (2010).

An ephemeral sedgeland with partially-burnt fuels. Without standing water or wet peat, fire can burn underground for weeks.
Mark Parsons, QPWS, Sunday Creek, Girringun National Park (2010).

Discussion

- Due to its porous nature and high carbon content peat is easily ignited when dry and can burn / smoulder for an extended period of time, causing re-ignitions and long-term damage to ecosystems.
- Be aware of peat issues when burning in areas adjacent to melaleuca communities or wetlands. The condition of the peat should be checked to ensure that if fire encroaches, a peat fire will not be unintentionally ignited. If it is necessary to burn adjacent areas in less then ideal conditions to avoid peat fires, manage the fire carefully to minimise the risk of fire entering peat areas (use suitable tactics such as burning away from wetland edges).
- Peat fires should be avoided. However peat fires that are not extensive, down to about a metre in depth, might form a desirable aspect of wetland systems and restore channels of water movement within the landscape. It is not necessary to plan to burn peat— it will burn occasionally due to minor fluctuations in topography and moisture.

What is the priority for this issue?

Priority	Priority assessment
Very high	Where peat is present, it is important to consider the most appropriate management during burn planning and implementation.

Assessing outcomes

Formulating objectives for burn proposals

Every proposed burn area contains natural variations in topography, understorey or vegetation type. It is recommended that you select at least three locations that will be good indicators for the whole burn area. At these locations walk around and if visibility is good look about and average the results. Estimations can be improved by returning to the same locations before and after fire, and by using counts where relevant.

Measurable objectives	How to be assessed	How to be reported (in fire report)
The planned burn does not result in a peat fire.	Ongoing visual assessment during and post burn to ensure the fire has not carried into peat layer and developed into a peat fire.	**Achieved:** Fire did not carry into peat layer and develop into a peat fire. **Not Achieved:** Fire carried into peat layer and developed into a peat fire.

If the above objectives are not suitable, refer to the compendium of planned burn objectives found in the monitoring section of the QPWS Fire Management System or consider formulating your own.

Fire parameters

What fire characteristics will help address this issue?

Fire severity

- **Low** to **moderate**.

After a low-severity fire adjacent to Melaleuca viridiflora community, where ground saturation was used to control fire encroachment.

Mark Parsons, QPWS, Sunday Creek, Girringun National Park (2010).

What weather conditions should I consider?

It is important to be aware of conditions prior to and following burns so that undesirable conditions and weather changes can be avoided, or to help with burn planning.

Season: Avoid late dry season fires in the vicinity of peat

FFDI: < 7
DI (KBDI): < 120

Wind speed: < 23 km/hr

Soil moisture: Standing water or waterlogged peat will avoid a peat fire.

What burn tactics should I consider?

When burning adjacent fire-adapted areas, where the conditions of standing water or water logged peat can not be achieved, use tactics that will limit encroachment of fire into the community with peat. See below.

- **Spot ignition.** Can be used effectively to alter the desired severity of a fire. Spots closer together will result in a line of a greater intensity (as spots merge and create hot junction zones) while increased spacing between spots will result in a lower-severity fire.
- **A low intensity backing fire.** Ensures fire intensity and rate of spread are kept to a minimum. **Do not create a running fire.**
- **Limit fire encroachment into non-target communities.** Where the non-target community is present in low lying areas e.g. riparian system, utilise the surrounding topography to create a low-intensity backing fire that travels down slope towards the non-target community. If conditions are unsuitable (the non-target community is too dry to ensure fire will self-extinguish on its boundary or it is upslope of a potential run of fire) use appropriate lighting patterns along the margin of the non-target community to promote a low intensity backing fire that burns away from the non-target community (refer to Issue 7, for tactics).

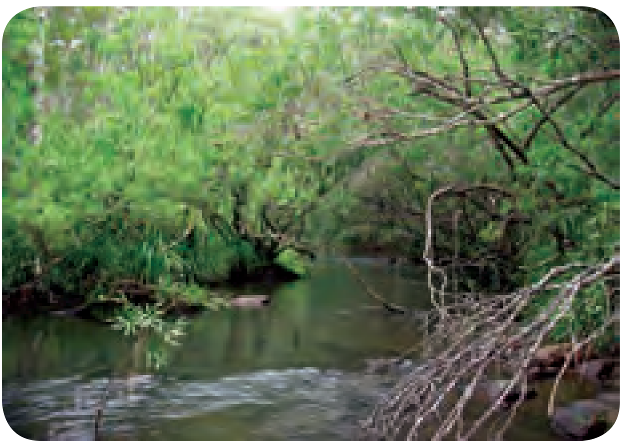
Issue 7: Limit fire encroachment into non-target fire vegetation group

Non-target fire vegetation groups include rainforests, saltmarsh, riparian, casuarina and foredune communities. These communities are often self-protecting if fire is used under appropriately mild conditions. If suitable conditions are not available, tactics such as burning away from these communities can be used to protect them. Other areas where you may wish to limit fire encroachment include melaleuca and wetland communities when the peat is dry (refer to Issue 6) or other fire vegetation groups which are not ready to burn.

Awareness of the environment

Indicators of fire encroachment risk:

- Cyclone or logging damage with dry fuel lying upon the ground inside of rainforest areas.
- Melaleuca, saltmarsh or wetland areas without standing water or water-logged conditions.
- Invasive grasses, Siam weed or lantana invading rainforest or riparian edges.
- The non-target community is upslope of (potentially) running fire.
- Conditions are not sufficiently mild so as to ensure fire extinguishes on the edge of the non-target fire vegetation group.



Avoid fire penetrating into most riparian communities.

This callistemon vegetation is fire sensitive.

Mark Parsons, QPWS, Stoney Creek, Girringun National Park (2008).

Foredune she-oaks are killed by fire. Wildfire fuelled by tinder dry Singapore daisy carried flames against the wind back onto the base of these horse tailed she-oak trees. Singapore daisy resprouted soon after the fire.

Mark Parsons, QPWS, Girramay National Park (2009).

Littoral Rainforest is vulnerable to scorching by fire.

Mark Parsons, QPWS, Orpheus Island National Park (2001).

A low-severity fire in a *Melaleuca viridiflora* community, where ground saturation has been used to control fire entering the community.

Mark Parsons, QPWS, Sunday Creek, Girringun National Park (2010).

A low-severity backing fire under the right conditions will not scorch the riparian community. Fire will trickle downhill and self extinguish before reaching the riparian zone.

Kerensa McCallie, QPWS, Davies Creek, Dinden National Park (2010).

The presence of weeds and a build-up of dead material can draw fire into rainforests.

Paul Williams, Vegetation Management Science Pty Ltd, Curtain Fig National Park (2009).

Surface water is used to control fire encroaching into saltmarsh.

Mark Parsons, QPWS, Waterfall Creek, Girringun National Park (2010).

Discussion

- Because wildfire often occurs under dry or otherwise unsuitable conditions (e.g. there is no guarantee that peat swamps or rainforest litter will be moist) it has the potential to damage non-target and fire-sensitive fire vegetation groups. Proactive broad-scale management of surrounding fire-adapted areas with mosaic burning is one of the best ways to reduce impacts of unplanned fire on non-target and fire-sensitive communities.
- Under appropriate planned burn conditions with good soil moisture, fire-sensitive communities tend to self-protect and additional protective tactics may not be required. Sometimes where a fire-sensitive community occurs at the top of a slope, it is necessary to avoid running fires upslope even in ideal conditions.
- If suitable conditions can not be achieved, specific tactics may be required to protect the fire-sensitive fire vegetation group. See the tactics at the end of this chapter.
- For melaleuca and wetland communities, ensure suitable conditions to avoid peat fires when burning surrounding areas (refer to Issue 6).
- Sometimes lantana forms a thicket that can draw fire into rainforest or riparian areas. Reduction of lantana may be advisable prior to burning to reduce biomass and avoid scorching rainforest or riparian edges (refer to Issue 4).
- The presence of high-biomass grasses increases the severity of fire and may contribute to rainforest contraction (Bowman 2000). If high-biomass grasses are present, use fire with caution (refer to Issue 3).
- Many riparian communities contain a high proportion of fire-sensitive species and/or habitat trees. Too frequent and/or severe fire removes, or inhibits the development of structurally complex ground and mid-strata and may open-up the canopy. This in turn may increase the risk of weed invasion and soil erosion, and lead to greater production of fine fuel (mainly grass) and hence an increase in the fire hazard. It is highly desirable to exclude fire or at least minimise the frequency and intensity of fire in many riparian communities in order to promote structurally complex ground and mid-strata.
- Coastal she-oaks are an important food tree for the red-tailed black cockatoo. When burning adjacent fire-adapted communities, care should be taken to avoid any fire penetration. A bare earth buffer can easily be scratched with a rake-hoe through casuarina needles on sand to prevent fire trickling into these communities.
- The main strategy for saltmarsh is to burn with king tide or recent rain with groundwater seepage protecting saltmarsh vegetation. Saltmarsh is most vulnerable to scorching if fire promoting plants (especially flammable grasses) occur within or adjacent to them.

What is the priority for this issue?

Priority	Priority assessment
Very high	Planned burn required to maintain areas of **special conservation significance.**
High	Planned burns to **maintain ecosystems** in areas where **ecosystem health** is **good**.

Assessing outcomes

Formulating objectives for burn proposals

Every proposed burn area contains natural variations in topography, understorey or vegetation type. It is recommended that you select at least three locations that will be good indicators for the whole burn area. At these locations walk around and if visibility is good look about and average the results. Estimations can be improved by returning to the same locations before and after fire, and by using counts where relevant.

Choose objectives as appropriate:

Measurable objectives	How to be assessed	How to be reported (in fire report)
No scorch of margin of non-target fire vegetation group.	**After the burn** (immediately or very soon after): visual estimation of percentage of margins scorched from one or more vantage points, or from the air. **Or** **After the burn** (immediately or very soon after): walk the margin of the non-target community or representative sections (e.g. a 100 m long section of the margin in three locations) and estimate the percentage of margin scorched.	**Achieved:** No scorch. **Partially Achieved:** < 5 % scorched. **Not Achieved:** > 5 % scorched.
Fire penetrates no further than one meter into the edge (if there is a well defined edge).	**After the burn** (immediately or very soon after): visual assessment from one or more vantage points, or from the air. **Or** **After the burn** (immediately or very soon after): walk the margin of the non-target community, or representative sections (e.g. a 100 m long section of the margin in three locations) and determine whether the fire has penetrated further than one meter into the edge.	**Achieved:** Fire penetrates no further than 1m into the edge. **Not Achieved:** Fire penetrates further than 1m into the edge.

If the above objectives are not suitable, refer to the compendium of planned burn objectives found in the monitoring section of the QPWS Fire Management System or consider formulating your own.

Fire parameters

What fire characteristics will help address this issue?

The below characteristics apply to fires in areas adjacent to the non-target fire vegetation group.

Fire severity

- A **Low**-severity fire in the adjacent fire-adapted community will help ensure the objective of limited fire encroachment is achieved. A backing fire will help ensure good coverage. If there are overabundant saplings in the area being burnt, a higher-severity fire may be required, in which case appropriate tactics and moisture conditions will help to limit scorch of non-target areas.

Mosaic (area burnt within an individual planned burn)

- Consult the recommended patchiness for the fire vegetation group being burnt. Aim for the higher end of the recommended patchiness, as this will help mitigate the movement of wildfire into fire-sensitive communities.

Landscape mosaic

- Proactive broad-scale management of surrounding fire-adapted areas with mosaic burning is one of the best ways to reduce impacts of unplanned fire on non-target and fire-sensitive communities.

What weather conditions should I consider?

When planning a burn it is important to be aware of weather predictions prior to and following burns so that undesirable conditions and weather changes can be avoided.

FFDI: Refer to the relevant fire vegetation group

DI (KBDI): Refer to the relevant fire vegetation group

Wind speed: < 15 km/hr

Soil moisture: If fuel moisture within a fire-sensitive community is insufficient or the fire-sensitive community is upslope from the planned burn consider using tactics outlined below.

What burn tactics should I consider?

Tactics will be site specific and different burn tactics may need to be employed at the same site (e.g. due to topographical variation). During the burn, regularly review and adjust tactics as required to achieve burn objectives. What is offered below is not prescriptive; rather it is a toolkit of suggested tactics that may assist in this issue.

- **Test burn** of interface to ensure non-target areas do not burn.
- **Do not create a running fire.** Rather, back fire toward non-target areas.
- **Commence lighting on the leeward (smoky) edge** of the non-target fire vegetation group to promote a low-intensity backing fire. Depending on available fuels and the prevailing wind on the day this may require either spot or strip lighting or a combination of both.
- **Afternoon ignition.** Planned burning in areas adjacent to non-target communities undertaken late in the afternoon will assist with promoting a low-severity fire that may trickle along the edge of these communities and generally self-extinguish due to milder conditions overnight.
- **Limit fire encroachment into non-target communities** (refer to Figures 1–3 below). Where the non-target community is present in low-lying areas (e.g. riparian system), utilise the surrounding topography to create a low intensity backing fire that travels down slope towards the non-target community. If conditions are unsuitable (the non-target community is too dry to ensure fire will self extinguish on its boundary or it is upslope of a potential run of fire) use appropriate lighting patterns along the margin of the non-target community to promote a low intensity backing fire that burns away from the non-target community.
- **Strip ignition to draw** fire away from the non-target community edge. Using more than one line of ignition 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.
- Even low-intensity fire trickling into **she-oak communities** on dunes can kill these species. Ensure fire is not lit on the windward side of these communities. Sea breeze can be used to help avoid fire encroachment. In some cases where suitable conditions are not available, scratch a break between fire-adapted and fire-sensitive communities to bare earth. Often it is sufficient to walk the break dragging the flat edge of a rake-hoe as casuarina needles are easily removed from sand. Storm burning may be useful to minimise impacts on mature she-oak. Be aware that dense Singapore daisy *Sphagneticola trilobata* and Mossman river grass *Cenchrus echinatus* infestations can draw fire into these communities.

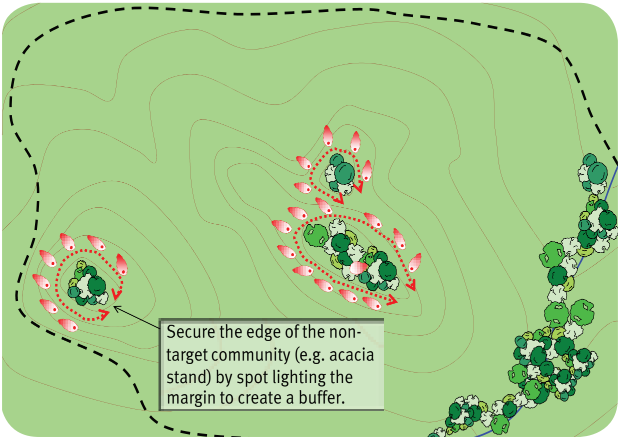
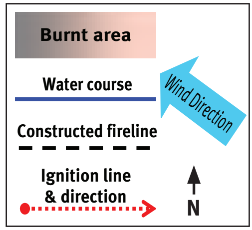


Figure 1: Example of initial lighting pattern to limit fire encroachment into non-target fire vegetation group.



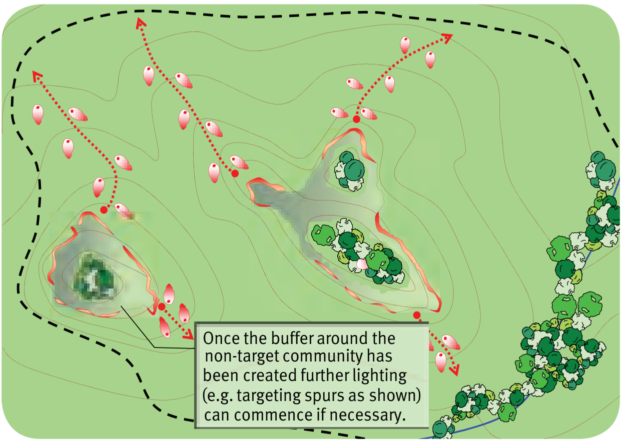


Figure 2: Example of strategic ignition adjacent to non-target community and along spurs.

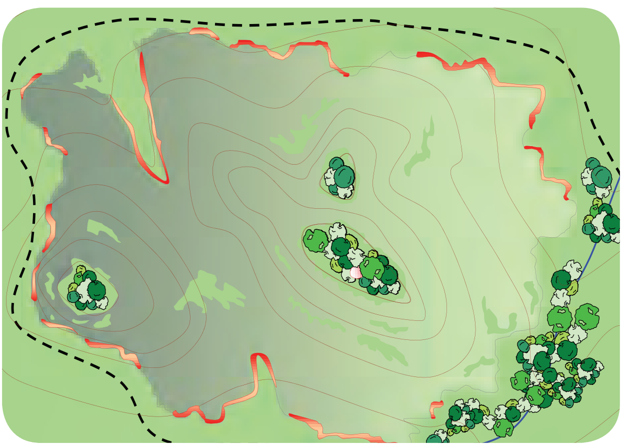


Figure 3: It was not necessary to burn back from the non-target community at the bottom of the slope, as the backing fire naturally extinguished against its edge due to greater moisture in the low lying area.

Issue 8: Assess regrowth areas with regard to fire management

Many areas in the wet tropics contain regrowth vegetation. Regrowth areas should be assessed individually with regard to their fire management needs.

If the area is regrowing rainforest, and the land manager's objective is that it develop into mature rainforest, limit fire encroachment (refer to Issue 7).

If the regrowth is a fire-adapted community, the regrowth appears healthy, but generally the regrowth is less than five metres high, it is advisable to avoid burning until the trees grow tall enough to survive a fire. Consider planned burns in adjacent areas to mitigate encroachment by wildfire. When planned burning in nearby areas, use appropriate conditions and/or tactics to limit fire encroachment (refer to Issue 7).

If the fire-adapted regrowth is healthy and above five metres high, consider implementing the recommendations for the fire vegetation group that the regrowth will become once it matures, but favour lower-severity fires.

If the regrowth is fire-adapted, but the regrowth does not appear healthy due to the presence of weeds or other health issues, consider using a moderate to high severity fire to stimulate the growth of native trees. Monitoring the results post fire is recommended.

What is the priority for this issue?

Priority	Priority assessment
Medium	Planned burn in areas where **ecosystem health** is **poor** but recoverable.
Low	Planned burn in areas where **ecosystem** structure and function has been **significantly disrupted**.
Very low	Ecosystem is **extremely difficult to recover**.

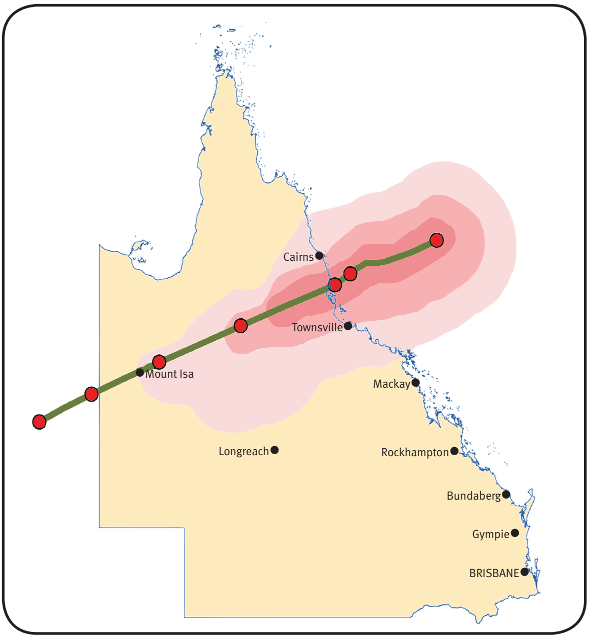
Issue 9: Post-cyclone planned burning

In the event of a severe tropical cyclone (category three or higher), the canopy of trees and shrubs may be stripped, accumulating on or suspended above the ground as leaves, fine leaf shred and branches. Snapped limbs can be left hanging in the canopy creating ladder fuel. In the event of a category four or higher cyclone, understorey vegetation is also damaged increasing elevated fuels. A high level of fallen tree damage can also be expected, increasing heavy fuel loads and impeding fire line access.

Once dry, the changed fuel conditions may lead to:

- the potential for extensive or high severity wildfires
- an increased fuel hazard near to assets and infrastructure
- altered fire behaviour during planned burning operations in the two years following a cyclone
- fire-sensitive communities becoming vulnerable to fire encroachment during certain dry periods
- an opportunity to re-introduce fire into areas that have been transitioning to closed forest.

Strategic planned burning with high soil moisture and avoiding dry conditions; encouraging landholders to mechanically reduce fuel; avoiding ignition sources during risk periods; and reviewing scheduled planned burns to make use of moister seasonal conditions are strategies to compensate for changed fuel conditions.



Illustrating the extensive region of wind damage caused by Cyclone Yasi which devastated the Cassowary Coast in February 2011.

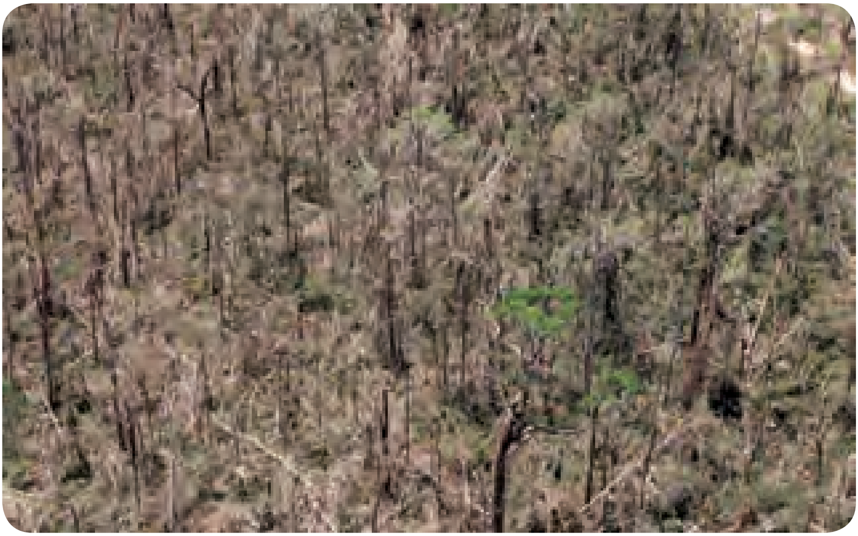
David Clark, QPWS (2011).

Awareness of the environment

Indicators of increased fuel hazard due to a severe tropical cyclone:

- there has been at least a **category three severe tropical cyclone** (165–224 km/hr, very destructive winds)
- vegetation and branches stripped from open forest trees
- leaf, leaf shred, branches and limbs accumulate on the ground as significant fuel loads
- branches and fine fuel elevated above ground where they can easily aerate and become an elevated fuel hazard
- the reduction in native vegetation cover has allowed the establishment of high biomass invasive grasses (refer to Issue 3)
- rainforest or other fire-sensitive community extensively stripped of canopy foliage creating an open structure, with fuel accumulation on the ground or suspended; the open structure creating conditions where forest floor fuels become flammable under dry conditions.
- there has been at least a **category four severe tropical cyclone** (225–279 km/hr, very destructive winds)
- in this case, understorey vegetation may also be severely damaged creating excessive vertical and ladder fuels leading to an increased fuel hazard.

Although cyclone categories have been used to indicate wind damage, be aware that the pattern of damage can be quite variable. For example, a forest might be stripped of canopy vegetation, however have no accumulated fuel, as the fuel was blown elsewhere. Similarly a forest that did not sustain wind damage (e.g. the protected side of a ridge) may have received the blown fuel. Therefore post cyclone assessments on the ground and/or by air are essential. Monitoring fuel conditions in the years following a cyclone is important as fuel matures and breaks down at different rates in different locations.



Strewn fuel and fallen branches will create a high fuel hazard when dry. Dead or fallen trees will allow fires to smoulder for some time, creating re-ignition risk.
Audrey Reilly, QPWS, Cyclone Yasi, Murray Falls (2011).

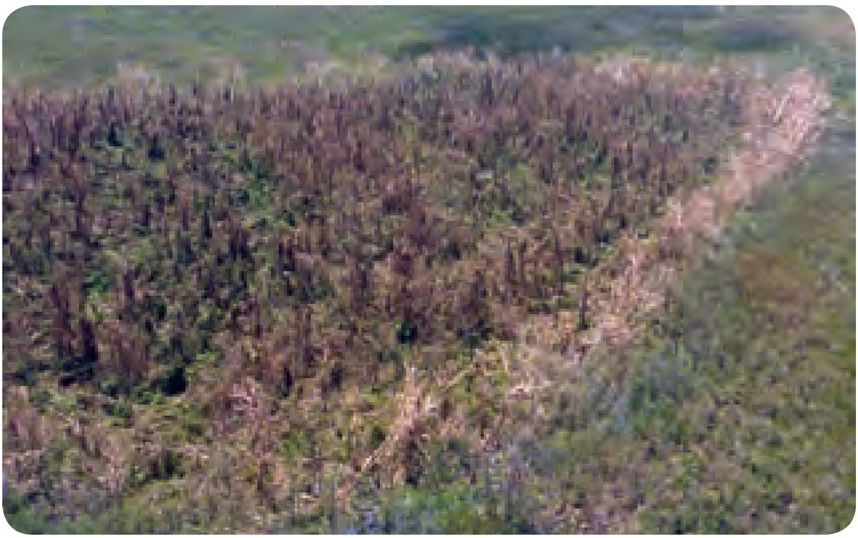
Category 5 cyclonic winds can cause build-up of fine and elevated fuels over substantial areas. Suspended fuel is aerated which decreases drying time and increases combustibility.
Richard Lindeman, QPWS, Cyclone Yasi, Stephens Island, Barnard Island Group National Park (2011).

These fallen fuels have dried to a point of ignition within 2 weeks of a cyclone.
Mark Parsons, QPWS, Cyclone Yasi, Lily Creek (2011).

Be aware of changed fuel conditions next to assets and infrastructure after cyclonic wind impact.
Audrey Reilly, QPWS, Cyclone Yasi, Bingal Bay (2011).

Usually not fire prone, coastal littoral communities can accumulate sufficient fuels to carry fire following a cyclone; if there are aerated fine fuels and fire is pushed by a sea-breeze.

Mark Parsons, QPWS, Cyclone Yasi, Foreshore, Girramay National Park (2011).



A melaleuca wetland severely impacted by cyclonic winds. Be aware that fuel lying upon wetlands may carry fire where it would not usually travel. Also, this wetland now has an enormous amount of ladder fuel which will increase fire severity leading to tree death if burnt inappropriately.

Audrey Reilly, QPWS, Cyclone Yasi, Hull River (2011).

Strewn fuel and trees fallen across fire lines is one of the many issues to consider when planning fires after cyclones.

Audrey Reilly, QPWS, Cyclone Yasi, Murray Falls (2011).

Melaleuca wetland damage by Category 5 cyclonic winds. Notice that most trees have been stripped and many lie on the ground.

Audrey Reilly, QPWS, Cyclone Yasi, Hull River (2011).

Category five cyclonic winds impacted these ridges and peaks, causing a build up of dead and flammable material next to vine forest. Avoid fires in the late dry season as vine forest/ rainforest edges are potentially vulnerable to fire in the two years after a cyclone, if they are upslope of a run of fire.

Audrey Reilly, QPWS, Cyclone Yasi, Cardwell Range (2011).

Discussion

- After a severe tropical cyclone, people will not naturally think about planned burning. However, without a fuel reduction strategy, there is a risk of extensive wildfires in the following dry season and a risk of fires that will impact on already stressed canopy.
- The canopy of trees damaged by severe cyclones is particularly susceptible to further impacts (such as canopy scorch) and may lead to tree death. Until the health of the canopy is restored, fires which may impact them should be avoided.
- The best time to act on post cyclone fuel reduction is soon after rain. Moist and humid conditions create slow moving, trickling fires with good residence time. Such fires have good fuel consumption, a low severity, are easy to control and allow disorientated and distressed fauna to find refuge areas. Also, they are less likely to further stress the canopy. The next best time to utilise moist conditions is the following storm season.
- Where ignition sources can be reliably controlled, consider avoiding fires altogether for a period. Especially where fires are likely to scorch stressed canopy.
- Despite best efforts, after a cyclone that causes extensive damage, it will not be possible to reduce fuel hazard in all the areas where it would be desirable to do so. A prioritised approach is required.
- The best way to protect property and infrastructure is emphasising the landholder's responsibility to mechanically clean up fuel. However, planned burning in moist conditions may form part fuel reduction strategies.
- Expectations of how fire behaves in a normal year must be reconsidered post cyclone (or even after a severe storm). It is likely programmed fire management can continue, but only after re-assessment of planned burn areas. Be aware that increased finer fuels and increased native or high biomass invasive grass cover, suspended and aerated fuel, open canopies and continuous fuel will change the way fire behaves. Fire will be more severe and may carry where it would not normally (e.g. over gullies, over streams, over fire lines, and over wetlands). Site preparation, careful consideration of tactics and a different burning window may be required, using more moist and humid seasonal conditions than normal years in order to compensate for increased fuel.

- If it is not possible to use moister seasonal conditions and yet it is still important to reduce fuel, careful consideration of ignition tactics will be required. Backing fires away from risk areas, down slope and/or against the wind can be considered. Afternoon and evening conditions can also be considered.
- In some locations cyclones may provide a rare opportunity to reintroduce fire into open forests and woodlands which are in the late stages of transition to closed forest communities through seedling/sapling and rainforest invasion. Species found in eucalypt forest and woodland in particular need abundant light and bare soil to establish. Temporarily reducing the understory through planned burning may allow seedlings of canopy trees such as eucalypts to establish and thus halt or slow the transitioning process.
- After a severe cyclone, there will be a substantial number of fallen trees that may smoulder long after fire (especially after the second year), creating a re-ignition risk if burning in increasing fire hazard periods (mid to late dry season). Planned burning will not normally consume fallen trees, and the problem is likely to persist for years after a cyclone. Burning with moisture and in periods of stable moist conditions, or in declining fire hazard, will minimise the risk.
- During the late dry season in the two years after a cyclone, rainforest edges are vulnerable to upslope runs of fire. Lantana, high biomass grass invasion and severe cyclone events (causing a more open canopy) increases the risk of encroachment.

What is the priority for this issue?

Priority	Priority assessment
Highest	Planned burn required to **protect life** and/or **property**, usually within **protection zones**.
Very high	Planned burn required to **mitigate hazard** or **simplify vegetation structure**, usually within **wildfire mitigation zones**.

Assessing outcomes

Formulating objectives for burn proposals

Every proposed burn area contains natural variations in topography, understorey, or vegetation type. It is recommended that you select at least three locations that will be good indicators for the whole burn area. At these locations, walk around or if visibility is good, look about and average the results. Return to the same location and record counts before and after the burn to support the estimations.

Choose objectives as appropriate:

Measurable objectives	How to be assessed	How to be reported (in fire report)
No canopy scorch.	There are two options: 1. From one or more vantage points, estimate extent of canopy scorched. 2. In three locations (that take account of the variability of landform within burn area), walk 300 or more metres through planned burn area estimating percentage of canopy scorched within visual field.	**Achieved:** No canopy scorch. **Partially Achieved:** 1–20 % of canopy scorched. **Not Achieved:** > 20 % of canopy scorched.
Reduce overall fuel hazard to low. **Or** Reduce fuel load to less than five tonnes/ha.	Post fire; use the Overall Fuel Hazard Guide (Hines et al. 2010b), or Step 5 of the QPWS Planned Burn Guidelines: How to Assess if Your Burn is Ready to Go, to visually assess the remaining fuel in at least three locations.	**Achieved:** Fuel hazard has been reduced to low; Or fuel load has been reduced to less than five tonnes/ha. **Not Achieved:** Fuel hazard has not been reduced to low Or fuel load is greater than five tonnes/ha.

Fire patchiness of 70–100 % burnt.	There are three options: 1. From one or more vantage points, estimate aerial extent of ground burnt. 2. In three locations (that take account of the variability of landform within burn area), walk 300 or more metres through planned burn area estimating percentage of ground burnt within visual field. 3. Walk into one or more gully heads, and down one or more ridges and estimate percentage of ground burnt within visual field.	**Achieved:** Mosaic or patchiness of > 70 %. **Partially Achieved:** Mosaic or patchiness of 50–70 %, the extent and rate of spread of any subsequent wildfire would still be limited. **Not Achieved:** Mosaic or patchiness of < 50 %. High proportion of patchiness, unburnt corridors extend across the area (the extent and rate of spread of any subsequent wildfire would not be limited).

If the above objectives are not suitable, refer to the compendium of planned burn objectives found in the monitoring section of the QPWS Fire Management System, or consider formulating your own.

Monitoring the issue over time

Many issues are not resolved with a single fire and it is important to keep observing the land. To support this, for important issues, it is recommended that observation points be established. Observation points are usually supported by photographs and a small amount of recorded data. Instructions for establishing observation points can be obtained from the monitoring section of the QPWS Fire Management System.

Fire parameters

What fire characteristics will help address this issue?

Fire severity

- **Low** and occasionally **moderate**. Slow moving trickling fires preferred. Be aware that in the two years after a cyclone, burning in dryer months might create higher than anticipated fire severity.

Fire frequency / interval

- After a cyclone, it may be imperative to reduce fine fuels to reduce risk.

Patchiness (mosaic of individual burns)

- Mosaic or patchiness of > 70 per cent to reduce litter fuels.

Other consideration

- Planned burning in moist conditions is only one of the ways to reduce risk after a cyclone. Mechanical fuel reduction and avoiding ignition sources during risk periods are also important strategies.
- Fires should not scorch the canopy of trees which have been cyclone damaged. Be aware that this may be more difficult following cyclones due to higher fuel loads and considerable care should be taken.

What weather conditions should I consider?

It is important to be aware of conditions prior to and following burns so that undesirable conditions and weather changes can be avoided, or to help with burn planning.

Recent rain: Burn soon after rain events as this increases the controllability of fire where excessive fuels have accumulated. Use the drying tables available in the QPWS Planned Burn Guidelines: How to Assess if Your Burn is Ready to Go, to estimate how soon the site will be ready to carry fire after rain (but take account of the fact there are suspended aerated fuels that might dry sooner). Moist conditions will recur in the following storm burning season (November to January).

Season: Aim for **summer** til **autumn**. Also, storm burns during **December** til **January**.

Humidity: > 50 per cent humidity will create conditions where fire will trickle. This helps to create a low-severity fire with sufficient residence time to consume fuel.

Wind speed: < 15 km/hr (higher for storm burning).

FFDI: < 11.

What burn tactics should I consider?

Tactics will be site-specific and different burn tactics may need to be employed at the same site (e.g. due to topographical variation). During your burn regularly review and adjust tactics as required to achieve the burn objectives. What is offered below is not prescriptive, rather a toolkit of suggested tactics.

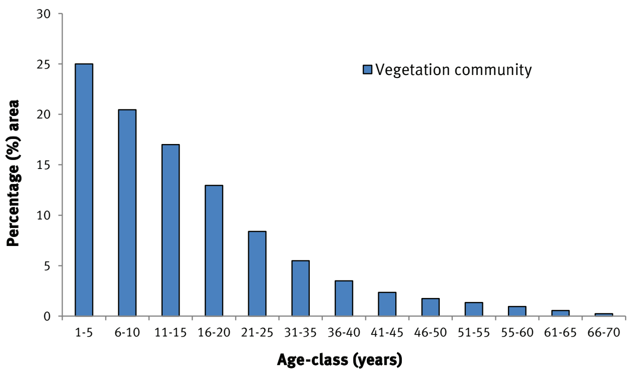
- **Progressive burning** is very useful after a cyclone when combined with careful observations of fire behaviour, as this will indicate when conditions are becoming too dry for easy control of fires.
- **Commence lighting on the leeward (smoky) edge** to contain the fire and promote a low intensity backing fire.
- **A low intensity backing fire.** A slow moving, low intensity backing fire will generally result in a better consumption of surface fuel. This tactic ensures the fire has a greater amount of residence time and reduction of available fuels, particularly fine fuels (grasses, leaf litter, twigs etc), while minimising fire severity and rate of spread.
- **Spot ignition.** Can be used to alter the desired intensity of a fire particularly where there is a high accumulation of available and volatile fuels. Increased spacing between spots will result in a lower severity fire. The spacing of the spots should be varied throughout the burn to take into consideration changes in weather conditions, topography, fuel loads etc.
- **Afternoon ignition.** This is particularly useful where suitable conditions are not available during the day. This will assist in promoting a low-severity fire that may trickle along the edge of non-target communities and generally self-extinguish due to milder conditions overnight.
- **Limit fire encroachment into non-target communities.** Where the non-target community is present in low lying areas (e.g. riparian systems), utilise the surrounding topography to create a low-severity backing fire that travels down slope towards the non-target community. If conditions are unsuitable (the non-target community has been damaged by cyclone and is upslope) use appropriate lighting patterns combined with active suppression along the margin of the non-target community to promote a low severity backing fire that burns away from the non-target community (refer to Issue 7).

- **Strip ignition to draw** fire away from non-target community edge. Using more than one line of ignition can create convective updrafts which draw fires together and away from non-target areas. It is important to have safe refuges when undertaking this type of burning. For example for lighting along a track the person furthest from the track should walk parallel to the track and at least 20 m ahead of the person lighting nearer the track. This reduces the chance of the 'outer' person becoming cut off from the refuge area (the track).
- **Wet lines, blower lines (to clear strewn material) and/or rake-hoe lines** may have to be established along the edge of non-target areas. It is time consuming to establish wet lines, blower lines or rake-hoe lines especially where the boundary is extensive and where there has been considerable fallen timber, so use this tactic only where the prevailing weather conditions or the above tactics are not suitable to limit fire encroachment into non-target areas.

Glossary of fire terminology

(**Primary source:** Australasian Fire Authorities Council 2012).

<table>
<tr><th>Terminology</th><th>Definition</th></tr>
<tr><td>Aerial ignition</td><td>The lighting of fine fuels for planned burning by dropping incendiary devices or materials from aircraft.</td></tr>
<tr><td>Available fuel</td><td>The portion of the total fuel that would actually burn under current or specified conditions.</td></tr>
<tr><td>Age-class distribution</td><td>The distribution of groups of similar aged vegetation (age-class) of a particular vegetation community after fire. In fire ecology this is used to indicate the success of mosaic burning in achieving varied habitat conditions. This is usually represented as a plot of areas (y-axis) versus age-class (x-axis) (e.g. 25 per cent of a fire vegetation group burnt between one and five years ago) (refer to Figure 1).

Figure 1: Idealised age-class distribution (concept only)


</td></tr>
<tr><td>Burn severity</td><td>Relates to the amount of time necessary to return to pre-fire levels of biomass or ecological function.</td></tr>
<tr><td>Backing-fire</td><td>The part of a fire which is burning back against the wind or down slope, where the flame height and rate of spread is minimal.</td></tr>
</table>

Terminology	Definition
Beaufort scale	A system of estimating and reporting wind speeds, invented in the early nineteenth century by Admiral Beaufort of the Royal Navy. It is useful in fire management to indicate wind speed and relies on visual indicators rather than instruments. It equates to: • Beaufort force (or Beaufort number) • wind speed • visible effects upon land objects or seas surface.
BOM	Bureau of Meteorology.
Crown scorch	Browning of the needles or leaves in the crown of a tree or shrub caused by heat from a fire.
Char height	The height to which former green leaves still suspended on plants that are turned black by the flame of the fire. NB: This cannot be measured on the stems of plants as fire 'climbs' the bark.
Dew point temperature	This is a measure of the moisture content of the air and is the temperature to which air must be cooled in order for dew to form. The dew-point is generally derived theoretically from dry and wet-bulb temperatures, with a correction for the site's elevation (BOM).
Drought	A **drought** is defined by the Bureau of Meteorology (BOM) as an 'acute rainfall deficiency'. For the purpose of quantifying the severity of a drought, the BOM describe rainfall deficiency in two categories: '**Serious** rainfall deficiency—rainfall lies above the lowest five per cent of recorded rainfall but below the lowest 10 per cent (decile 1 value) for the period in question, **Severe** rainfall deficiency—rainfall is among the lowest five per cent for the period in question.' For more information, refer to <www.bom.gov.au/climate/glossary/drought.shtml>
Drought index (DI)	A numerical value (e.g. the Byram-Keetch Drought Index), reflecting the dryness of soils, deep forest litter, logs and living vegetation.
Duff layer	Refer to 'humus layer'.

Terminology	Definition
Fire behaviour	The manner in which a fire reacts to variables of fuel, weather and topography.
Fire Danger Index (FDI)/ Fire Danger Rating (FDR)	A relative number and rating denoting an evaluation of rate of spread, or suppression difficulty for specific combinations of fuel moisture and wind speed.
FFDI/FFDR	Forest Fire Danger Index/Danger Rating.
Fire frequency	The frequency of successive fires for a vegetation community in the same point of the landscape (refer to fire interval).
Fire extent	Refer to patchiness.
Fire intensity	The amount of energy released per unit length of fire front, in units of kilowatts per metre of the fireline (also known as the Byram fire-line intensity).
Fire interval	The interval between successive fires for a vegetation community in the same point of the landscape. Often expressed as a range indicating a minimum and maximum number of years that an area should be left between fire events (refer to Appendix 2).
Fireline	Constructed or treated lines/trails (sometimes referred to as fire trails or control lines) or environmental features that can be used in the management of a fire. Permanent firelines should (usually) have a primary purpose other than that of a control line (e.g. access track to a campground). Firelines are **NOT** fire breaks. Although the term 'fireline' is not without its shortcomings it should be used in preference to 'firebreak' to avoid the perception that a fire will stop at a break.

<table>
<tr><th>Terminology</th><th>Definition</th></tr>
<tr><td>Clarification over the terms

‘fire vegetation group’ and ‘fire management zone’.</td><td>The fire management requirements within a conservation fire management zone are based on the fire vegetation groups (FVGs)—groups of related ecosystems that share common fire management requirements. Fire regimes for FVGs are identified in the Bioregional Planned Burn Guidelines and are reflected in fire strategies. Other fire management zones (e.g. protection, wildfire mitigation, special conservation, sustainable production, rehabilitation, exclusion, and reference) will have specific management objectives that override the FVG fire regime requirements. Further, if there are a number of these other zones within a strategy they are identified as fire management subzones (FMSz) (e.g. P1, P2, P3, WM1, WM2, etc) each with specific fire management requirements.

<table>
<tr><th>Fire management zone</th><th>Fire management sub-zone or Fire vegetation group</th></tr>
<tr><td rowspan="2">Conservation</td><td>FVG1</td></tr>
<tr><td>FVG2</td></tr>
<tr><td rowspan="2">Protection</td><td>P1</td></tr>
<tr><td>P2</td></tr>
<tr><td rowspan="2">Wildfire mitigation, etc</td><td>W1</td></tr>
<tr><td>W2</td></tr>
</table>
</td></tr>
<tr><td>Fire perimeter</td><td>The outer containment boundary in which fire is being applied.</td></tr>
<tr><td>Fire regime</td><td>The recommended use of fire for a particular vegetation type or area including the frequency, intensity, extent, severity, type and season of burning.</td></tr>
<tr><td>Fire regime group (FRG)</td><td>A group of related ecosystems that share a common fire management regime including season, severity, recommended mosaic etc. These are a sub-grouping of the fire vegetation groups to provide more detail about specific fire management requirements. Fire regime groups are provided as a more detailed alternative for use with fire strategies or in mapping.</td></tr>
</table>

Terminology	Definition
Fire season	The period(s) of the year during which fires are likely to occur, spread and cause sufficient damage to warrant organised fire control.
Fire severity	A measure of the effect of fire on vegetation and soil immediately after the fire (e.g. vegetation consumption, vegetation mortality, soil alteration). Can be used to indicate fire intensity.
Fire vegetation group (FVG)	A group of related ecosystems that share common fire management requirements. For the purpose of practical fire management, these ecosystems are treated as a group.
Flame height	The vertical distance between the average tip of the flame and ground level, excluding higher flares.
Fuel	Any material such as grass, leaf litter and live vegetation, which can be ignited and sustains a fire. Fuel is usually measured in tonnes per hectare.
Fuel hazard	The condition of the fuel and takes into consideration such factors as quantity, arrangement, current or potential flammability and the difficulty of suppression if fuel should be ignited.
Fuel load	The dry weight of combustible materials per area, usually expressed as tonnes per hectare. A quantification of fuel load does not describe how the fuel is arranged, nor its state or structure.
Fuel moisture content	The water content of a fuel particle expressed as a percentage of the oven dry weight of the fuel particle (% ODW).
Grid ignition	A method of lighting prescribed fires where ignition points are set at a predetermined grid-like spacing through an area.
GFDI/GFDR	Grassland Fire Danger Index/Danger Rating.

Terminology	Definition
High biomass grasses	Tend to be exotic species of grasses which can out-compete native species to form dense mono-specific stands. They: • are generally taller than native species • can lead to decreased biodiversity • increase biomass • increase fire severity • increase threat to life and property.
Humus (or duff layer)	The mat of partly decomposed vegetation matter on the forest floor, the original vegetative structures still being recognisable.
Junction zone	An area of greatly increased fire intensity caused by two fire fronts (or flanks) burning towards one another.
Keetch-Byram Drought Index (KBDI)	A numerical value reflecting the dryness of soils, deep forest litter, and heavy fuels and expressed as a scale from 0–203.
Landscape mosaic	A mosaic burn at a landscape level, usually achieved by planning a series of fires across a reserve, a bioregion or broader area.
Lighting pattern	The lighting pattern adopted by fire fighters during planned burning operations, or indirect attack.
Litter	The top layer of the forest floor composed of loose debris of dead sticks, branches, twigs, and recently fallen leaves and needles, little altered in structure by decomposition. (The litter layer of the forest floor).
Mesophyll pioneers	Large-leaved (12.5–20 cm long) rainforest tree species able to establish in neighbouring communities.
Mineral earth	Being completely free of any vegetation or other combustible material.

Terminology	Definition
Mosaic burn	An approach which aims to create spatial and temporal variation in fire regimes. This can occur within an individual burn and at a landscape level (refer to Appendix 2).
Obligate seeders (obligate seed regenerating species)	Shrubs that are killed by fire and rely on soil-stored seed bank to regenerate. In fire ecology, the time it takes obligate seeders to mature and establish a seed bank often indicates the minimum frequency with which a vegetation community should be burnt in order to avoid the local extinction of these species.
Patchiness	A percentage or proportion of the ground layer vegetation (grasses, herbs and trees/shrubs less than one metre) not affected by fire (i.e. 20 per cent patchiness = 80 per cent burnt).
Perennial plants	Plants that last for more than two growing seasons, either dying back after each season as some herbaceous plants do, or growing continuously like many shrubs.
Planned burn	The controlled application of fire under specified environmental conditions to a pre-determined area and at the time, intensity, and rate of spread required to attain planned resource management objectives. In the context of QPWS operations: a fire that is deliberately and legally lit for the purposes of managing the natural and/or cultural and/or production resources of the area (e.g. reducing fire hazard, ecological manipulation), and protecting life and property.

Terminology	Definition
Progressive burning	Progressive burning is an approach to planned burning where ignition is carried out throughout much of the year as conditions allow. In northern Queensland, ignition can begin early in the year after heavy seasonal rain, with numerous small ignitions creating a fine scale mosaic. These burnt areas can provide opportunistic barriers to fire for burning later in the year. They also provide fauna refuge areas. Progressive burning helps create a rich mosaic of intensities, burnt/unburnt areas, and seasonal variability. Be aware of how fire behaves differently in different seasons. Depending on local climatic conditions, there can be up to four seasons in the wet tropics (this will vary from moister to drier climatic areas): The **early burn period** following seasonal heavy rain where fire self extinguishes overnight and will not burn through areas burnt the year before. **Secondary burn season** where fires will burn through the night and will extinguish within areas burnt the year before. **Falling leaf season**, where a blanket of leaves often crosses natural water features. This is the dry season and fires will not go out. Fires in dry conditions will often favour woody species over grasses. **Storm burning**, where climatic conditions allow, from December through to January, is a useful way to achieve intense, wind supported fire where rain can be reliably expected to follow; providing good conditions for regeneration (Mick Blackman pers. comm., 10 September 2011).
Rate of spread (ROS)	The forward progress per unit time of the head fire or another specified part of the fire perimeter, defined as metres per hour.
Relative humidity (RH)	The amount of water vapour in a given volume of air, expressed as a percentage of the maximum amount of water vapour the air can hold at that temperature.
Scorch height	Is the height to which former green leaves still suspended on plants are turned brown by the heat of a fire.
Strip burning	Setting fire to a narrow strip of fuel adjacent to a fire-line and then burning successively wider adjacent strips as the preceding strip bums out.
Test fire	A controlled fire of limited extent ignited to evaluate fire behaviour.

References

Ash J 1988, 'The location and stability of rainforest boundaries in north-eastern Queensland, Australia', *Journal of Biogeography*, vol. 15, pp. 619–630.

Australasian Fire Authorities Council (AFAC) 2012, *Glossary of rural fire terminology*, Australasian Fire Authorities Council, Canberra.

Bowman DM 2000, *Australian rainforests. Islands of green in a land of fire*, Cambridge University Press, Cambridge.

Commonwealth of Australia 1999, *Environment Protection and Biodiversity Conservation Act 1999,* Sustainability, Environment, Water, Population and Communities, Attorney-General's Department, Canberra.

Corporative Research Centre (CRC) for Australian Weed Management 2003, *Pond Apple–Annona glabra, weeds of national significance weed management guide*, Canberra.

Dennis AJ, 2001, *Recovery plan for the Northern bettong, Bettongia tropica 2000–2004*, Report to Environment Australia, Canberra, Queensland Parks and Wildlife Service, Brisbane.

Department of Environment and Resource Management (DERM) 2010a, *Operational policy –Management of cultural heritage places on QPWS estate*, Queensland Government, Brisbane.

Department of Environment and Resource Management (DERM) 2010b, *Procedural guide–Management of cultural heritage places on QPWS estate*, Queensland Government, Brisbane.

Harrington GN, and Sanderson KD 1994, 'Recent contraction of wet sclerophyll forest in the Wet Tropics of Queensland due to invasion by rainforest', *Pacific Conservation Biology,* vol. 1, pp. 319–327.

Harrington GN, Bradford MG, Sanderson KD, Irvine AK, and Thomas MR 2000, 'Structure and plant species dominance in North Queensland wet sclerophyll forests', *Proceedings of the Royal Society of Queensland,* vol. 109, pp. 59–74.

Hines F, Tolhurst KG, Wilson AAG and McCarthy GJ 2010a, *Fuel hazard assessment guide,* 1st edition April 2010, Fire and adaptive management report no. 82. Fire Management Branch, Department of Sustainability and Environment, Victoria.

Hines F, Tolhurst KG, Wilson AAG and McCarthy GJ 2010b, *Overall fuel hazard assessment guide,* 4th edition July 2010, Fire and adaptive management report no. 82, Fire Management Branch, Department of Sustainability and Environment, Victoria.

Lucas C 2010, 'On developing a historical fire weather data-set for Australia', *Australian Meteorological and Oceanographic Journal,* vol. 60, pp. 1–14.

Parks Victoria 1995, *Parks Victoria pest plant mapping and monitoring protocol,* Parks Victoria.

Queensland Parks and Wildlife Service (QPWS) 2001, *Mahogany Glider recovery plan 2000–2004,* Report to Environment Australia, Canberra, Queensland Parks and Wildlife Service, Brisbane.

Queensland Government 2004, *Aboriginal Cultural Heritage Act 2003,* Queensland Government, Brisbane.

Queensland Herbarium 2011a, *Regional ecosystem description database (REDD)*, version 6.0b, Department of Environment and Resource Management, Brisbane.

Queensland Herbarium 2011b (16 September), *Survey and mapping of 2006 remnant vegetation communities and regional ecosystems of Queensland spatial layer, version 6.1,* Queensland Government, Brisbane.

Sattler P and Williams R (eds.) 1999, *The conservation status of Queensland's bioregional ecosystems,* Environmental Protection Agency, Queensland.

Stanton JP 1989, 'Fire management on national parks in a range of tropical environments. A manager's perspective' *Fire Research in Rural Queensland,* University of Southern Queensland, Toowoomba, pp. 412–415.

Smith K 1993, 'Fire management in Lumholtz National Park', *Proceedings of a workshop on fire management on conservation reserves in tropical Australia,* Malanda, pp. 82–84.

Tran C, Gilroy J and Williams P 2008, 'Quantifying fuel loads and fire hazard in a wet sclerophyll community of South-eastern Queensland', *The International Bushfire Research Conference 2008,* Adelaide.

Wet Tropics Management Authority 2004, *Wet Tropics conservation strategy: the conservation, rehabilitation and transmission to future generations of the Wet Tropics World Heritage Area,* WTMA, Cairns.

Williams P, Parsons M, and Devlin T 2006, 'Rainforest recruitment and mortality in eucalypt forests of the Wet Tropics – refining the model for better management', *Proceedings of the Bushfire Conference 2006,* Brisbane, Paper no. 16.

Williams P, Douglas J, Parsons M and Roberts M 2008, *The mortality of siam weed (Chromolaena odorata) caused by fire in the Wet Tropics of northern Australia,* Queensland Parks and Wildlife Service, internal report, Townsville.

Williams P, and Tran C 2009, *Evaluating fire management in wet sclerophyll forests in Queensland parks,* unpublished internal report, Queensland Parks and Wildlife Service, Brisbane.

Williams P, Parsons M, Tran C, and Jensen R 2010, *Results of 13 years of monitoring data in wet tropical eucalypt forests,* unpublished internal report, Queensland Parks and Wildlife Service, Vegetation Management Sciences, SEQ Fire and Biodiversity Consortium, Serco Sodexo Defence Services and Australia Wildlife Conservancy, Cairns.

Williams P, Parsons M, Jensen R, and Tran C 2012, 'Mechanisms of rainforest persistence and recruitment in frequently burnt wet tropical eucalypt forests', *Austral Ecology,* vol. 37, pp. 268–275.

Wilson AAG 1992, *Assessing the fire hazard on public lands in Victoria: fire management needs and practical research objectives,* research report no. 31, Fire Management Branch, Department of Conservation and Environment, Victoria. In: Hines F, Tolhurst K, Wilson A and McCarthy G 2010a, *Fuel hazard assessment guide,* 1st edition April 2010, Fire and adaptive management report no. 82. Fire Management Branch, Department of Sustainability and Environment, Victoria.

Mark Parsons, QPWS, Stoney Creek, Girringun National Park (2008).

Appendix 1: List of regional ecosystems

A fire vegetation group is a group of related regional ecosystems that share common fire management intent for the purpose of practical fire management.

Fire vegetation group	Hectares within New England Tableland bioregion	Percentage
Lowland open forest	65 354	3.0
Open forests of the foothills and ranges	484 103	24.0
Tall open forest	93 352	5.0
Grasslands, sedgelands, fernlands	4 812	0.2
Montane communities	43 350	2.0
Fire sheltered shrubland	3 107	0.2
Melaleuca communities	41 929	2.0
Riparian, fringing and dune communities	21 503	1.0
Rainforests	706 822	35.0
Mangroves and saltmarsh	49 917	3.0
Other issues	4 615	0.2
Other bioregions	473 389	24.4
TOTAL	**1 992 253**	**100.0**

Chapter	Issues	Fire vegetation group	Fire regime group	Map label (if required)	**Regional ecosystems** (Sattler and Williams 1999; Queensland Herbarium 2011a; 2011b).	**WTMA vegetation unit**
1	1	**Lowland open forest**	Lowland open forest		7.11.18, 7.11.18a, 7.11.18b, 7.11.18c, 7.11.18d, 7.11.18e, 7.11.18f, 7.11.18g, 7.11.18h, 7.11.34, 7.11.34b, 7.11.43, 7.11.50b, 7.11.51c, 7.11.5c, 7.11.5d, 7.11.5e, 7.12.23, 7.12.23a, 7.12.23b, 7.12.23c, 7.12.23d, 7.12.23e, 7.12.23f, 7.12.28b, 7.12.29c, 7.12.53b, 7.12.53c, 7.12.5c, 7.12.5d, 7.12.5e, 7.2.3a, 7.2.3b, 7.2.3, 7.2.3c, 7.2.3d, 7.2.3e, 7.2.3g, 7.2.4, 7.2.4a, 7.2.4b, 7.2.4c, 7.2.4d, 7.2.4e, 7.2.4f, 7.2.4i, 7.2.4j, 7.2.6, 7.2.6a, 7.2.6c, 7.2.11g, 7.3.12, 7.3.12, 7.3.12a, 7.3.12b, 7.3.12c, 7.3.16c, 7.3.19b, 7.3.19c, 7.3.19d, 7.3.19e, 7.3.20, 7.3.20a, 7.3.20b, 7.3.20c, 7.3.20d, 7.3.20e, 7.3.20f, 7.3.20h, 7.3.20i, 7.3.20j, 7.3.20l, 7.3.20m, 7.3.45, 7.3.45a, 7.3.45 c, 7.3.45d, 7.3.45e, 7.3.46, 7.3.47, 7.3.49c, 7.3.7, 7.3.7a, 7.3.7b, 7.12.53g, 7.12.5, 7.12.5a, 7.12.5b, 7.2.4n, 7.3.19f, 7.3.19h, 7.3.20g, 7.3.21c, 7.3.7c, 11.3.30b	21b, 22a, 25b, 25c, 25d, 26a, 28a, 28b, 28c, 31a, 31b, 31c, 37a, 37b, 41a, 42a, 47e, 48a, 48b, 49b (spatial split based on if upland or coastal), 64c

Chapter	Issues	Fire vegetation group	Fire regime group	Map label (if required)	**Regional ecosystems** (Sattler and Williams 1999; Queensland Herbarium 2011a; 2011b).	WTMA vegetation unit
2	1	**Open forests of the foothills and ranges**	Open forest - moist grassy		7.11.16, 7.11.16a, 7.11.16b, 7.11.19, 7.11.19a, 7.11.20, 7.11.31, 7.11.31a, 7.11.31e, 7.11.32e, 7.11.33, 7.11.33b, 7.11.33c, 7.11.45, 7.11.46, 7.11.47, 7.11.50, 7.11.50a, 7.11.50, 7.11.51, 7.11.51a, 7.12.24, 7.12.24a, 7.12.24b, 7.12.25, 7.12.25a, 7.12.25b, 7.12.27, 7.12.27a, 7.12.27b, 7.12.27c, 7.12.28, 7.12.28a, 7.12.29a, 7.12.29b, 7.12.29d, 7.12.33, 7.12.33a, 7.12.33b, 7.12.24, 7.12.52, 7.12.53, 7.12.53a, 7.12.53d, 7.12.56, 7.12.56a, 7.12.61b, 7.3.13, 7.3.16, 7.3.16a, 7.3.16b, 7.3.19, 7.3.19a, 7.3.20k, 7.3.21, 7.3.21a, 7.3.39, 7.3.39a, 7.3.45b, 7.5.2, 7.5.2a, 7.5.2b, 7.5.2c, 7.5.4, 7.5.4a, 7.5.4c, 7.5.4d, 7.5.4e, 7.5.4f, 7.11.16d, 7.11.19b, 7.11.33a, 7.11.5, 7.11.5a, 7.11.5b, 7.11.5c, 7.11.5d, 7.11.5e, 7.11.5f, 7.11.5g, 7.3.19i, 7.3.43, 7.8.17a, 7.8.17b, 7.8.17c, 7.8.19, 7.8.7a, 7.8.8, 7.8.8a, 7.8.8b.	22d, 25a, 28f, 28e, 29a, 29b, 31d, 34a, 37c, 42b, 43a, 43b, 43c, 44a, 44b, 44d, 47a, 47b, 49b, 60d, 60f, 19b.
2	1		Open forest - dry grassy		7.11.16c, 7.11.21, 7.11.21a, 7.11.3, 7.11.35, 7.11.35a, 7.11.35b, 7.11.35c, 7.11.35d, 7.11.37, 7.11.37a, 7.11.37b, 7.11.49, 7.11.51b, 7.12.24c, 7.12.25c, 7.12.25d, 7.12.30, 7.12.30a, 7.12.30b, 7.12.30c, 7.12.34, 7.12.35, 7.12.51b, 7.12.53e, 7.12.55, 7.12.59, 7.12.61c, 7.12.62, 7.12.62a, 7.12.62b, 7.12.63, 7.12.65d, 7.12.69, 7.12.69a, 7.12.69b, 7.3.14, 7.3.14a, 7.3.14b, 7.3.19f, 7.3.19g, 7.3.21b, 7.3.44, 7.3.48, 7.3.48a, 7.3.48b, 7.5.2d, 7.5.3, 7.5.3a, 7.5.3b, 7.5.4b, 7.3.19g, 7.5.1b, 7.5.2e, 7.5.2f, 7.5.2g, 7.5.3a, 7.8.10, 7.8.10a, 7.8.10b, 7.8.18, 7.8.18a, 7.8.18b, 7.8.18c, 7.8.18d.	24a, 27a, 27b, 30a, 31e, 32a, 33a, 34b, 34c, 35a, 35b, 36a, 36b, 37d, 37e, 37g, 39a, 39b, 40a, 42c, 43e, 45b, 47d.
2	1		Open forest - shrubby		7.11.32g, 7.11.36, 7.11.38, 7.11.38a, 7.11.42, 7.12.12c, 7.12.26c, 7.12.26d, 7.12.26e, 7.12.26f, 7.12.37h, 7.12.51, 7.12.51a, 7.12.58, 7.12.5f, 7.12.65c, 7.12.66, 7.12.66a, 7.12.66c, 7.12.66d, 7.11.38b, 7.11.41b, 7.11.41c, 7.12.4, 7.12.5g, 7.8.16, 7.8.16a, 7.8.16b, 7.8.16c.	20a, 21c, 21d, 21e, 21f, 22b, 23a, 28d, 37f, 43d, 43f, 43g, 44c, 44e, 46a, 47f, 49a, 49c, 67e, 67i.

Chapter	Issues	Fire vegetation group	Fire regime group	Map label (if required)	**Regional ecosystems** (Sattler and Williams 1999; Queensland Herbarium 2011a; 2011b).	WTMA vegetation unit
3	1	**Tall open forest**	Tall open forest - moist grassy and shrubby		7.11.31c, 7.11.31d, 7.11.44, 7.12.61, 7.12.61a, 7.3.40, 7.3.43a, 7.3.43b, 7.5.1a, 7.5.1c, 7.5.1d, 7.11.31b, 7.11.6, 7.11.14, 7.11.14a, 7.11.14b, 7.11.14c, 7.11.14d, 7.11.32, 7.12.21, 7.12.21a, 7.12.21b, 7.12.21c, 7.12.21d, 7.12.22, 7.12.22a, 7.12.22b, 7.12.22c, 7.12.22d, 7.12.22e, 7.3.42, 7.3.42a, 7.3.42b, 7.8.15, 7.8.15a, 7.8.15b.	38a, 38b, 45a, 47c, 60a, 60b.

Chapter	Issues	Fire vegetation group	Fire regime group	Map label (if required)	**Regional ecosystems** (Sattler and Williams 1999; Queensland Herbarium 2011a; 2011b).	WTMA vegetation unit
4	1	Grasslands, sedgelands, fernlands	Wetland grasslands	Gw	7.3.1, 7.3.1a, 7.3.1b, 7.3.32, 7.3.32a, 7.3.32b, 7.3.32c.	68a, 68b, 68c.
4	2		Wetland sedgelands and fernlands	SFw	7.1.3, 7.2.9c, 7.3.1c, 7.3.29, 7.3.29a, 7.3.29b, 7.3.31, 7.3.30.	69c, 69e.
4	3		Upland grasslands	Gu	7.12.29e, 7.12.29f, 7.8.7b, 7.8.7c.	68d (split based on location).
4	3		Upland sedgelands and fernlands	SFu	7.11.1f, 7.11.29c, 7.11.40, 7.11.40c, 7.11.40g, 7.11.40h, 7.12.37f, 7.12.37g, 7.12.64e, 7.3.39b, 7.3.39c, 7.3.39d, 7.12.67.	65a, 65b, 69a, 69b, 69d, 69f.
4	6		Grasslands of the Coastal slopes	Gcs	7.11.39, 7.11.39a, 7.11.39b, 7.11.39c, 7.12.54f, 7.12.56b, 7.11.34c, 7.3.19j, 7.11.21b.	68e, 68d (split based on location).
4	8		Sedgeland of volcanic lakes	Sv	7.3.2, 7.3.33a.	69g, 69h.

Chapter	Issues	Fire vegetation group	Fire regime group	Map label (if required)	**Regional ecosystems** (Sattler and Williams 1999; Queensland Herbarium 2011a; 2011b).	**WTMA vegetation unit**
5	1	**Montane communities**	Montane communities		7.11.26, 7.11.26a, 7.11.26b, 7.11.32a, 7.11.32c, 7.11.32d, 7.11.32f, 7.12.37, 7.12.37a, 7.12.37b, 7.12.37c, 7.12.37d, 7.12.37e, 7.12.37i, 7.12.57, 7.12.64, 7.12.64a, 7.12.64b, 7.12.64c, 7.12.65, 7.12.65a, 7.12.65b, 7.12.65e, 7.12.65f, 7.12.65g, 7.12.65h, 7.11.26c, 7.11.26d, 7.11.26e, 7.11.26f, 7.11.32h, 7.11.32i, 7.5.2h, 7.12.26a, 7.12.26b, 7.12.26, 7.12.62c.	22c, 60e, 60g, 66c, 66d, 66f, 67f.
6	1	**Fire sheltered shrubland**	Fire sheltered shrubland		7.11.34a, 7.11.34b, 7.12.41, 7.12.54, 7.12.54a, 7.12.54b, 7.12.54c, 7.12.54d, 7.12.54e, 7.12.65i, 7.12.66b, 7.2.2d, 7.2.5b, 7.11.10, 7.11.10b, 7.11.19c, 7.11.38c, 7.11.10b, 7.11.10b, 7.12.65j, 7.2.4k, 7.2.4l, 7.2.4m, 7.3.35a, 7.3.35b, 7.3.35c, 7.11.32b.	18f, 66a, 66b, 66e, 66g, 66h, 67a, 67b, 67c, 67h.

Chapter	Issues	Fire vegetation group	Fire regime group	Map label (if required)	**Regional ecosystems** (Sattler and Williams 1999; Queensland Herbarium 2011a; 2011b).	WTMA vegetation unit
7	1	Melaleuca communities	Melaleuca forest/ woodland.	Mfw	7.11.40a, 7.11.40b, 7.11.41, 7.11.41a, 7.11.48, 7.11.48b, 7.12.60b, 7.2.11b, 7.2.11c, 7.2.3h, 7.2.4h, 7.3.8b, 7.3.8c, 7.3.9, 7.3.9a, 7.3.9b, 7.5.4g, 7.11.40d, 7.11.48a, 7.12.56c.	52a, 52c, 54a, 55b, 56f, 57a, 58a, 59b, 59c, 59d, 59f, 60c.
7	1	Melaleuca communities	Melaleuca gallery forest	Mg	7.3.50, 7.3.50a, 7.3.50b.	50a, 53a.
7	1	Melaleuca communities	Melaleuca on gley soils	Mgl	7.1.5, 7.12.60, 7.12.60a, 7.2.11, 7.2.11a, 7.2.11e, 7.2.11f, 7.3.34, 7.3.5, 7.3.5a, 7.3.5b, 7.3.5c, 7.3.5d, 7.3.5e, 7.3.5f, 7.3.5g, 7.3.8, 7.3.8a, 7.2.4l, 7.3.8d.	56b, 56d, 59a, 59e, 59g.
7	1	Melaleuca communities	Submerged Melaleuca/ palm/ vine forest swamps	Ms	7.1.3a, 7.2.10c, 7.2.4g, 7.2.8, 7.2.9b, 7.3.25, 7.3.25a, 7.3.6, 7.3.6a, 7.3.6b, 7.2.9, 7.2.9a, 7.2.9d.	51a, 52b, 55a, 56a, 56c, 56e, 63b.
8	1	Riparian, fringing and dune communities	Riparian, fringing and dune communities		7.11.42a, 7.11.42b, 7.2.10, 7.2.10a, 7.2.10b, 7.2.10d, 7.2.10e, 7.2.11d, 7.2.2a, 7.2.2g, 7.2.3f, 7.2.5a, 7.2.7, 7.2.7a, 7.2.7b, 7.3.16d, 7.3.25b, 7.3.26a, 7.3.28, 7.3.28a, 7.3.28b, 7.3.28c, 7.3.49, 7.3.49a, 7.2.3i, 7.2.3j, 7.3.23a, 7.3.23c, 7.3.25c, 7.3.26b, 7.3.28d, 7.3.49b.	8a, 10c, 21a, 22e, 22f, 49d, 62a, 62b, 62c, 62d, 62e, 64a, 64b, 67d, 67g, 67j, 67k.

Chapter	**Issues**	**Fire vegetation group**	**Fire regime group**	**Map label (if required)**	**Regional ecosystems** (Sattler and Williams 1999; Queensland Herbarium 2011a; 2011b).	**WTMA vegetation unit**
9	1	**Rainforests**	Rainforests		7.1.3b, 7.1.4b, 7.11.10a, 7.11.12, 7.11.12a, 7.11.12b, 7.11.12c, 7.11.12d, 7.11.12e, 7.11.12f, 7.11.13, 7.11.1, 7.11.1a, 7.11.1b, 7.11.1c, 7.11.1d, 7.11.1e, 7.11.1g, 7.11.23, 7.11.23a, 7.11.23b, 7.11.24, 7.11.24a, 7.11.24b, 7.11.24c, 7.11.24d, 7.11.24e, 7.11.24f, 7.11.24g, 7.11.25, 7.11.25a, 7.11.25b, 7.11.27, 7.11.27a, 7.11.27b, 7.11.28, 7.11.29, 7.11.29a, 7.11.29b, 7.11.2, 7.11.2a, 7.11.2b, 7.11.30, 7.11.3, 7.11.3a, 7.11.3b, 7.11.40e, 7.11.40f, 7.11.7, 7.11.7a, 7.11.7b, 7.11.7c, 7.11.7d, 7.11.7e, 7.12.10, 7.12.10a, 7.12.10b, 7.12.11, 7.12.11a, 7.12.11b, 7.12.11c, 7.12.11d, 7.12.12, 7.12.12a, 7.12.12b, 7.12.13, 7.12.16, 7.12.16a, 7.12.17, 7.12.19, 7.12.19a, 7.12.19b, 7.12.19c, 7.12.19d, 7.12.1, 7.12.1a, 7.12.1b, 7.12.1c, 7.12.20, 7.12.2, 7.12.2a, 7.12.2b, 7.12.2c, 7.12.38, 7.12.38b, 7.12.39, 7.12.39a, 7.12.39b,7.12.40, 7.12.40a, 7.12.40b, 7.12.40c, 7.12.40d, 7.12.40e, 7.12.42, 7.12.42a, 7.12.42b, 7.12.43, 7.12.44, 7.12.45, 7.12.46, 7.12.46a, 7.12.46b, 7.12.47, 7.12.47a, 7.12.47b, 7.12.48, 7.12.49, 7.12.50, 7.12.5, 7.12.5a, 7.12.5b, 7.12.68, 7.12.6, 7.12.6a, 7.12.6b, 7.12.7, 7.12.7a, 7.12.7b, 7.12.7c, 7.12.7d, 7.12.9, 7.2.1, 7.2.1a, 7.2.1b, 7.2.1c, 7.2.1d, 7.2.1e, 7.2.1f, 7.2.1g, 7.2.1h, 7.2.1i, 7.2.2, 7.2.2b, 7.2.2c, 7.2.2h, 7.2.5, 7.2.6b, 7.3.10, 7.3.10a, 7.3.10b, 7.3.10c, 7.3.10d, 7.3.10e, 7.3.10f, 7.3.17, 7.3.20g, 7.3.23, 7.3.23a, 7.3.23b, 7.3.23c, 7.3.35, 7.3.35a, 7.3.36b, 7.3.36c, 7.3.38, 7.3.3, 7.3.3a, 7.3.3b, 7.3.3c, .7.3.4, 7.3.49b, 7.11.24h, 7.11.29d, 7.11.2c, 7.11.2d, 7.12.10c, 7.12.16b, 7.12.16c, 7.12.1d, 7.12.1e, 7.12.2d, 7.12.2e, 7.12.38c, 7.12.9, 7.2.2e, 7.2.2f, 7.2.6b, 7.3.10g, 7.3.17, 7.3.23b, 7.3.36a, 7.3.37, 7.3.3a, 7.3.3b, 7.3.3c, 7.3.4, 7.8.11, 7.8.11a, 7.8.11b, 7.8.12, 7.8.13, 7.8.14, 7.8.1, 7.8.1a, 7.8.1b, 7.8.1c, 7.8.2, 7.8.2a, 7.8.2b, 7.8.2c, 7.8.3, 7.8.3a, 7.8.3b, 7.8.4, 7.8.4a, 7.8.4b, 7.8.4c, 7.8.4d, 7.11.8a, 7.11.8b, 7.11.8c.	1a, 1b, 1c, 1d, 1e, 2a, 2b, 2c, 2d, 2e, 2f, 3a, 3b, 3c, 4a, 4b, 4c, 5a, 5b, 6a, 6b, 6c, 7a, 7b, 7c, 7d, 8b, 8c, 8d, 8e, 9a, 9b, 9c, 9d, 10a, 10b, 10d, 10e, 10f, 10g, 10h, 10i, 10j, 10k, 10l, 11a, 12a, 12b, 12c, 13a, 13b, 13c, 13d, 14a, 14b, 14c, 14d, 14e, 14f, 15a, 15b, 15c, 15d, 16a, 16b, 17a, 17b, 18a, 18b, 18c, 18d, 18e, 19a, 61a, 61b, 63a.

Chapter	Issues	Fire vegetation group	Fire regime group	Map label (if required)	Regional ecosystems (Sattler and Williams 1999; Queensland Herbarium 2011a; 2011b).	WTMA vegetation unit
10	1	Mangrove and saltmarsh	Mangroves		7.1.1, 7.1.4a, 7.1.4, 7.1.4c, 7.1.3c, 7.1.4d.	70a, 70b, 70c, 70d.
10	1	Mangrove and saltmarsh	Saltmarsh		7.1.2a, 7.1.2, 7.1.2b.	70e, 70f.
11	8	Other Issues	Regrowth		n/a	61c.
11	345	Other Issues	Weeds		n/a	61d, 61e.
n/a	n/a	Rock	Rock		7.11.34d, 7.11.40i, 7.12.54g, 7.12.65k, 7.12.64d, 7.12.66e, 7.12.38a.	71b, 71c.
n/a	n/a	Sand	Sand		7.2.7c.	71f.
n/a	n/a	Water	Water		7.3.33b.	71a, 71g, 71h, 71i, 71j.
n/a	n/a	Cleared	Cleared		n/a	72a, 72b, 72c, 72d, 72e, 72f, 71d, 71e.

The spatial data is based on version 6.1 of the “Queensland Remnant Vegetation Cover 2006” layer (16 September 2011) data (refer to Figure 1).

Some of the Regional Ecosystems (RE) listed above will not be matched in the spatial data. This may be because the RE is ‘not of a mappable size’, the RE ‘has been moved’ (i.e. it has been reclassified into a new RE code), the RE exists only as a sub-dominant RE within the spatial data or the RE has not yet been mapped. In the Regional Ecosystem Description Database (REDD) system, the comments section indicates if the RE is not of a mappable size or if it has been moved.

The RE’s listed below are those RE’s from the classifications listed above that do not have any matching records in version 6.1 of the Survey and Mapping of 2006 Remnant Vegetation Communities and Regional Ecosystems of Queensland spatial layer (16 September 2011).

Unmatched regional ecosystems	7.11.12e, 7.11.14c, 7.11.1g, 7.11.41c, 7.11.5g, 7.8.7c.

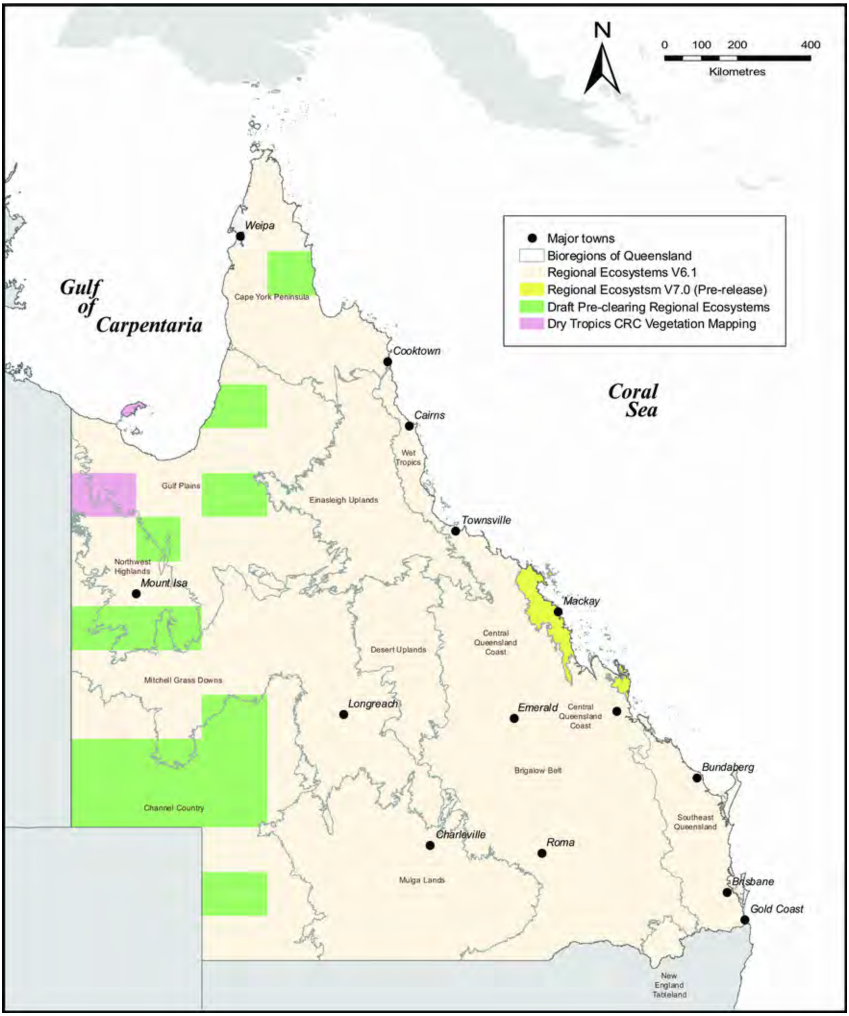


Figure 1: Map of Queensland indicating the different GIS data sources used to produce the spatial fire vegetation group mapping product.

Appendix 2: Mosaic burning

Mosaic burning is an approach to planned burning which aims to maintain and maximise diversity within fire-adapted vegetation communities. At various scales, a mosaic of vegetation in different stages of post-fire response can provide a greater range of habitats for plants and animals including those that prefer open country, those that need dense vegetation or the presence of a particular food source and all ecological requirements in between.

In practice, mosaic burning is achieved through the use of appropriate weather conditions, variation in topography, frequency, intensity, season and ignition patterns to create a patchwork of burnt and unburnt areas. Over time the patches overlay to build a more complex mosaic of vegetation at various stages of response from fire (Figures 1–5 provide a simplified example). This practice can apply to burning at a **landscape scale**—how much of a particular fire vegetation group is targeted within a given year (across a bioregion or management area) or can refer to the area burnt within an individual fire event. Both are important.

The land manager should apply mosaic burning and be guided by the recommended fire frequency. **Note that it is a common mistake to interpret the fire interval as a formula for applying fire.** Consider the following example: A fire strategy might recommend burning with a fire interval of between 8–12 years. In this case the land manager would apply mosaic burning (as often as required) but generally not burning any single patch more frequently than the minimum fire interval (e.g. eight years), or less frequently than the maximum fire interval (e.g. 12 years) (refer to Figures 1–5).

This is relevant because the minimum fire interval represents the amount of time it takes for each species to regenerate sufficiently to tolerate a second fire, and the maximum fire interval represents the amount of time an ecosystem can be left without fire before it begins to decline in health and species might be lost.

As ParkInfo/geographic information systems (GIS) and monitoring tools evolve it will become easier to evaluate if the fire vegetation groups are on track in terms of maintaining an age class distribution and conforming to recommended fire frequencies. Irrespective of monitoring and GIS tools it is important to learn to observe the health of the country and to understand its fire management needs to appropriately apply fire in a way that maintains a healthy ecosystem. This planned burn guideline provides key indicators supported by photographs to help you assess the health of the ecosystems and their fire management needs.

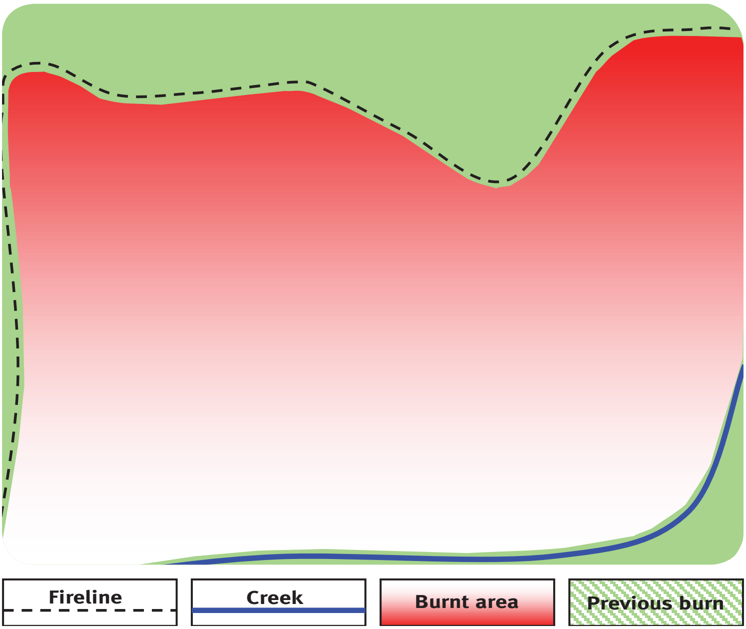


Figure 1: Example area between fireline and creek burnt in a wildfire—year 0. (Recommended fire interval for fire vegetation group is eight–12 years).

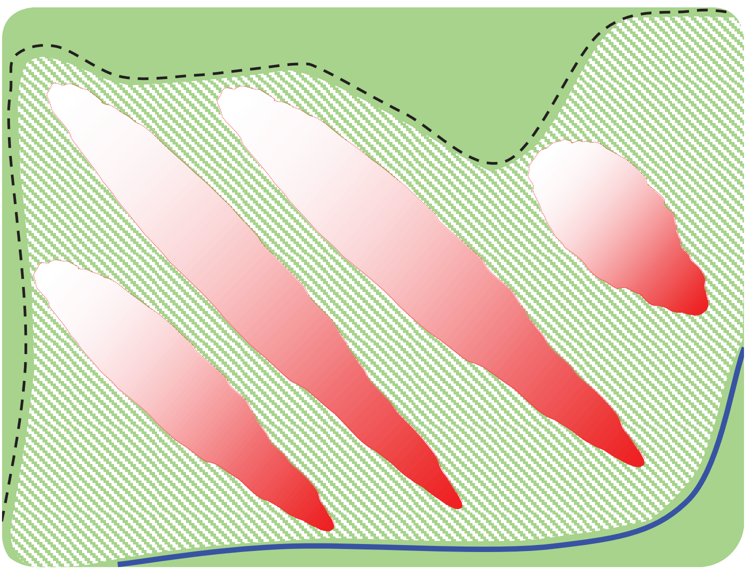


Figure 2: Planned mosaic burn—year 8.

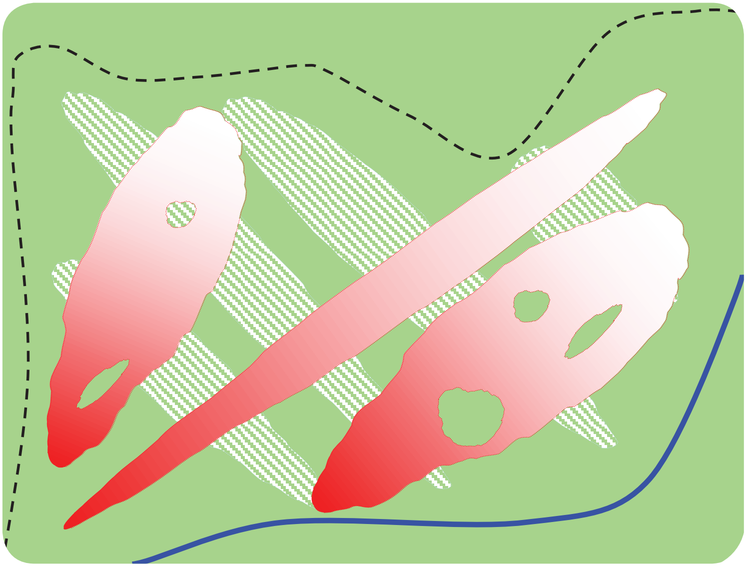


Figure 3: Planned mosaic burn—year 20.

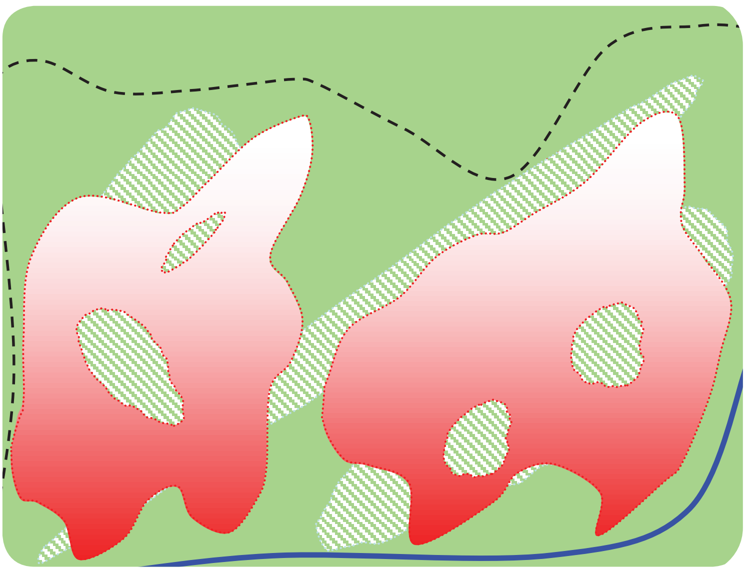


Figure 4: Planned mosaic burn—year 28.

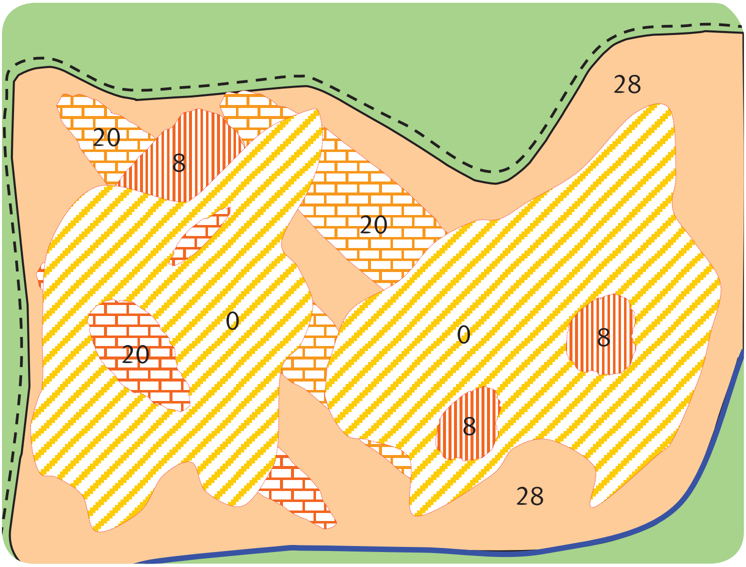


Figure 5: Fire history summary—year 28.
Wildfire and mosaic burn patterns overlaid (with years since last burnt).

Mosaic burn on Girringun National Park.
Mark Parsons, QPWS, Bishops Peak, Girringun National Park (2010).

13 QGOV (13 74 68)

www.nprsr.qld.gov.au