Chapter 11: Mangroves and saltflats

This fire vegetation group occurs along intertidal flats and is subject to inundation.

Mangroves

Mangroves are most common near or within estuarine or brackish water on intertidal flats which are often dissected by tidal streams. They can extend into the upper tidal reaches of creeks and rivers where there is a high freshwater influence. They are periodically inundated through seasonal tidal action and storms. The structure of mangroves varies (according to their position in regards to inundation) however, in most instances they occur in stands as low trees or shrubs with very little other vegetation present. The presence of a low shrub layer can vary and is often made up of a mix of mangrove species including juvenile canopy species and samphires (a group of succulent sub-shrubs, shrubs and annuals, such as *Halosarcia* spp).

Salt flats

Grasslands, forblands, and sedgelands occur on saltflats and mudflats, generally on the landward side of intertidal flats—which are often only inundated by the highest of spring tides. Grasses such as saltwater couch *Sporobolus virginicus* are common within this fire vegetation group. Plants within the shrub layer can include *Suaeda australis* and *Halosarcia indica*, forbs, sedges and occasionally stunted mangroves around the edges.

Fire management issues

Mangroves

Mangroves are not fire dependent and generally do not burn. Mangroves can be scorched in nearby planned burning operations particularly along the margin of flammable vegetation, but it is rare that any lasting damage is done. Rubber vine *Cryptostegia grandiflora* has been recorded in this fire vegetation group.

Saltflats

While some species in this community are tolerant of occasional fire (e.g. saltwater couch *Suaeda australis* and *Halosarcia indica*) (Williams 2009), they do not require fire, and in general should not be deliberately targeted for burning. Fires have been known to occasionally carry into this community from conservation burns in surrounding fire-adapted communities and when targeting weeds such as rubber vine *Cryptostegia grandiflora* and para grass *Urochloa mutica* with fire. Such fires are not known to cause lasting impacts.

In most instances fire management will aim to limit fire encroachment into mangroves and saltpan areas by burning surrounding fire-adapted vegetation communities. Occasionally, burns may be planned within these communities as part of a control program targeting invasive species such as rubber vine and para grass.

Issues:

1. Limit fire encroachment into mangroves and saltpans.
2. Manage invasive grasses.
3. Manage rubber vine.

Extent within bioregion: 206 136 ha, 1 per cent; **Regional ecosystems:** Refer to Appendix 1 for complete list.

Examples of this FVG: Bowling Green Bay National Park, 22 937 ha; Bowling Green Bay Conservation Park, 2 460 ha; Townsville Town Common Conservation Park, 1 712 ha; Proposed Cromarty Wetlands Conservation Park, 595 ha; Cape Upstart National Park, 337 ha; MacKenzie Island Conservation Park, 245 ha; Broad Sound Islands National Park, 200 ha; Sandfly Creek (South Bank of Ross River), 194 ha; Shoalwater Bay Conservation Park, 172 ha; Charon Point Conservation Park, 161 ha; Newport Conservation Park, 113 ha; Cape Upstart Reserve for Env Purp (Adj to Cape Upstart NP), 64 ha; Causeway Lake Conservation Park, 53 ha; Keppel Sands Conservation Park, 39 ha; Rundle Range National Park, 25 ha; Abbott Bay Resources Reserve, 19 ha; Rundle State Forest, 16 ha; Magnetic Island National Park, 7 ha; Bolger Bay Conservation Park, 2 ha; Capricorn Coast National Park, 1 ha.

Issue 1: Limit fire encroachment into mangroves and saltpans

Refer to Chapter 12 (Issue 1), regarding fire management guidelines.

Mosaic burning of surrounding fire-adapted vegetation communities will assist in limiting potential impacts of unplanned fires on non-target communities such as mangroves and saltpans. Due to their location, these communities are generally self-protecting during planned burning in appropriate conditions. Coinciding planned burns with high tides and inundation will further limit the chance of fire encroaching into this community.

Depending upon conditions at the time of burning, if a planned burn does carry into a saltpan area it is unlikely to cause any lasting impacts and this community has in the past, demonstrated good post-fire recovery (Williams 2009).

Saltwater couch on salt flats. Although this species can tolerate occasional fires (such as a fire used to target rubber vine) it is generally not deliberately burnt.

Bill McDonald, Queensland Herbarium.

Marine couch grassland and samphire herbland.
Rhonda Melzer, QPWS, Coorooman Creek (2007).

Low mangrove forest.
Rhonda Melzer, QPWS, Coorooman Creek (2007).

Issue 2: Manage invasive grasses

Refer to Chapter 12 (Issue 5), regarding fire management guidelines.

It is important to be aware of the presence of invasive grasses as they can dramatically increase fire severity, are often promoted by fire and may result in significant damaging impacts upon the vegetation community in which they have invaded.

Issue 3: Manage rubber vine

Refer to Chapter 12 (Issue 7), regarding fire management guidelines.

Rubber vine *Cryptostegia grandiflora* is an aggressive, vigorous climber that can rapidly spread and smother a range of vegetation communities—most notably riparian zones and waterways. Fire has been proven to be an effective control measure for rubber vine as well as being an effective follow-up to other control methods such as mechanical and herbicide control.

Rubber vine occurring in A marine samphire forbland. Forblands such as this can tolerate some fire. A series of fires may help reduce rubber vine.

Barry Nolan, QPWS, Cape Upstart (2007).

Chapter 12: Common issues

In the Brigalow Belt bioregion there are some issues where the fire management approach is similar irrespective of fire vegetation group. Rather than repeating these 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. Limit fire encroachment into non-target fire vegetation group.
2. Hazard reduction (fuel management) burns.
3. Planned burning near sensitive cultural heritage sites.
4. Avoid peat fires.
5. Manage invasive grasses.
6. Manage lantana and other weeds.
7. Manage rubber vine.
8. Post cyclone planned burning.
9. Manage severe storm or flood disturbance.

Issue 1: Limit fire encroachment into non-target fire vegetation groups

Non-target fire vegetation groups include rainforests, riparian, casuarina and foredune communities, as well as melaleuca communities, wetlands, saltmarsh, shrublands and tall open forests that are not-yet ready to burn. 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 should be used to protect them.

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 area without standing water or water logged conditions.
- Invasive grasses, rubber vine or lantana invading rainforest or riparian edges.
- The non-target community is upslope of a potentially running fire.

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

Mark Parsons, QPWS, Stoney Creek (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. The Singapore daisy re-sprouted soon after the fire.

Mark Parsons, QPWS, Yingalinda (2009).

Littoral Rainforest is vulnerable to scorching by fire.

Mark Parsons, QPWS, Orpheus Island (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 (2010).

A low-severity backing fire used under appropriate conditions will not scorch the riparian community. Fire will trickle downhill and self-extinguish before reaching the riparian zone.

Kerensa McCallie, QPWS, Dinden National Park (2010).

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

Justine Douglas, QPWS, Curtain Fig National Park (2009).

Surface water is used to control fire encroaching into saltmarsh.

Mark Parsons, QPWS, Waterfall Creek (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 the impacts of unplanned fire on non-target and fire-sensitive communities.
- Under appropriate planned burn conditions with good soil moisture, non-target communities tend to self-protect and additional protective tactics may not be required. Sometimes where a non-target community occurs at the top of a slope, it is necessary to avoid running fires upslope, even in ideal conditions.
- If suitable conditions cannot be achieved specific tactics may be required to protect the non-target fire vegetation group. See the tactics at the end of this chapter.
- Ensure suitable conditions exist prior to burning melaleuca and wetland communities to avoid peat fires (refer to Issue 4 for fire management guidelines).
- 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 6 for fire management guidelines on managing lantana and other weeds).
- The presence of high-biomass grasses can increase 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 5 for fire management guidelines on managing invasive grasses).
- 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 vegetation and may open up the canopy. This in turn may increase the risk of weed invasion and soil erosion and lead to a greater production of fine fuels and an increase in fire hazard. It is highly desirable to exclude fire or at least minimise the frequency and intensity of fire in many riparian communities to promote structurally complex ground and mid-strata vegetation and retain mature habitat trees (all of which are important fauna habitat).
- 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 recent rain, the king tide or groundwater seepage—this will protect the saltmarsh vegetation. Saltmarsh is most vulnerable to scorching if fire-promoting plants (particularly flammable grasses) occur within or adjacent to them.

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 the following as appropriate for the site:

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 100m 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 metre 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 100m long section of the margin in three locations) and determine whether the fire has penetrated further than one metre into the edge.	**Achieved:** Fire penetrates no further than one metre into the edge. **Not Achieved:** Fire penetrates further than one metre 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 adjacent fire-adapted communities will help achieve the objective of limited fire encroachment. A backing fire will help ensure good coverage (refer to the mosaic section below). 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 limit scorch to the non-target areas).

Mosaic (area burnt within an individual planned burn)

- Consult the recommended mosaic for the fire vegetation group being burnt. Aim for the higher end of the recommended mosaic as this will help mitigate the movement of wildfire into fire-sensitive communities.

Landscape Mosaic

- Proactive broad-scale management of surrounding fire-adapted areas using mosaic burning is one of the best ways to reduce impacts of unplanned fire on non-target fire vegetation groups 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.

FDI: Refer to relevant fire vegetation group

DI (KBDI): Refer to relevant fire vegetation group

Wind speed: Beaufort scale 1–3, < 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 the 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 location (e.g. due to topographical variation). Also, 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.

- **Test burn** the site to ensure non-target communities will not be affected.
- **Do not create a running-fire.** When burning in adjacent sclerophyll forest during dry conditions use a low-intensity perimeter burn from the edge of non-target community to protect its margins.
- **Commence lighting on the leeward (smoky) edge** to establish 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.
- **Afternoon ignition.** Planned burning in areas adjacent to non-target communities can be undertaken late in the afternoon. The milder conditions during this period help promote a low-severity fire that trickles along the edge and usually self-extinguishes, especially during winter.
- **Limit fire encroachment into non-target communities.** Where the non-target community is present in low-lying areas (e.g. sedgelands), utilise the surrounding topography to create a low-intensity backing fire that travels down the slope towards the non-target community. If conditions are unsuitable (e.g. the non-target community is too dry to ensure the 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. This will promote a low-intensity backing fire that burns away from the non-target community.
- **Use Strip ignition to draw** fire away from the non-target community's edge. When more than one line of ignition is used it can create micro wind conditions that can draw fire away from non-target areas. It is important to have safe refuges when undertaking this type of burning.

Issue 2: 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.

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.**

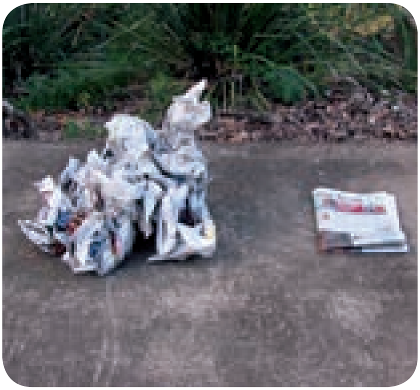


Photo 1a: The two samples above have the same **fuel load** (eighteen pages of newspaper) but a different fuel arrangement.

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 m or more 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

- **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: < 12

DI (KBDI): < 120

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). Also, 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 regularly vary throughout the burn due to changes in weather conditions, topography, fuel loads, etc.
- **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 r**unning 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**. Caution is required if the area is small in size or a narrow strip and the two lit lines will converge, creating a hot junction zone and greater than desired severity with the chance of fire escaping through a spot-over.

Issue 3: 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).

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
Highest	Fuel management through the implementation of planned burns within **Protection Zones** to protect life, property, and conservation values.
Very high	Burns protecting **significant cultural heritage sites**.

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 the fire.

Select the following for the site:

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. **Partially Achieved:** minimal impact. **Not Achieved:** there was significant 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 discussion)

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

Mosaic (area burnt within an individual planned burn)

- If possible, a patchy fire will give greater overall protection to cultural heritage sites and items.

Landscape Mosaic

- A landscape proactively managed with mosaic burning will help reduce fuel hazard and thereby limit the spread and severity of wildfires, giving overall 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: < 11

DI (KBDI): < 100 for areas where there are combustible historic sites

Wind speed: < 15 km/hr

Wind direction: Closely monitor the wind direction to avoid smoke, flame and/or radiant heat coming into contact with sensitive cultural heritage sites.

Soil moisture: Ensure 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 location (e.g. due to topographical variation). Also, 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.

- **Manual fuel management.** Prior to undertaking planned burns near sites of cultural significance (e.g. scar trees and rock art sites), manual reduction of fuel may be required. This may include the raking, clearing (e.g. rake-hoe line), trimming or leaf blowing the surface fuels away from the site to limit potential impacts. If it is not necessary to manually reduce the fuel level, it is preferable to leave the site completely undisturbed.
- **Spot ignition.** Can be used to effectively 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 spot ignition is preferred around cultural heritage sites as it will promote a slow-moving and manageable low-severity fire and limit the chances of a high-severity junction zone developing.
- **A low-severity backing fire.** A slow-moving, low-severity backing fire can help ensure fire severity and rate of spread are kept to a minimum. Depending on the conditions, **spot light the windward (clear) edge** to direct the active fireline and smoke away from the cultural heritage site. Use a chipped or wet line around the site so the resulting backing fire can be extinguished or will self-extinguish at the chipped or wet line.

Smoke directed away from rock art site during a planned burn.

Mark Parsons, QPWS, Fishers Creek (2010).

Issue 4: Avoid peat fires

Low-lying communities (including wetlands and melaleuca communities) can gradually accumulate partially decayed, densely-packed vegetation known as peat. In the absence of good soil moisture the peat can be easily ignited and result in a peat fire. Peat fires can burn for months, and can have very negative impacts on the whole ecosystem. Peat takes hundreds of years to re-form.

Awareness of the environment

Key indicators of suitable conditions that will avoid peat fires:

- Presence of visible standing water on the 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).

A melaleuca community with an understorey of ferns and sedges with standing water present.

Sylvia Millington, QPWS, Mount Coom (2010).

Post-fire in a melaleuca community with standing water.
Mark Parsons, QPWS, Sunday Creek (2010).

An ephemeral sedgeland with partially burnt fuels. Without standing water or moist soil, fire can burn underground for weeks or months.
Mark Parsons, QPWS, Sunday Creek (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, the peat will not ignite. If it is necessary to burn adjacent areas in less than ideal conditions, manage the fire carefully to minimise the risk of it entering peat areas (use suitable tactics such as burning away from wetland edges).
- 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.

Select the following for the site:

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 determine if the fire has 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**.

A low-severity fire adjacent to a *Melaleuca viridiflora* community where ground saturation has been used to control fire encroachment.

Mark Parsons, QPWS, Sunday Creek (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 (August to September) fires in the vicinity of peat.

FDI: < 7

DI (DI (KBDI)): < 80

Wind speed: Beaufort scale 1–4, < 23 km/hr (ideally between 10–23 km/hr in forests)

Soil moisture: Ensure standing water or water logged peat is present as it will avoid peat fires.

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 to effectively alter the desired severity of a fire. Spots closer together will result in a line of a greater intensity (as spots merge they create hot junction zones). Spots further apart will result in a lower-severity fire.
- **A low-intensity backing fire** ensures the 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 systems, utilise the surrounding topography to create a low-intensity backing fire that travels down slope towards the non-target community). If conditions are unsuitable (e.g. the non-target community is too dry to ensure the 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.

Issue 5: Manage invasive grasses

It is important to be aware of the presence of invasive grasses as they can dramatically increase fire severity, are often promoted by fire and may result in significant damaging impacts upon the vegetation community that it has invaded. Many invasive grasses are capable of out-competing native species to form dominant stands. Buffel grass, guinea grass, thatch grass and green panic are of particular concern in the Brigalow Belt bioregion.

The spread of invasive grasses has resulted in significant changes to traditional fire regimes within the Brigalow Belt bioregion due largely to a significant increase in fuel load; in turn increasing flame height and fire intensity and providing fuel connectivity across the landscape, allowing fires to spread across a much greater area than previously possible (Eyre et al. 2009). This results in greater tree death particularly of acacias and loss of habitat features with flow on effects to native fauna and a cycle of damaging high-severity fires which gradually results in the fragmentation and overall decline in the extent of most vegetation communities in particular brigalow and dry scrub communities. While fire can be used as part of control for some species, in most cases high biomass grasses both promote fire and are promoted by fire. It is important to be aware of the presence of high biomass grasses during planned burn operations.

Awareness of the environment

Key indicators:

- Invasive grasses are able to form a dense mono-specific stands.
- Invasive grasses are starting to penetrate the edge of brigalow and SEVT or other fire-sensitive communities or have become established throughout the community.
- The grasses have a large amount of biomass and/or dead material.
- Typically first appear along fire-lines and roads and similarly highly disturbed areas.
- Species such as green panic will generally grow taller than most native species and is also able to out-compete these species for space and resources (Butler and Fairfax 2003).
- Dead trees with charring high up the trunk may be present.

Discussion

- Be on the look out for newly forming stands and be especially vigilant in disturbed areas, particularly those where disturbance is ongoing (e.g. roadsides) and areas adjacent to or down stream from existing high biomass grass infestations (Melzer and Porter 2002). Control is often easier if their presence is detected and addressed early before it has become established.
- Prior to undertaking planned burns in areas where high biomass grasses occur, become familiar with the response of this grass to fire (e.g. if it is promoted or killed) and other factors such as fire severity type and weather conditions which may favour and further its spread.
- The closed canopy of healthy, mature acacia stands will often suppress and prevent the encroachment and establishment of invasive grasses. Healthy eucalypt forests with a native grassy understorey that fringe acacia and softwood scrub communities that are maintained in a healthy condition will often also act as a preventive buffer that limits the spread of invasive grasses into acacia communities.
- Invasive grasses can cause the progressive loss of fire-sensitive communities and increase the risk of wildfires carrying into the canopy of the community (particularly during dry conditions). This can cause the loss of mature trees, and contribute to the gradual decline, fragmentation, and/or loss of fire-sensitive communities.
- Be aware of weed hygiene issues when managing high-biomass grasses. Vehicles, machinery and quad bikes aid their spread and should be washed down after exposure. Invasive grasses easily spread along fire control lines (usually due to machinery spreading seeds). Caution and awareness of weed hygiene issues are paramount when constructing and maintaining firelines and roads.
- In many cases it is important to avoid burning invasive grasses due to the likely increase in fire severity and risk of further promotion. However, the risk of wildfire later producing an even higher-severity fire must be considered. In some situations, burning invasive grasses under mild conditions with planned fire may be more desirable than allowing them to burn with wildfire.
- In some instances fire may be useful as part of an integrated weed control program when implemented in conjunction with herbicide for some grass species. Fire may assist in reducing the biomass of grasses (pre or post spraying) and stimulate available seed bank stores that can be targeted with herbicide before seedling can mature and set seed (Greig 2008).

- Once an area has been impacted by invasive grasses (in particular within fire-sensitive communities) the aim of the land manager often becomes one of fuel management. This may involve implementing mild or 'cool' fires (both within the site and in surrounding areas) by implementing tactics that burn away from the non-target community and limit the edge effects on the margin. Other techniques which may be effective include slashing, spraying with herbicide and in some instances grazing (Melzer and Porter 2002; Butler and Fairfax 2003).
- The most effective control method for invasive grasses must be determined on a case-by-case basis and will need to be tailored to suit the site and long term management objectives of an area. For some species, the application or exclusion of fire can be an aspect of control often in combination with spraying and/or grazing.

Information for the control of specific species of invasive grasses is offered below:

Buffel grass

- Buffel grass is of particular concern to fire-sensitive communities. This species can penetrate and establish a dense sward penetrating several hundred metres into gidgee/brigalow woodland across a front several kilometres long, greatly increasing fuel loads and future impacts upon gidgee/brigalow (Butler and Fairfax 2003).
- The use of fire to control buffel grass is debated. Fire is known to promote the spread of buffel grass through disturbance. However, it may be used in tandem with other control methods such as spraying or grazing. In this case, fire is used to reduce the biomass of buffel grass providing access for herbicide treatment of the remaining clumps and seedlings. Be aware of the need to commit to follow-up spraying of the affected site for some time, as buffel grass will usually germinate en masse after fire and rain.
- Buffel grass is most vulnerable when at the end of its growing season when it is storing reserves. Consistent grazing at this time has helped in its control. Targeting burning at this time of the year may weaken buffel grass (Chamberlain 2003).
- The curing rate for buffel grass differs from native grasses—buffel grass tends to remain greener for longer periods of time. Consideration should be given to burning adjacent areas when there is good soil moisture and when buffel grass is green and unlikely to carry a fire.
- In some instances creating a buffer through mechanical or chemical means (of about 50–100 metres) adjacent to an area of buffel grass may be useful in limiting its further spread.

A close-up of the flowering head and clump-mass of buffel grass.
Paul Williams, Vegetation Management Science Pty Ltd, Bald Rock (2005).

Buffel grass is fire and drought promoted. Following a disturbance (such as fire) it is able to rapidly invade and form dense swards within a vegetation community.
Rhonda Melzer, QPWS, Nairana National Park (2005).

Excluding fire from areas affected by buffel grass may allow the canopy to recover and shade-out the buffel grass. Note the halo effect and shading-out of buffel grass as the canopy begins to close.

Rhonda Melzer, QPWS, Albinia Conservation Park (2010).

Guinea grass and green panic

- Herbicide is the most effective broad-scale control measure of green panic and guinea grass (alternatively use hand removal for small areas).
- Fire is not known to be an effective tool to manage guinea grass but can be useful in facilitating other control methods such as spraying. Be aware that too-frequent fire (every one to two years) promotes the spread of these species through disturbance and possibly through reducing canopy cover. Maintaining canopy cover (and therefore shade) will assist in guinea grass management.
- Green panic is shade-tolerant unlike many other grasses.
- Both species remain greener for longer periods than native grasses and will burn with a high-intensity due to the high amount of accumulated biomass when sufficiently cured.
- If either of these grasses must be burnt for any reason timing is a critical factor together with follow-up herbicide treatment. Avoid burning late in the season for a variety of reasons such as risk of creating high severity fire and protection of riparian zones.

Close up of guinea grass.

Paul Williams, Vegetation Management Science Pty Ltd, near Pattersons 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).

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 occurs within ephemeral swales that have dried out (limited windows of opportunity occur late season). Burning has been found to be more effective if used later in the year or in combination with chemical control.

Olive hymenachne

- Fire has been shown to be an effective tool to control this grass when used in combination with other methods such as grazing or herbicide control.
- Fire should be applied just prior to the wet season when plants have dried out sufficiently to provide suitable fuel. Fire should be followed by grazing or herbicide control.
- Fire will destroy seeds on the surface of the soil, but not buried seed, so follow up will be required.

Para grass is a significant threat to wetlands as it will out-compete and smother native grasses and choke up waterways. Fire followed by the application of herbicide has successfully been used to assist with the control of para grass infestations and promote the recovery of native grasses such as *Paspalidium udum* (Williams and Collet 2010).
Paul Williams, Vegetation Management Science Pty Ltd, Townsville Town Common Conservation Park (2007).

Other invasive grasses

- Thatch, grader and coolatai are becoming more widespread (particularly along roadsides) and are likely to influence fire management in the future.
- Coolatai can produce seed in the first growth season and is self-fertile, enabling new populations to arise from a single plant (CRC Weeds 2007). It needs to be actively growing (during late spring to summer) for herbicide to be effective. Fire can be used to remove dead biomass and stimulate regrowth before spraying six to eight weeks after and ideally before flowering.
- Rhodes and red natal grass are common along roadsides and due to their differing curing rates to native grasses, burning surrounding areas can be difficult. Too-frequent fire or fires under dry conditions will promote red natal grass particularly where there are bare patches of earth. Due to its location (predominately road edges) there is often good access to these species for herbicide treatment. Be sure to treat infestations early before they can become established.
- Successful fire management techniques for other species of high-biomass grasses in the Brigalow Belt bioregion are not yet established and will need to be subject to experimentation. The examples above might be useful as a starting point.

This thatch infestation is adjacent to Ooline scrub. Black speargrass in the foreground gives an indication of the height of the thatch.

Dan Beard, QPWS, Carnarvon National Park (2009). **Insert:** Thatch grass seed head.

A mono-culture of thatch has replaced native pasture and begun to encroach into adjoining communities. Note the remnant scrub within the sheltered gullies.

Dan Beard, QPWS, Gladstone (2009).

What is the priority for this issue?

Priority	Priority assessment
High	It is important to be aware of the presence of invasive grasses (particularly where it is a new infestation) so that their negative effects can be managed and the potential of control can be considered.

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)
Distribution of invasive grass has not increased as the result of the burn.	**Before and after the burn** (after suitable germination or establishment conditions): GPS the boundary of the invasive grass in the area or take photographs. Compare the pre and post burn distribution of the weed species.	**Achieved:** No increase in the distribution of the weed. **Partially Achieved:** Minor expansion of weed species distribution; will not increase fuel loads (e.g. scattered individuals spread into burn area; easily controlled). **Not Achieved:** Significant advance in the spread of the weed; will increase fuel loads in the newly invaded areas.

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. from dense before the fire to light after the fire). **Partially Achieved:** Weed infestation 'drops' one 'density category' (e.g. from dense before the fire to light after the fire). **Not Achieved:** No change in density category or weed density gets worse.
Reduction of fuels adjacent to non-target communities to low.	**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. **Not Achieved:** Fuel hazard has not been reduced to low.

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 invasive grasses, it is important to continue to monitor the site to ensure the objectives of the burn have been achieved and to ensure invasive grasses do not re-establish at the site.

As highly invasive weeds, exotic 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 continuous grass cover.
Mark Parsons, QPWS, Princess Hill (2007).

Fire parameters

What fire characteristics will help address this issue?

Fire severity

- This will depend on the species of invasive grass being targeted and often it is best to avoid fire all together. If burnt, in general invasive grasses should be burnt in ways that minimise fire severity. A **high**-severity fire may be required however, for specific objectives (e.g. when targeting para grass that is starting to become abundant in wetlands and swamps).

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

- Fire frequency is dependent upon the grass species and objectives of the burn (see discussion above).

Mosaic (area burnt within an individual planned burn)

- Mosaic is dependent upon the species and objectives of the burn (see discussion above).

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: Late wet season to early dry season (March–April) is preferable though this will largely be dependant upon the degree of curing of the grass.

GFDI: < 7, Low to moderate

DI (KBDI): < 100

Wind speed: Beaufort 1–2, < 10 km/hr. Be aware that graziers will take advantage of hot and windy conditions, often late in the year (late October to December) when it is dry, to ensure the fire will carry through pasture grasses. This is to maintain pasture or to remove brigalow regrowth, but may also result in fires carrying into adjoining protected areas. This will often occur on a five year cycle and is largely dependant upon rainfall.

Soil moisture: Ensure good soil moisture to retain a duff layer and limit the opening of bare ground and further encroachment of weeds.

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). Also, 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.

- **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 to effectively alter the desired intensity of a fire, particularly where there is an invasive grass infestation. Increased spacing between spots will result in a fire of lower-intensity. The spacing of the spots may vary throughout the burn due to changes in weather conditions, topography and fuel loads, etc.
- **A low-intensity backing fire.** A slow-moving, low-intensity backing fire (lit against the wind or slope) will generally result in a more complete coverage of an area and reduction of fuels. This tactic ensures the fire has a greater amount of residence time, while ensuring fire intensity and rate of spread is kept to a minimum.
- **Running fire.** For many invasive grasses it is recommended to burn early in the season. Conditions which favour a running fire will help carry the fire through the infestation (particularly if weather conditions are too mild or the grasses are not sufficiently cured). This can be achieved by shortening the spacing of lit spots or alternatively using line or strip ignition.

- **Limit fire encroachment into non-target communities.** Use appropriate lighting patterns (e.g. spot lighting with matches) in combination with favourable weather conditions along the margin of the community to promote a low intensity backing fire that burns away from the non-target community. Undertake burning in areas adjacent to invasive grass infestations while the grass is green and not cured, under mild conditions, early morning on the dew or late afternoon or at night will assist in creating a low severity fire that burns away from the non-target community. Where the non-target community is present in low-lying areas (e.g. drainage lines) utilise the surrounding topography to create a low-intensity backing fire that travels down-slope towards the non-target community. In both instances ensure good soil moisture is present within the non-target community.
- **Fire exclusion.** Fire exclusion from an infested area of buffel grass may provide the opportunity for species such as brigalow or other acacias to out-compete the invasive grass. Ideally the acacia community would remain unburnt long enough to form a closed canopy that disadvantages and shades-out the buffel grass. This however requires active fire management in surrounding fire-adapted communities to prevent unplanned fire.

Issue 6: Manage lantana and other weeds

Lantana is found predominately in the northern extent of the Brigalow Belt bioregion in a range of 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 grass, which in turn inhibits low-severity planned burns, but at the same time carries wildfire (Williams 2008). Where it occurs along rainforest edges, it increases the severity of fire against this edge, impacting on fire-sensitive ecosystems.

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.

Key indicators of *Lantana camara* where it is a dense infestation:

- *Lantana camara* occurs as a dense infestation.
- There is an absence of grass or fine fuels.

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 control lantana.

Mark Parsons, QPWS (2010).

Lantana/ guinea grass infestation.

Jenise Blaik, QPWS, Smithfield Conservation Park (2010).

Discussion

- A series of fires (with increased fire frequency) can be used to control lantana as the sole management method. This can be effective to reduce the abundance and density of lantana, or can 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 is effective in the management of the density and occurrence of lantana where it is scattered as an understorey plant.
- In areas where lantana density is high but where some native grasses remain beneath it, the introduction of a low to moderate-severity fire on its own 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 on its own may prove sufficient).
- The use of fire in inappropriate conditions may promote lantana or scorch 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 (or at least reduce lantana back to root stock).

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 re-sprouting.	**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 for successful control is repetitive fire.

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

- Apply successive fires frequently (within three years of each other) until the observations indicate that the issue is under control. Then, re-instate the recommended fire regime for the fire vegetation group and continue to monitor the issue over time.
- Where lantana exists as a scattered understorey plant, it may be sufficient to apply the standard recommended fire frequency for the fire vegetation group in which it occurs. In any case, increasing the fire frequency for a while will assist control. Monitor the situation.

Mosaic (area burnt within an individual planned burn)

- Burn 90 per cent of the area where lantana has become a dense infestation.
- Within the fire vegetation group, increase the 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 using this method adjacent to fire-sensitive vegetation and along creek lines.

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 are possible including burning early in the year with good moisture, or alternatively, progressive burning to secure a late season burn under dry conditions. The treatment of lantana by fire has been very successful when implemented in the wet season with high relative humidity and temperatures, impending rain and good soil moisture.

FFDI: < 12 and occasionally up to 18 for higher severity fires

DI (KBDI): 80–120

Wind speed: Variable depending on objective and density of lantana infestation (denser infestation may require some fanning by wind so that the fire will carry).

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). Also, 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.

- **Line or strip ignition** can be 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). This tactic 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 the presence of sufficient surface fuels) will ensure 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 an effective control method (particularly useful along rainforest margins). Alternatively, it is possible to knock down the lantana 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.
- **Aerial incendiary using a 'heli-torch.** In moist shaded areas such as creek lines applying fire using a heli-torch may help control lantana. This involves aerial incendiary using gelled gasoline to ignite the lantana directly or to strip light where a higher intensity fire is required. The surrounding vegetation needs to be moist to wet, in order to ensure the fire doesn't spread and to provide optimum conditions to promote native grass recruitment.
- **Progressive burning** has been used to good effect in the wet tropics where lantana is present as a dense infestation. Implementing low-severity, early season burns (April onwards) to create a safe perimeter around the lantana infestation, followed by a burn in November–December of a **moderate** to **high** intensity can effectively target the lantana infestation.

Issue 7: Manage rubber vine

Rubber vine *Cryptostegia grandiflora* is most common in the northern extent of the Brigalow Belt. Rubber vine has the ability to smother trees and shrubs and shade-out grasses and marine forbs, often forming impenetrable thickets. It is found initially in riparian areas and once established in these areas it can aggressively spread into surrounding communities. It has also been found in higher areas and in isolated pockets where seeds have been dispersed by wind, water and birds.

Fire is known to be an effective control method to treat rubber vine both alone and in combination with other treatments such as herbicide application.

Awareness of the environment

Key indicators of where rubber vine can be managed with fire:

- Rubber vine can be managed with fire where it occurs in non fire-sensitive vegetation or where the fire extent can be limited.
- Where grass or forbland fuels are still continuous despite the occurrence of rubber vine.
- When grass fuel crumbles in the hand (an indicator that the grass is sufficiently cured), fire will be able to carry.
- Controlling rubber vine with fire when it is affected by rust or when the latex appears grey will often result in a better kill.

Fire killed rubber vine. Fire can be a useful technique to kill rubber vine in inaccessible or remote locations.

Barry Nolan, QPWS, Cape Upstart (2009).

Key indicators of rubber vine in situations where care should be taken in using fire or fire alone would be insufficient:

- Where rubber vine occurs in areas of insufficient fuel to sustain fire.
- Where rubber vine occurs in fire-sensitive vegetation or where fire is not desired.

Rubber vine smothering native trees. Fire has been applied to kill rubber vine in the foreground but due to low fuel, has not reached some plants.

Above: Rubber vine flower, Col Dollery.

Barry Nolan, QPWS, Cape Upstart National Park (2008).

Rubber vine beside a spring. Fire might be a useful tool near watercourses in which herbicide use poses an environmental risk.
John Clarkson, QPWS, Undara (2009).

Emergent seedlings. If fire were to trickle between the boulders the low fuel load may provide insufficient residence time to cause the sap to boil and kill the plants.
Kerensa McCallie, QPWS, Gloucester Island (2005).

Rubber vine on beach dunes. Fire should not be applied where rubber vine occurs in fire-sensitive vegetation such as beach scrubs unless the impact of fire is limited or other control options are not available.
Kerensa McCallie, QPWS, Gloucester Island (2005).

Discussion

- A single fire can often be useful to reduce or eliminate rubber vine seeds, seedlings and plants where sufficient fuel is available and also to promote native grass recruitment. A follow-up fire may then be required to treat any remaining seedlings or plants. Plants should be scorched to the tip or all leaves completely browned.
- More mature plants require increased residence time to allow the sap to boil, which will kill the plant. Simply scorching mature rubber vine is not sufficient to kill them.
- Insufficient residence time or fire severity will not kill mature rubber vine plants. They are able to re-grow from undamaged material at the base of the plant. In some circumstances, such as rubber vine growing in harsh conditions such as sand, an enlarged root system may develop allowing greater capacity to recover after fire.
- In areas where rubber vine has shaded-out native grasses, mechanical or chemical control may be necessary. A combination of fire and chemical control could also be useful where grasses abut an infestation. A running fire into the rubber vine may reduce the area requiring chemical treatment or increase accessibility.
- Care should be taken using fire where fire-adapted communities adjoin fire-sensitive communities such as rainforest. Accumulated dead plant material or high-severity fire could draw fire in to these communities.
- Be aware of weed hygiene issues when planning burns in areas with rubber vine. Fire vehicles and machinery can aid seed spread along firelines and should be washed down after exposure.
- A heli-torch can be used to control rubber vine in fire-sensitive communities, inaccessible areas or where chemical use is not viable. The flammable petroleum-based gel is applied directly to the plant then ignited. The success of this method is generally reliant upon the moisture content of the rubber vine (which needs to be high to effectively cause the sap to boil and kill the plant). In some areas this method has been very successful; however mixed results have been reported in other areas. See tactics below.

A sequence of images showing the successful control of rubber vine with fire. The above image was taken in December 2004. A moderate-severity fire was used to scorch smaller plants to their tips and brown the leaves of the taller plants. Taken in October 2005, the image below shows the high mortality of young rubber vine plants and the significant reduction of climbing adult plants. The fire has also promoted a good cover of native grasses.

Paul Williams, Vegetation Management Science Pty Ltd, St Helliers (2004 and 2005).

Paul Williams, Vegetation Management Science Pty Ltd, St Helliers (2004 and 2005).

Rubber vine control by 'heli-torch'. One technique used with success in areas where fire is not desired is aerial ignition using flammable gel. The gel produces fires of limited extent in the right conditions.

Barry Nolan, QPWS, Cape Upstart (2008).

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 the following for the site:

Measurable objectives	How to be assessed	How to be reported (in fire report)
> 90 % reduction in number of rubber vine seedlings, saplings and young plants or mature plants.	**Before and after the burn** (after suitable germination/ establishment conditions, or a growing season): In three locations (that take account of the variability of landform and weed density within burn area), one year after fire estimate what percentage of saplings have been killed. **Or** If using the 'heli-torch' method, retrace the flight path in three locations and estimate the percentage of mature rubber vine plants killed.	**Achieved:** > 90 % understorey saplings killed*. **Partially Achieved:** 75–90 % understorey saplings killed*. **Not Achieved:** < 75 % understorey saplings killed*. *Killed for the purposes of this guide relates to the death of the above ground component of the sapling (rather than the lignotuber). *If there are a high percentage of saplings re-sprouting, follow up planned burns may be required. *It is not necessarily a good outcome if you have killed most of the overabundant saplings, and yet the fire was too severe.

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 residence time. Slow-moving fire or fire applied at a high-intensity (sufficiently enough to boil the sap of the plants) is required to kill mature rubber vine.
- A second fire may be required where mature plants have re-sprouted or seedlings emerged from the seed bank.

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

- Apply a follow-up burn in the following year if the observations indicate that the issue is not under control. In some cases a third fire may be required to completely remove the infestation. Once resolved, re-instate the recommended fire regime for the fire vegetation group. Continue Monitoring the issue over time.
- Where rubber vine occurs in fuel loads sufficient to ignite the area surrounding, applying the standard recommended fire frequency for the fire vegetation group in which it occurs may be sufficient. In any case, increasing fire frequency for a while will assist control. Monitor the situation.

Mosaic (area burnt within an individual planned burn)

- Burn 90 per cent of the area where rubber vine has become a dense infestation; or
- Within the fire vegetation group, increase the coverage of fire to 50–70 per cent where rubber vine 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 rubber vine occurs.
- For a dense infestation, a **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.
- Use a **high**-severity fire applied using a ‘heli-torch’ to scorch the plant top visible from the air for a sufficient length of time so that the sap is boiled.

Post a moderate-severity fire to control rubber vine. The fire has scorched most of the young plants and adult trees that had begun to smother trees.

Paul Williams, Vegetation Management Science Pty Ltd, St Helliers (2004).

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.

FFDI: < 12 and sometimes 18 for higher severity fires.
DI (KBDI): 80–120.

Season: Different approaches are possible and include burning early in the year with good moisture or progressive burning to secure a late season burn under dry conditions. In some areas the treatment of rubber vine by fire has been very successful when implemented with storm burning under conditions of high relative humidity and temperatures, impending rain and good soil moisture.

Wind speed: Beaufort scale 1–4, < 23 km/hr. Wind speed is variable and depends on the objectives and density of rubber vine infestation (denser infestation may require some wind so that the fire will carry).

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). Also, 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.

- **Line or strip ignition** is 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. This tactic may be required where the rubber vine infestation is of such a density that spot ignition will not be sufficient or only minimal surface fuels are available (e.g. grasses).
- **A low to moderate-severity backing fire.** Where rubber vine 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. This has proven to be successful in killing seeds, seedlings, young and some mature rubber vine plants.
- **Subdividing rubber vine 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.** In areas where dense rubber vine shades out grasses limiting fuel available for fire, initial herbicide treatment could be used. Care should be taken when applying fire to dead rubber vine plants which remain hanging in the canopy as they may act as elevated fuels. The biological control agent rubber vine rust, rarely kills mature plants on its own. However it may defoliate the rubber vine allowing fuel loads to increase such that fire can be applied.
- **Aerial incendiary using a 'heli-torch'.** In areas where rubber vine has invaded communities where fire is either not required or desired such as those which are fire sensitive, applying fire using a heli-torch may help control the issue. This involves aerial incendiary using gelled gasoline to ignite the rubber vine directly. The surrounding vegetation needs to be moist to wet to ensure the fire doesn't spread.

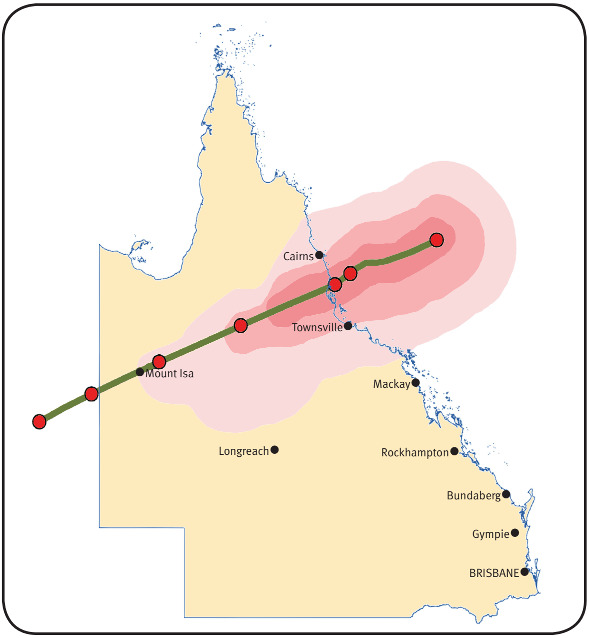
Issue 8: Post cyclone planned burning

In the event of a severe tropical cyclone (category three or higher) the canopy of trees and shrubs may be stripped, accumulating upon 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 further increasing elevated fuels. A high level of fallen tree damage can also be expected, increasing heavy-fuel loads and impeding fireline 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).

Strewn fuel and trees fallen across fire lines is one of the many issues to consider when planning fires after cyclones.

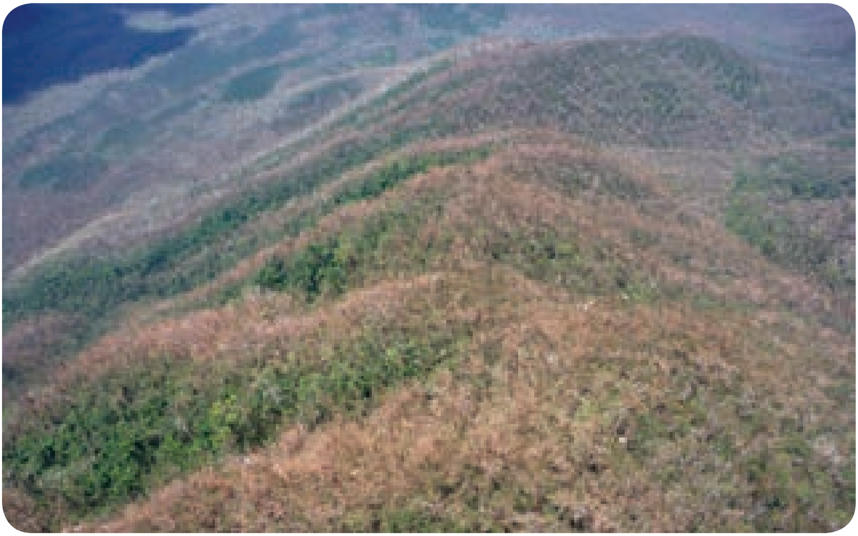
Audrey Reilly, QPWS, Cyclone Yasi, Murray Falls (2011).

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).

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 an 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 completely 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, are of low-severity, are easy to control and allow disorientated and distressed fauna to find refuge areas. These fires are also less likely to stress the canopy. Another effective time to utilise moist conditions is the following storm season.
- On islands where ignition sources can be reliably controlled, consider avoiding fires altogether, particularly where fires are likely to lead to canopy scorch.
- 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 firelines, 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.

- After a category four cyclone in fire-adapted communities that have been transitioning to closed forest, it becomes easier to re-introduce fire because the community has been opened due to wind damage. Be aware of the opportunity to re-introduce fire especially for ecosystems where few examples remain in an open state. This might be one of the few opportunities to recover transitioning ecosystems.
- After at least a category four 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. 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.
- If there is a dry period immediately after a cyclone (within a few weeks), prior to canopy and vines closing over, rainforests may become vulnerable to fire. If this occurs, consider actions (e.g. fire bans and park closures) that would limit ignition sources until the risk passes.
- During the October–November period in the two years after a cyclone, rainforest edges are vulnerable to upslope runs of fire. Lantana, high biomass grass invasion and multiple severe cyclone events (causing an increasingly open canopy) increases risk of encroachment.
- Be aware of how the three dimensional structure of fuel influences fire behaviour. To estimate fuel hazard (recommended for use in open forests and woodlands) use the Overall Fuel Hazard Assessment Guide (Hines et al. 2010b). The digital version can be sourced online from the Victorian Department of Sustainability and Environment <www.dse.vic.gov.au>. Fuel hazard is 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).
- 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 shrub and vine forest 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.

What is the priority for this issue?

Priority	Priority assessment
Highest	Fuel management through the implementation of planned burns to protect life, property, and conservation values.
Very high	Simplifying the vegetation structure and maintaining relatively low fuels is an important issue for proactive wildfire management and limiting the potential impact and spread of wildfires. Conservation burn in areas where applying fire or limiting encroachment of fire is critical to conserve remaining examples of an ecosystem.

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 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 m or more through planned burn area estimating the percentage of canopy scorched within visual field.	**Achieved:** No canopy scorch. **Partially Achieved:** One to 20 % of canopy scorched. **Not Achieved:** Greater > 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 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** 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 mosaic 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 m or more through planned burn area estimating the percentage of ground burnt within visual field. 3. Walk into one or more gully heads, and down one or more ridges and estimate the percentage of ground burnt within visual field.	**Achieved:** Mosaic > 70 %. **Partially Achieved:** Mosaic 50–70 %, the extent and rate of spread of any subsequent wildfire would still be limited. **Not Achieved:** Mosaic < 50 %. High proportion of 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.

Fire parameters

What fire characteristics will help address this issue?

Fire severity

- **Low** and occasionally **moderate**. Slow-moving trickling fires are preferred. Be aware that in the two years after a cyclone, burning during dryer months may create a higher than anticipated fire severity.

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

- After a cyclone, it may be imperative to reduce fine fuels to reduce risk.

Mosaic (area burnt within an individual planned burn)

- Burn 70 per cent of the area 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 the higher fuel loads—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** until **autumn**. Also, storm burns during **December** until **January**

FFDI: < 11

Relative humidity: > 60 per cent humidity will create conditions where fire will trickle. This helps create a low-severity fire with sufficient residence time to consume fuel.

Wind speed: < 15 km/hr (higher for storm burning)

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). Also, 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.

- **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. Fauna that has been disorientated or distressed post cyclone will find this sort of fire easier to take refuge from.
- **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-intensity fire. The spacing of the spots will regularly vary throughout the burn due to changes in weather conditions, topography and 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-intensity backing fire that travels down slope towards the non-target community. If conditions are unsuitable (e.g. the non-target community has been damaged by a cyclone and is upslope) use appropriate lighting patterns combined with active suppression 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 1, for fire management guidelines).
- **Use strip ignition to draw** fire away from the non-target community's edge. Using more than one line of ignition can create convective updrafts which draws 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.
- **Wet lines, blower lines (to clear strewn material) and/or rake-hoe lines** may have to be established along the edge of non-target communities. It is time consuming to establish wet lines, blower lines or rake-hoe lines especially where the boundary between ecosystems 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.

Issue 9: Manage severe storm or flood disturbance

In the event of a severe storm, the canopy of trees and shrubs may be stripped, with the debris accumulating on the ground or left suspended. Snapped limbs can be left hanging in the canopy increasing elevated fuels, and high numbers of fallen trees can greatly increase fuel loads and impede fireline access.

Major flood events can have a significant impact on riparian communities, by removing ground and mid-stratum vegetation and in some cases canopy trees. Invasion of exotic grasses and other weeds may often follow, increasing fuel loads and creating a fire-prone community which can inhibit the recovery of riparian vegetation.

Changed fuel conditions from severe storm or flood disturbance may lead to:

- the potential for high-severity wildfires
- an increased fuel hazard close to assets and infrastructure
- altered fire behaviour during planned burning operations in the months and years following a severe storm or flood event
- fire-sensitive communities (e.g. riparian) becoming vulnerable to fire encroachment during drought periods
- an opportunity to re-introduce fire into areas with overabundant saplings at an advanced stage.

An initial assessment and review of strategic fire control lines and the fire management zoning plan will usually be required. Possible strategies to manage changed fuel conditions include strategic planned burning with high soil moisture (and avoiding dry conditions), encouraging neighbouring landholders to mechanically reduce fuel, avoiding ignition sources during risk periods and reviewing scheduled planned burns to make use of moister seasonal conditions.

Severe storm events can dramatically alter forest structure. Reassessment of zoning plans may be required in response to greatly increased fuel loads.

Peter Cavendish, QPWS, D'Aguilar National Park (2008).

Riparian vegetation has been completely removed during a severe flood event and replaced by flammable exotic grasses. Although previously used as a strategic fireline, flood impacts have instead created a potential fire corridor.

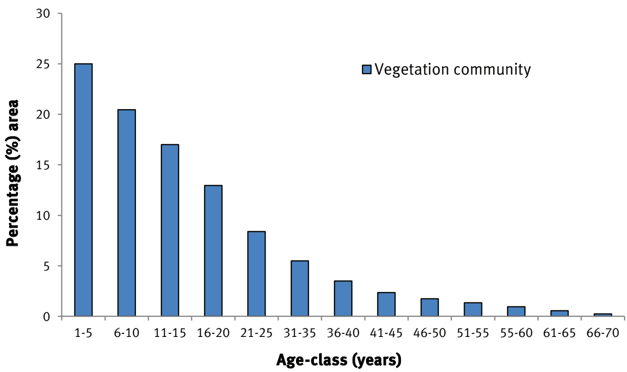
Dave Kington, QPWS, Lockyer National Park (2011).

Flood events can create concentrated areas of high fuel hazard. Large deposits of debris adjacent to or within fire-sensitive communities can increase the risk of fire encroachment.

Dave Kington, QPWS, Lockyer National Park (2011).

Glossary of fire terminology

(**Primary source:** Australasian Fire Authorities Council 2012).

Terminology	Definition
Aerial ignition	The lighting of fine fuels for planned burning by dropping incendiary devices or materials from aircraft.
Available fuel	The portion of the total fuel that would actually burn under current or specified conditions.
Age-class distribution	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)** 
Burn severity	Relates to the amount of time necessary to return to pre-fire levels of biomass or ecological function.
Backing-fire	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.

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.

Terminology	Definition
Clarification over the terms **'fire vegetation group'** and **'fire management zone'.**	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.

Fire management zone	Fire management sub-zone or Fire vegetation group
Conservation	FVG1
	FVG2
Protection	P1
	P2
Wildfire mitigation, etc	W1
	W2

Terminology	Definition
Fire perimeter	The outer containment boundary in which fire is being applied.
Fire regime	The recommended use of fire for a particular vegetation type or area including the frequency, intensity, extent, severity, type and season of burning.
Fire regime group (FRG)	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.

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

Australasian Fire Authorities Council (AFAC) 2012, *Glossary of rural fire terminology, Australasian Fire Authorities Council*, Canberra.

Bailey A (ed.), 1984, *The Brigalow Belt of Australia*, Royal Society of Queensland, Brisbane, Queensland.

Bowman DM 2000, *Australian rainforests. Islands of green in a land of fire,* Cambridge University Press, Cambridge.

Butler DW 2007, Recovery plan for the *"Brigalow (Acacia harpophylla dominant and co-dominant" endangered ecological community (draft of 1 May 2007),* Department of the Environment and Water Resources, Canberra.

Butler DW and Fairfax RJ 2003, 'Buffel grass and fire in a gidgee and brigalow woodland: a case study from central Queensland', *Ecological Management and Restoration*, vol. 4, pp. 120–125.

Chamberlin J 2003, *Transcript from NRM workshop*, Nairana National Park.

Christensen P, Recher H and Hoare 1981, 'Response of open forests (dry sclerophyll forests) to fire regimes', pp. 367–93, in AM Gill, RH Groves and IR Noble (eds.), *Fire and the Australian Biota*, Australian Academy of Science, Canberra.

Corporative Research Centre (CRC) for Australian Weed Management 2007, *Weed management guide – Coolatai grass (Hyparrhenia hirta)*, Australian Government, Canberra.

Commonwealth of Australia 1999, *Environment Protection and Biodiversity Conservation Act 1999,* Sustainability, Environment, Water, Population and Communities, Attorney-General's Department, Canberra.

Crowley G 2003, *Brigalow belt north recommendations for ecological fire management based regional ecosystems* - draft for comment, Queensland Parks and Wildlife, Queensland Government, Brisbane, unpublished works.

Department of Employment, Economic Development and Innovation (DEEDI) 2011, *Rubber vine (Cryptostegia grandiflora) fact sheet,* Queensland Government, Brisbane.

Department of Environment and Resource Management (DERM) 2002, *Draft-Currawinya National Park fire strategy'*, Queensland Government, 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.

Eyre TJ, Wang J, Venz MF, Chilcott C and Whish G 2009, 'Buffel grass in Queensland's semi-arid woodlands: response to local and landscape scale variables, and relationship with grass, forb and reptile species', *The Rangeland Journal,* vol. 31, pp. 293–305.

Greig C 2008, 'Lion's tail control at Boodjamulla National Park', *Proceedings of the 16th Australian Weed Conference*, Queensland Weeds Society, Brisbane, pp. 491–3.

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.

Hodgkinson K 2002, 'Fire regimes in Acacia wooded landscapes: effects on functional processes and biological diversity', pp. 351–372, in RA Bradstock, JE Williams and AM Gill (eds.), *Flammable Australia: the fire regimes and biodiversity of a continent,* Cambridge University Press, Cambridge.

Keith DA, McCaw WL and Whelan RJ 2001, 'Fire regimes in Australian heathlands and their effects on plants and animals', pp. 199–237, in RA Bradstock, JE Williams and AM Gill (eds.), *Flammable Australia: the fire regimes and biodiversity of a continent,* Cambridge University Press, Cambridge.

Lucas C 2010, 'On developing a historical fire weather data-set for Australia', *Australian Meteorological and Oceanographic Journal,* vol. 60, pp. 1–14.

Lynn J 2009, *Cape Upstart National Park fire strategy,* Queensland Parks and Wildlife Service, Queensland Government, Brisbane, unpublished work.

Lundie-Jenkins G and Payne A 2000, *Recovery plan for the bull oak jewel butterfly (Hypochysops piceatus) 1999–2003*, Queensland Parks and Wildlife Service, Brisbane.

McDonald WJF 1996, 'Spatial and temporal patterns in the dry seasonal subtropical rainforests of eastern Australia, with particular reference to the vine thickets of central and southern Queensland', PhD thesis, University of New England.

Melzer R and Porter G 2002, *Guidelines for the management of buffel grass on conservation reserves*, Queensland Parks and Wildlife Service, Brisbane, unpublished work.

Myers B, Allan G, Bradstock R, Dias L, Duff G, Jacklyn P, Landsberg J, Morrison J, Russell-Smith J and Williams R 2004, *Fire management in the rangelands*, Tropical Savannas CRC, Darwin.

Orr DM 1975, 'A review of Astrebla (Mitchell grass) pastures in Australia', *Tropical Grasslands*, vol. 9, no.1, pp. 21–36.

Parks Victoria 1995, *Parks Victoria pest plant mapping and monitoring protocol*, Parks Victoria.

Price O and Bowman DM 1994, 'Fire-stick forestry: a matrix model in support of skilful fire management of *Callitris intratropica* by north Australian Aborigines', Journal of Biogeography, vol. 21, pp. 573–580.

Price O, Russell-Smith J and Edwards A 2003, 'Fine-scale patchiness of different fire intensities in sandstone heath vegetation in northern Australia', *International Journal of Wildland Fire,* vol. 12, pp. 227–236.

Queensland Government 2004, *Aboriginal Cultural Heritage Act 2003*, Queensland Government, Brisbane.

Queensland Government 1992, *Queensland Nature Conservation Act 1992*, 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.

Queensland Murray Darling Committee (QMDC) 2006, 'Spinifex grasslands fact sheet', viewed 3 June 2011.
<www.qmdc.org.au/publications/browse/11/flora-fauna>.

Queensland Parks and Wildlife Service (QPWS) nd., 'Natural grassland in the central highlands an endangered community', viewed 3 June 2011,
<www.derm.qld.gov.au/register/p00844aa.pdf>.

Queensland Parks and Wildlife Service (QPWS) 2007, 'Conservation management profile semi-evergreen vine thicket regional ecosystems in the Brigalow Belt bioregion - an overview', viewed 6 June 2011,
<www.derm.qld.gov.au/register/p02186aa.pdf>.

Sattler P and Williams R (eds.) 1999, *The conservation status of Queensland's bioregional ecosystems,* Environmental Protection Agency, Queensland.

Taylor D and Swift S 2003, *Prescribed burning guidelines and post burning assessment,* Department of Primary Industry and Forestry, Queensland Government, Brisbane, unpublished work.

The Encyclopedia of Earth (EoE) 2007, Brigalow tropical savanna, viewed 13 June 2011, <www.eoearth.org/article/Brigalow_tropical_savanna>.

Williams PR, Congdon RA, Grice AC and Clarke PJ 2003, 'Effect of fire regime on plant abundance in a tropical eucalypt savanna of north-eastern Australia', Ecological Society of Australia, vol. 28, pp. 327–338.

Williams P, Collins E and Mason D 2006, 'Variation in the age at first flowering for seedlings of 15 fire-killed shrubs and trees on sandstone outcrops and sand plains in central and north-western Queensland', *Ecological Management and Restoration,* vol. 7, no. 1, pp. 1–3.

Williams P 2008, 'Weedy fire regimes: incorporating weed issues into fire programs', *Proceedings of the 16th Australian Weed Conference,* Queensland Weeds Society, Brisbane, pp. 454–56.

Williams P, Collins E, Greig C, Devlin T and McLachlan G 2008, *Fire management of lancewood (Acacia shirleyi) forests - seedling survival, growth rates and seed reserves,* internal report, Queensland Parks and Wildlife Service.

Williams P 2009, *Extended notes for Brigalow Belt north regime guidelines,* unpublished work.

Williams P and Collett A 2009, 'Control of the exotic para grass allows the expansion of the rare native wetland grass *Paspalidium udum* in a north Queensland wetland, vol. 1, no 3, pp. 60–61, *Ecological Management and Restoration,* Ecological Society of Australia.

Williams P and Tran C 2009, *Evaluating fire management in sandstone landscapes on Queensland parks*, internal report, Queensland Parks and Wildlife Service, Brisbane.

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.

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 the Brigalow Belt bioregion	Percentage
Eucalypt forest and woodland	9 394 566	26
Grasslands	516 922	1
Heath and shrublands	43 999	0
Melaleuca communities	80 936	0
Wetlands and swamps	44 917	0
Cypress pine and bull oak communities	1 435 480	4
Acacia dominated communities	1 647 279	5
Brigalow communities	1 019 659	3
Riparian, springs, fringing and dune communities	473 840	1
Rainforest and vine thicket	313 984	1
Mangroves and saltpans	206 136	1
Non-remnant and other land	21 166 016	58
Other bioregions	161 659	0
Plantations	596	0
Sand, water and other	88 871	0
TOTAL	**36 594 860**	**100**

Chapter	Issues	Fire vegetation group	Fire regime group	Map label (if required)	**Regional ecosystems** (Sattler and Williams 1999; Queensland Herbarium 2011a; 2011b).
1	1	Eucalypt forest and woodland	Eucalypt forest and woodland-grassy		11.10.1, 11.10.1a, 11.10.1d, 11.11.10, 11.11.10a, 11.11.11, 11.11.20, 11.11.9, 11.12.1b, 11.12.2, 11.12.2a, 11.12.2b, 11.12.2c, 11.2.1, 11.3.10, 11.3.13, 11.3.2, 11.3.29, 11.3.2a, 11.3.30, 11.3.30a, 11.3.30d, 11.3.35, 11.3.35a, 11.3.7, 11.3.9, 11.3.9a, 11.4.13, 11.4.2, 11.5.5, 11.5.5a, 11.5.5c, 11.5.8c, 11.7.3, 11.8.14, 11.8.15, 11.8.4, 11.8.4a, 11.9.2, 11.9.9, 11.9.9a.
	2		Eucalypt forest and woodland-shrubby		11.10.11, 11.10.11a, 11.10.12, 11.10.13, 11.10.13a, 11.10.13b, 11.10.7, 11.10.7a, 11.11.12, 11.11.15, 11.11.15a, 11.11.15b, 11.11.15c, 11.11.15d, 11.11.3, 11.11.3c, 11.11.4, 11.11.4a, 11.11.4b, 11.11.4c, 11.11.4d, 11.11.6, 11.11.7, 11.11.7a, 11.11.7x1, 11.11.8, 11.12.1, 11.12.10, 11.12.13, 11.12.13a, 11.12.13b, 11.12.17, 11.12.19, 11.12.1a, 11.12.20, 11.12.3, 11.12.5, 11.12.5a, 11.12.6, 11.12.6a, 11.12.6b, 11.12.8, 11.12.8a, 11.12.8b, 11.12.9, 11.12.9a, 11.3.29a, 11.4.12, 11.5.12, 11.5.12a, 11.5.2, 11.5.20, 11.5.21, 11.5.3, 11.5.8a, 11.5.8b, 11.5.9, 11.5.9a, 11.5.9b, 11.5.9c, 11.5.9d, 11.7.4, 11.7.4c, 11.7.6, 11.7.7, 11.8.2, 11.8.2a, 11.8.5, 11.8.8, 11.9.7, 11.9.7a.
	3		Eucalypt forest and woodland-tall		11.10.2, 11.10.2a, 11.10.5, 11.5.7, 11.8.1.

Chapter	Issues	Fire vegetation group	Fire regime group	Map label (if required)	**Regional ecosystems** (Sattler and Williams 1999; Queensland Herbarium 2011a; 2011b).
	1		Eucalypt forest and woodland-alluvial plains		11.3.23, 11.3.26, 11.3.28, 11.3.3, 11.3.36, 11.3.37, 11.3.38, 11.3.39, 11.3.3b, 11.3.3c, 11.3.4, 11.3.6, 11.3.3x1.
2	1	**Grasslands**	Tussock grasslands		11.11.17, 11.12.16d, 11.12.16x1, 11.12.1c, 11.3.20, 11.3.21, 11.3.24, 11.3.31, 11.4.11, 11.4.4, 11.8.11, 11.8.10, 11.9.12, 11.9.3, 11.9.3a.
	2		Spinifex grasslands		11.5.6, 11.5.14.
3	1	**Heath and shrublands**	Heath and shrublands		11.12.14, 11.12.18, 11.12.18a, 11.3.33, 11.5.10, 11.5.18, 11.7.5, 11.7.5a, 11.8.12, 11.8.7.

Chapter	Issues	Fire vegetation group	Fire regime group	Map label (if required)	**Regional ecosystems** (Sattler and Williams 1999; Queensland Herbarium 2011a; 2011b).
4	1	**Melaleuca communities**	Melaleuca communities		11.12.11, 11.2.5, 11.2.5a, 11.2.5b, 11.3.12, 11.3.12a, 11.3.38a, 11.5.8, 11.8.11a.
5	1	**Wetlands and swamps**	Wetlands and swamps		11.2.4, 11.3.24a, 11.3.27, 11.3.27a, 11.3.27b, 11.3.27c, 11.3.27d, 11.3.27e, 11.3.27f, 11.3.27g, 11.3.27h, 11.3.27i, 11.3.27x1a, 11.3.27x1b, 11.3.27x1c, 11.3.2b, 11.5.17, 11.5.3b.
6	1	**Cypress pine and bull oak communities**	Cypress pine and bull oak communities		11.10.6, 11.10.9, 11.12.15, 11.3.14, 11.3.18, 11.3.19, 11.3.32, 11.5.1, 11.5.14a, 11.5.2a, 11.5.4, 11.5.4a, 11.5.5b, 11.8.9, 11.9.13.
7	1	**Acacia dominated communities**	Acacia dominated communities		11.10.3, 11.10.4, 11.10.4a, 11.10.4b, 11.10.4c, 11.10.4d, 11.11.1, 11.11.2, 11.12.16, 11.12.16a, 11.3.34, 11.4.12a, 11.5.11, 11.5.13, 11.5.1a, 11.7.2, 11.8.5a.
8	1	**Brigalow communities**	Brigalow communities		11.11.13, 11.11.14, 11.11.16, 11.11.19, 11.12.21, 11.3.1, 11.3.1a, 11.3.16, 11.3.17, 11.3.1b, 11.3.1d, 11.3.5, 11.3.8, 11.4.10, 11.4.3, 11.4.3a, 11.4.3b, 11.4.5, 11.4.6, 11.4.7, 11.4.8, 11.4.9, 11.4.9a, 11.4.9b, 11.5.16, 11.7.1, 11.9.1, 11.9.10, 11.9.11, 11.9.5, 11.9.5a, 11.9.6.

Chapter	Issues	Fire vegetation group	Fire regime group	Map label (if required)	**Regional ecosystems** (Sattler and Williams 1999; Queensland Herbarium 2011a; 2011b).
9	1	**Riparian, springs, fringing and dune communities**	Riparian, springs, fringing and dune communities		11.10.14, 11.2.2, 11.2.2a, 11.2.2b, 11.2.3, 11.3.15, 11.3.15a, 11.3.22, 11.3.25, 11.3.25a, 11.3.25b, 11.3.25c, 11.3.25d, 11.3.25e, 11.3.25f, 11.3.25g, 11.3.3a, 11.3.4a.
10	1	**Rainforest and vine thicket**	Rainforest and vine thicket		11.10.8, 11.11.18, 11.11.21, 11.11.5, 11.12.12, 11.12.4, 11.12.4a, 11.12.7, 11.3.11, 11.3.11x1, 11.4.1, 11.5.15, 11.7.1x1, 11.8.13, 11.8.6, 11.9.14, 11.9.4, 11.9.4a, 11.9.4c, 11.9.8, 11.11.5a, 11.8.3.
11	1	**Mangroves and saltpans**	Saltpans		11.1.1, 11.1.2, 11.1.2a, 11.1.2b, 11.1.3, 11.1.3a.
	1		Mangroves		11.1.4, 11.1.4a, 11.1.4b, 11.1.4c, 11.1.4d.

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. 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 regional ecosystem 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	11.10.14, 11.10.2a, 11.12.11, 11.12.5a, 11.3.1a, 11.3.22, 11.3.24a, 11.3.3b, 11.5.11, 11.5.5b, 11.7.1x1, 11.8.10, 11.8.4a.

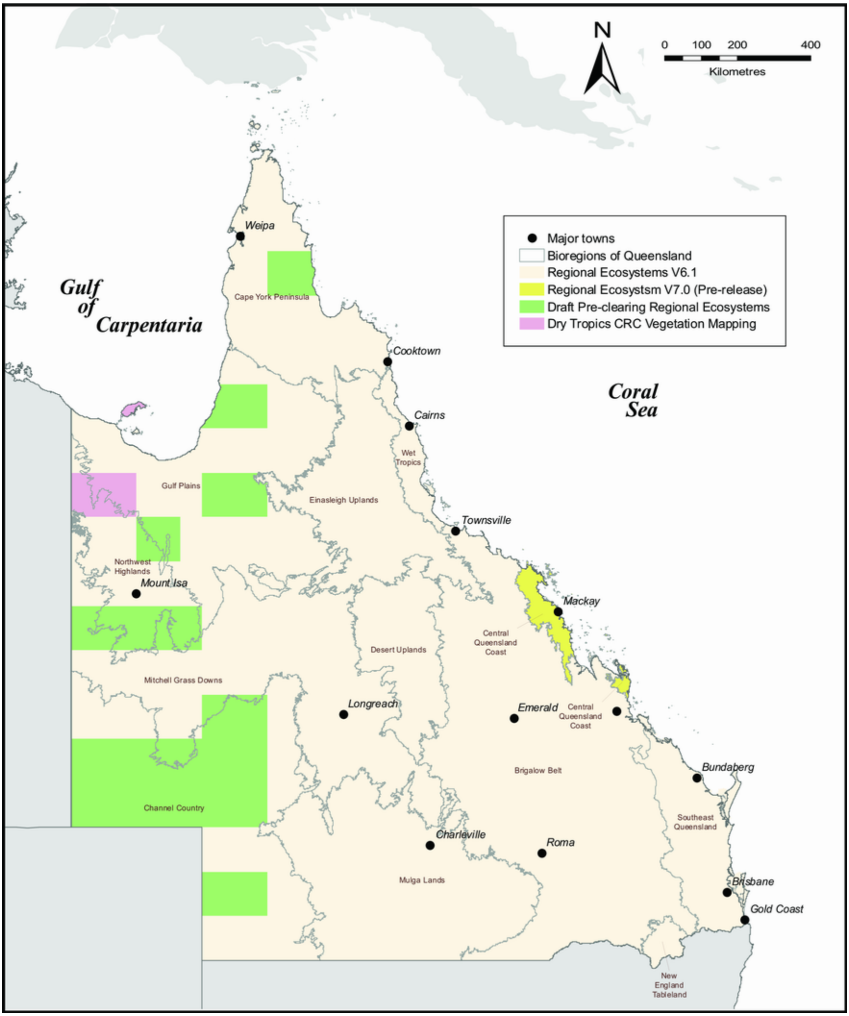


Figure 1: Map of Queensland indicating the different GIS data sources used to produce the spatial fire vegetation group mapping product.

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.

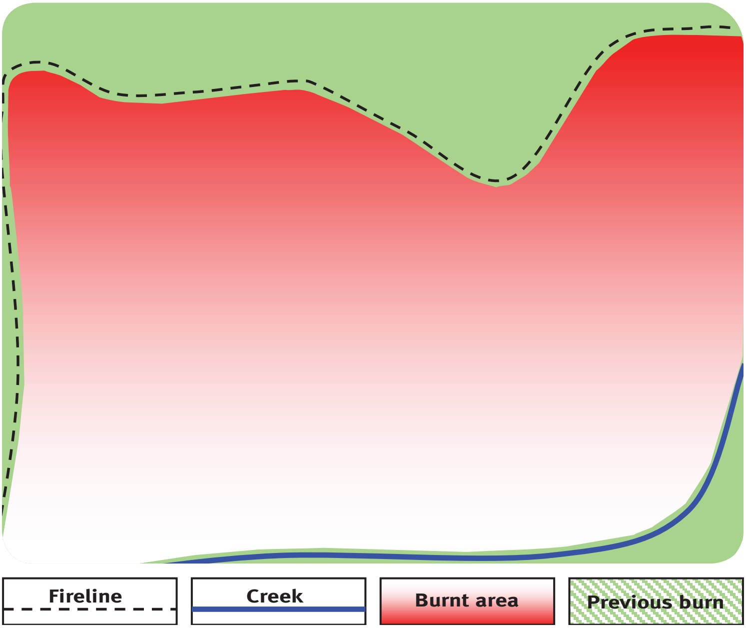


Figure 1: Example area between fireline and creek burnt in a wildfire—year 0. (Recommended fire interval for fire vegetation group is eight–12 years).

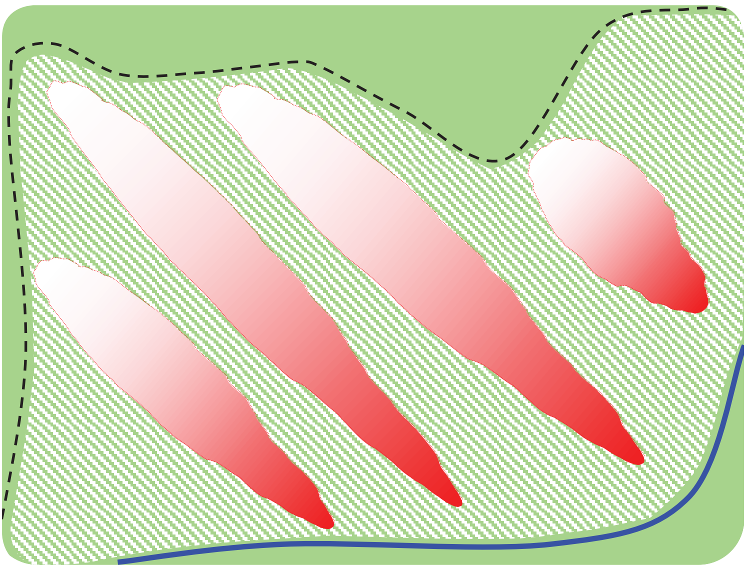


Figure 2: Planned mosaic burn—year 8.

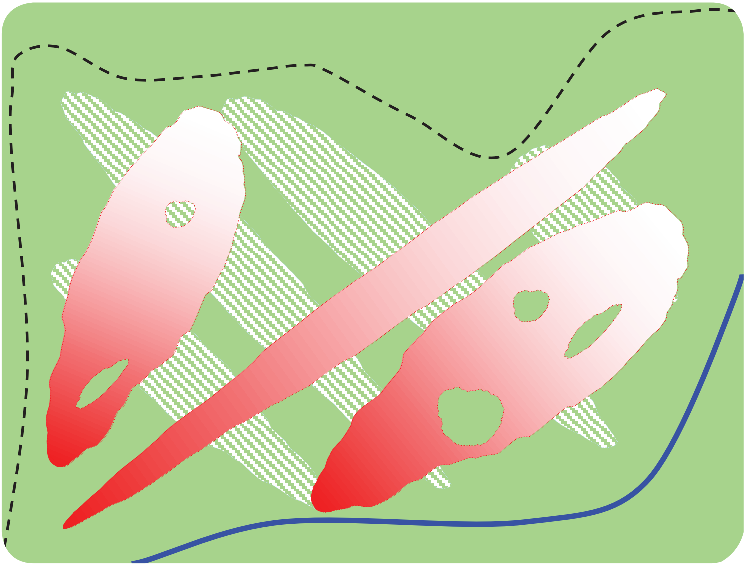


Figure 3: Planned mosaic burn—year 20.

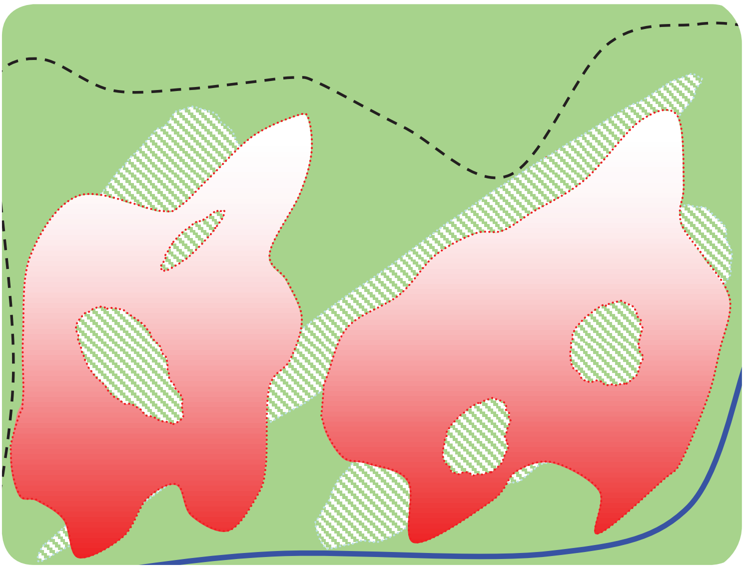


Figure 4: Planned mosaic burn—year 28.

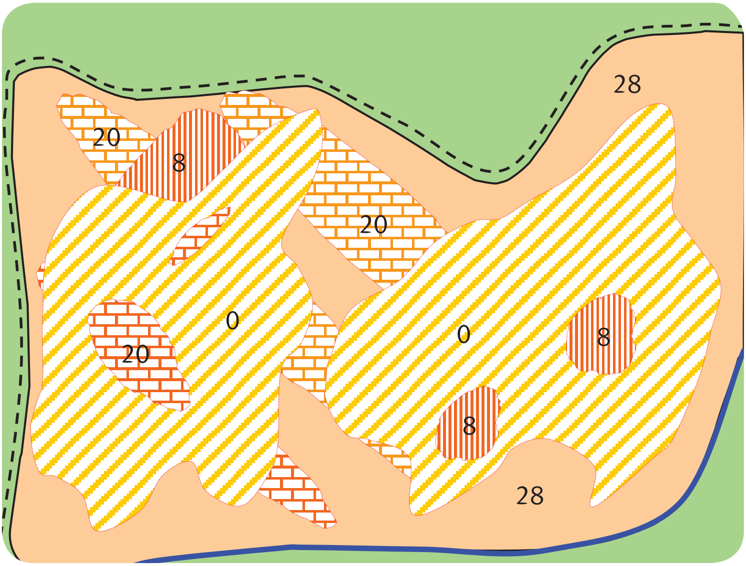


Figure 5: Fire history summary—year 28.
Wildfire and mosaic burn patterns overlaid (with years since last burnt).

Mosaic burn on Expedition National Park showing ~60 per cent coverage across the landscape.
Jono Handreck, QPWS, Expedition National Park (2011).

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