NATIONAL BURNING PROJECT

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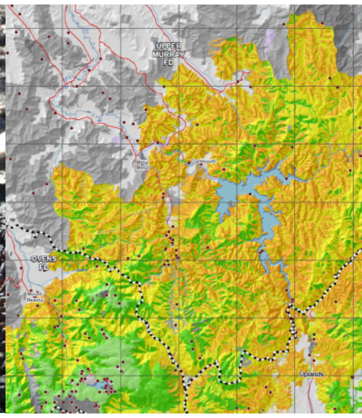

National Guidelines for Prescribed Burning Operations:

Case Study 4 – Multi-year landscape mosaic burning in forested mountain terrain using natural boundaries (Victoria)

National Burning Project: Sub-Project 4

An Australian Government Initiative

Australasian Fire and Emergency Service Authorities Council Limited (ABN 52 060 049 327)
Level 1, 340 Albert Street East Melbourne Victoria 3002

Telephone:	03 9419 2388	Facsimile:	03 9419 2389
Email:	afac@afac.com.au	Internet:	http://www.afac.com.au
Author:	AFAC Limited		

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This case study has been prepared by Paul de Mar (GHD) and Rob Caddell and Dan Jamieson of the Victorian Department of Environment, Land, Water and Planning (DELWP). It integrates knowledge and operational practice information from a range of sources including DELWP's Landscape Mosaic Burning Planning Guidelines (2009), and burn planning information for the Lake Dartmouth Landscape Mosaic Burn Unit. This case study will focus on the Lake Dartmouth Landscape Mosaic Burn Unit in order to illustrate broadscale, unbounded mosaic burning.

1 Context

DELWP has been pursuing a broadacre landscape mosaic burning (LMB) concept since about 2004, prompted in part by the land and fire management issues arising after the 2003 Alpine fires which burned more than 1.3 million hectares across the high country in north-east Victoria. It was foreseen at the time that a substantial risk had arisen that if further fires occurred within the 2003 burnt areas, before regenerating flora and fauna communities had attained reproductive maturity, then localised species losses could occur. This concern proved prescient as the 2006 the Great Divide fires also burnt more than 1 million hectares, including re-burning significant areas burnt in 2003. As a result, the need to pursue landscape mosaic burning strategies to break up fuel within large wildfire-burnt areas gained higher priority in order to reduce the potential for further large areas to be burnt twice at high intensity with an insufficient inter-fire interval.

The LMB concept developed at the time involved selection of relatively large areas, notionally in the order of 15,000 to 40,000 hectares, and progressively applying prescribed burns over a multi-year period, starting in fire-dependent communities (the communities most dependent on regular fire) and over time targeting more fire-influenced communities, with more fire-sensitive areas (those areas potentially damaged by regular fire) remaining as unburnt patches within the burn mosaic. The aim was to create a mosaic of burnt and unburnt patches across the LMB unit, to make the area more resilient to wildfire.

A range of policy and technical challenges were identified to making the concept work in practice, including:

- The first key challenge was of a policy nature. In Victoria at the time, the principle tool for deciding acceptable timeframes for reintroducing planned fire into burnt areas was the Tolerable Fire Interval[1] (TFI). Consideration of growth stage distributions was an emerging concept at the time. There was recognition that the over-representation of 2003 growth stages was a significant issue that needed to be addressed. The advice of ecologists, about how to address the issue, was to focus early burning on fire-dependent Ecological Vegetation Classes (EVCs). Convincing ecologists to support the reintroduction of fire into vegetation communities before the minimum TFI had been reached, and also keeping fire out of fire-sensitive areas without the use of traditional mineral earth containment lines, was a significant challenge. The 'too hard basket' alternative was to leave large areas of recovering fire-sensitive and vulnerable life-stage communities exposed to a higher likelihood and therefore higher risk of being burnt by uncontrolled high intensity fire under adverse fire weather conditions – potentially before reaching their minimum TFI;

- A second key challenge was technical. Many of the regenerating areas burnt by the 2003 fires had developed a near-continuous shrubby cover, a very high proportion of which was

[1] Minimum TFIs are by design inherently conservative, essentially representing the period required for the longest maturing flora species in a community to re-establish a viable seed bank.

live and green, with dead fine surface fuels near-absent. Key exceptions were in areas where wildfire intensity had been sufficiently low as to not consume or kill tree canopies, where lower canopy scorch resulted in significant litter fall, or where grass cover was significant. The technical challenge was to apply fire in such a way that it spread within the least fire-sensitive areas, with only limited incursion into more fire-sensitive areas, despite the presence of a near-continuous shrub layer; and

- Other technical challenges included:

    - Significant variation in altitude across the LMB Unit (ranging from 457 to 1362 metres) with dissected topography/aspect mosaics, and consequently substantial variability in fuel types and fuel moisture;

    - The choice not to use hard control lines;

    - The potentially fickle nature of weather in mountain environments; and

    - The lack of any validated, science-based fire behaviour models applicable for predicting low intensity, spot ignition point spread in shrubby post-fire regrowth fuels.

An additional issue existed in relation to other post-fire recovery programs. Unprecedented spending on ecological recovery was occurring in the 2003 fire area (pest management projects and post-fire threatened species re-introduction programs). Land managers where concerned planned burning prior to ecosystem recovery would impact on this work.

Despite these challenges, it was considered a high priority to explore ways to avoid a cycle of recurrent large-scale, high intensity fires by preventing widespread long-term fuel accumulation.

1.1 General issues, opportunities and constraints

A number of key issues, opportunities and constraints arise with multi-year landscape mosaic burning using natural boundaries. The issues are mostly technical in nature, but potentially also reputational or political.

Issues

Much prescribed burning experience gained by DELWP staff is through conducting burns within man made containment lines or using major natural features such as rivers or riparian vegetation in deep gullies, or other physical landscape features with low available fuel. Most planned burning aims to burn-out much higher proportions of a burn unit than will be targeted in an LMB. Therefore, landscape mosaic burns that target a subset of fuel types within the burn unit are largely beyond the experience of most current DELWP staff. Further, there are no tested procedural guidelines to follow and fire behaviour models are of limited utility because they are mostly designed for application in summer wildfire conditions for fire lines exceeding 100 metres wide.

The potential for reputational or political issues arises if an LMB does not meet the burn objective (i.e. burns vegetation in fire-sensitive growth stages that were intended to be avoided, or burns at a higher intensity than specified, or spreads beyond LMB Unit boundaries and impacts communities, assets or built structures). It can be a difficult proposition to defend unbounded burning as this can be seen by some as overly risky. However, the flip-side is that opportunities may be missed to protect the environment and community if improved methods and knowledge are not developed due to risk-averse attitude and behaviour. The imperative is to maximise the chances of success through careful and deliberate burn planning practices.

Opportunities

There are some key opportunities with landscape mosaic burning being pursued by DELWP. The higher-order opportunity is that high impact bushfire risk in areas recovering from major impact can be reduced and ecosystem heterogeneity and resilience increased. In addition, there are a range of other opportunities including:

Efficiency	A large landscape area can be planned for burning under a single prescribed burn plan, potentially generating process efficiencies relative to the more traditional approach of dividing the area up into many smaller units requiring a separate burn plan for each. Successfully burning, with suitable precision, to natural boundaries can be a much less resource-intensive method of burning than traditional burning techniques involving large numbers of resources operating from physical containment lines. Hence opportunities to conduct significant scale burns with a high degree of resource efficiency arise.
Improved knowledge	The degree of precision involved in implementing landscape mosaic burns requires a degree of finely scaled fuel and fire behaviour consideration not normally undertaken which can stretch staff knowledge and understanding to finer levels which can be used in other applications.
Innovation	Exploring new methods for burn program delivery demonstrates innovation and can increase public confidence that continual improvement is being pursued.

Constraints

DELWP is seeking to resolve some of the key constraints associated with landscape mosaic burning. For example, application of LMB is better suited to more remote areas where human life and property risks are low.

A further constraint is that there is a key imperative for monitoring and evaluation to be applied to confirm that impacts/benefits are consistent with predictions. This will help to improve information and knowledge of the practice and broaden its application. This requires commitment to a level of monitoring and evaluation that may be more rigorous than is routine for other burning practices. It also requires commitment to fire severity mapping after major wildfires, as the fire severity maps are a key tool for identifying where the earliest opportunity areas are for applying low intensity burning (least impacted fire-dependent EVCs within the wildfire-impacted area).

Finally, there is an imperative for a level of planning and operational supervision, approval and contingency planning that may exceed requirements for more tried and mature burning practices.

2 Planning considerations and general approach

Procedural guidelines for landscape mosaic burning are still in development but a number of general considerations are relevant. The large scale of LMB Units along with the potential complexity of both ecological planning and technical considerations necessitate a particularly deliberate multi-disciplinary planning approach.

2.1 LMB Unit location and outer boundaries

Landscape mosaic burning is mostly undertaken in Fire Management Zone 3 – the Landscape Management Zone, although the draft LMB Planning Guidelines provide that it may be considered in other zones. As previously discussed, LMB Units are mostly located in relatively remote areas, suitably distant from locations where life and property values are concentrated, or where there are reliable features for fire containment between such areas and the LMB Unit. LMBs should only be undertaken in autumn, to reduce the risk of fuels continuing to burn into summer.

The outer boundaries of LMB Units are generally defined by roads, reliable streams/waterbodies, topographic features or existing fuel or fire breaks. These provide a control option for containment of the burn from the outer boundaries should a situation arise where the burn requires active containment measures to be applied. The Lake Dartmouth LMB Unit referred to in this case study makes use of roads, trafficable fire trails, and permanent waterbodies, rivers or streams as its outer boundaries.

2.2 Burning season selection

Due to the larger scale and time frames involved in undertaking these burns, it may also be prudent to avoid areas where smoke sensitive crops or industry are present. Large burns may smoulder for considerable periods and smoke may settle in valleys or basins potentially causing conflicts.

Reliance on natural features for burn patch containment brings with it the inherent likelihood that fire can potentially persist for long periods within the LMB Unit. Fire can smoulder in dry coarse woody debris, old stumps, tree butt or branch hollows, or patches of dry peat among other places. It is important to recognise the potential for smouldering fire sources to reinvigorate and spread if subsequent adverse weather occurs. It is not possible to eliminate such risk, however, the likelihood of such an occurrence can be significantly reduced by burning on a ‘falling hazard’ (the time of year when weather conditions can reasonably be expected to become progressively cooler, day length shorter, with evaporation decreasing, and when the chance of hot, dry windy fire weather is decreasing). For these reasons, landscape mosaic burning is conducted in autumn, usually following a rainfall event which has reduced the drought index significantly from summer peak levels, restoring moisture to the soil profile, but enough time has elapsed since the rainfall event to render the target fuels sufficiently dry to burn.

Landscape mosaic burning is avoided in spring in Victoria, because soil moisture conditions will progressively dry out as conditions become warmer through spring into summer, potentially sustaining smouldering combustion and an increase in the likelihood of days with conditions promoting fire spread.

2.3 Burn timeframe and duration

LMB burns may consist of a sequence of discrete ignition events over a multi-year period. Generally, the aim for each ignition event is for lighting to occur on a single day, with contingency for an additional day if the burn results from the first day are assessed to require some follow up work to meet the burn objectives.

Due to the relatively large areas involved with LMB, aerial ignition techniques are commonly required. Due to the lighting pattern precision requirements, this necessitates use of helicopters (which are an expensive resource). For cost-efficiency it is necessary to plan ignition to occur over the shortest period possible.

While many sections of a LMB will self-extinguish overnight, it is rare that overnight self-extinguishment is complete, other than when substantial rainfall follows the burn. It is to be expected that smouldering combustion will occur for a number of days, and potentially weeks if conditions after ignition turn dry, until either fuels in burn patches burn out, or the combination of rainfall and cool conditions extinguish the burn.

2.4 Limiting conditions

There are conditions in which landscape mosaic burning must be conducted. These limits are defined by prescriptions:

- Forest Fire Danger Index should be less than 8;
- Relative humidity should be more than 45%;
- Atmospheric conditions should be stable;
- Fuel moisture levels in target fuels should generally be greater than 10%; and
- An upslope wind direction is preferable but not always possible in all areas of a LMB.

The key to successful burning is to select conditions and lighting patterns in which fire spread can be sustained in the target fuels, but peters out when it reaches non-target fuels, generally on shady aspects, or where a significant change in physical/structural fuel attributes occurs.

3 Landscape mosaic burning application at Lake Dartmouth LMB Unit

In this case study, the application of Landscape Mosaic Burning in forests surrounding Lake Dartmouth LMB Unit in north-east Victoria's high country is explored. LMB Unit key features are:

- The LMB covers 33,578 hectares;
- The entire area was burnt in the 2003 fires, over a period of days in mid-summer during a severe drought (some areas burnt during the day while other areas burnt in milder conditions at night). Some areas burnt by high intensity head fires in adverse weather, while other areas at lower intensity by flank or backing fire;

- Nearly half the LMB vegetated area is occupied by Ecological Vegetation Classes (EVC) made up of Heathy Dry Forest or Shrubby Dry Forest. Herb-rich Foothill Forest makes up about a quarter of the area, with the remainder comprised of Montane Forest and Woodland (~10%), Damp Forest (~5%), Grassy Dry Forest (~2%), and sub-alpine woodland (~0.1%);

- There are numerous rare flora present, and the vegetation communities present are known to provide habitat for a range of vulnerable, endangered or near-threatened fauna species;

- The burn unit is a water catchment with an extensive interface with Lake Dartmouth (an artificial water storage with dam and hydro-electric power station);

- Trail access within the LMB Unit is very limited;

- The 'high country' location in north-east Victoria experiences cold winters with a winter rainfall peak – the late spring and summer period is typically an increasing hazard period with increasing potential for adverse weather occurrence; and

- If a burn were to spread out of the LMB under adverse conditions there is a vast contiguous forested mountain landscape to the east and south-east, and therefore, a very large, high suppression difficulty and long duration bushfire is a credible scenario.

A map of the Lake Dartmouth LMB Unit is provided at Figure 1.

4 Fuel dynamics and fire behaviour context

Fuels within the LMB Unit have been in their early re-accumulation phase since the 2003 fire. However, by virtue of the large LMB area, wide elevation range and mountainous topography, there is a significant degree of forest /vegetation type and hence fuel variability within the LMB Unit.

4.1 Fuel variability

The following broad fuel descriptions applied to the site in 2010:

- Only small pockets of unburnt alpine ash remained, mostly in the most sheltered, moistest positions in the LMB Unit – these carried deep litter beds and a shrubby or ferny understorey;

- Lightly burnt alpine ash forest areas which survived the 2003 fire had a regenerating understorey consisting of live green shrubs, with some grass in ridge top areas;

- Intensely burnt alpine ash areas had been killed followed by a 'wheatfield' regeneration of dense seedlings, which by 2010 was a dense stand of alpine ash and shrub regeneration of about 3 metres high;

- In the lower elevation forest communities on the northern to western aspects there was a thick shrub layer (consisting mostly of dogwood, hopscrub and wattles), being thickest where tree crowns had been burnt-out in the 2003 fires, and less dense where crown cover had remained intact; and

- Lower elevation forests on the southern to eastern aspects mostly had herb-rich understorey but with a substantial shrub layer also present (see Figures 2 and 3 showing grassy and shrubby forest).

Overall, whilst there was a significant degree of variability in fuels a generally common feature was the presence of a shrub layer across a high proportion of the area, with more open grassy understorey areas restricted to relatively small patches. A high proportion of the regenerating shrub fuels were in a predominantly live, green condition with relatively little dead fuel. The presence of leaf litter fuels was mostly in areas that burnt at lower intensity during the 2003 fires.

Figure 1 Lake Dartmouth LMB Unit location

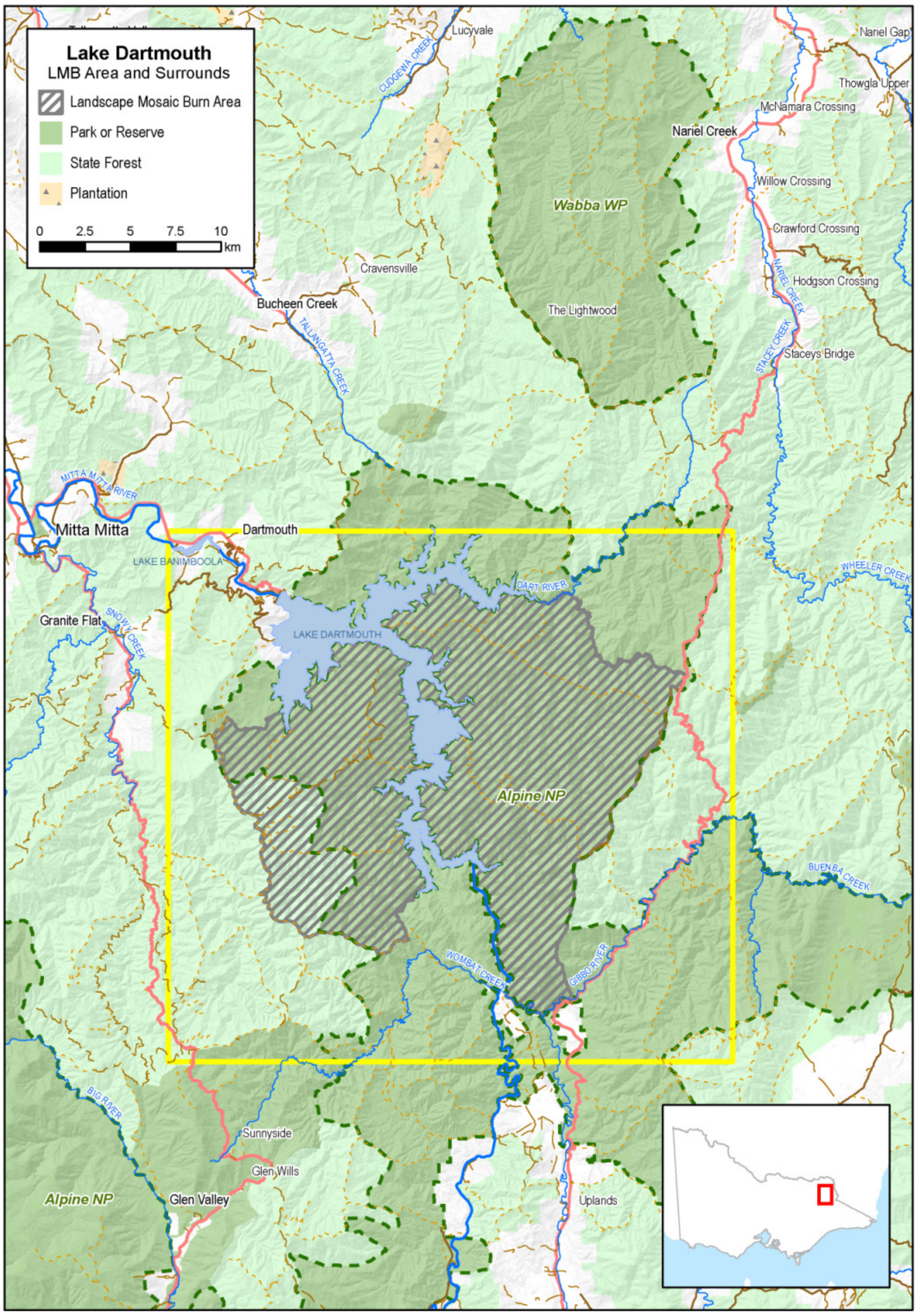


Figure 2 Fire-dependent EVC with open grass-dominated understorey

Figure 3 Fire-influenced EVC with shrub-dominated understorey

4.2 Fire behaviour implications

Within the LMB Unit, the fuels most conducive to carrying fire are the patches with grass dominated ground cover, and areas where sufficient litter had re-accumulated after the 2003 fire (mostly those lower fire intensity areas which retained intact crown cover).

In the grass dominated understory patches there was sufficient grass fuel to carry fire in relatively low wind conditions. These areas are the first to become available to carry planned low intensity fire.

In the areas lightly burnt in 2003, surface leaf litter loads were still relatively light and patchy. Litter fuels are expected to be too light to carry a low intensity planned burn during the first planned burn treatment, but after a further 2 or 3 years, there should be sufficient fuel to carry low intensity fire.

In the areas carrying dense live green regenerating shrub layers there was generally insufficient dead fine surface fuel to carry low intensity fire, and the live, green nature of the shrub layer meant it was only conducive to carrying fire under dry, windy conditions.

These fire behaviour potential differences facilitated patchy prescribed burning opportunities in which:

- The least fire-sensitive, grassy forest/woodland components (considered fire-dependent EVCs) could be burnt in first-stage burns;

- Then the more lightly impacted dry forest areas which had re-accumulated sufficient forest litter fuel could be burnt in second-stage burns (considered fire-influenced ecological vegetation classes); and

- Fire incursion into fire-sensitive juvenile shrub dominated areas could be avoided by burning in mild conditions and/or by using lighting patterns that provided slow, low intensity fire spread which could reasonably be expected to have negligible impact on any mature shrubs and trees that had survived the 2003 fires.

Topography and aspect are also significant influences on fire behaviour. By selecting burn timing when more exposed landscape positions have fuel moisture levels favourable for sustaining fire spread in mild weather conditions, but more sheltered aspects are too moist to carry fire under the same conditions, fire spread can be limited mostly to the exposed locations.

Considering the ‘no treatment’ scenario, the longer fire is excluded from the LMB Unit, the greater the fuel levels that accumulate, the higher the dead fuel proportion, and the more contiguous fire spread-conducive fuel areas become. The result of sustained fire absence is a near-contiguous fuel array that can support fire spread under a wide range of weather conditions, which will support a higher fire intensity (relative to lower fuel areas) with greater physical and ecological impacts.

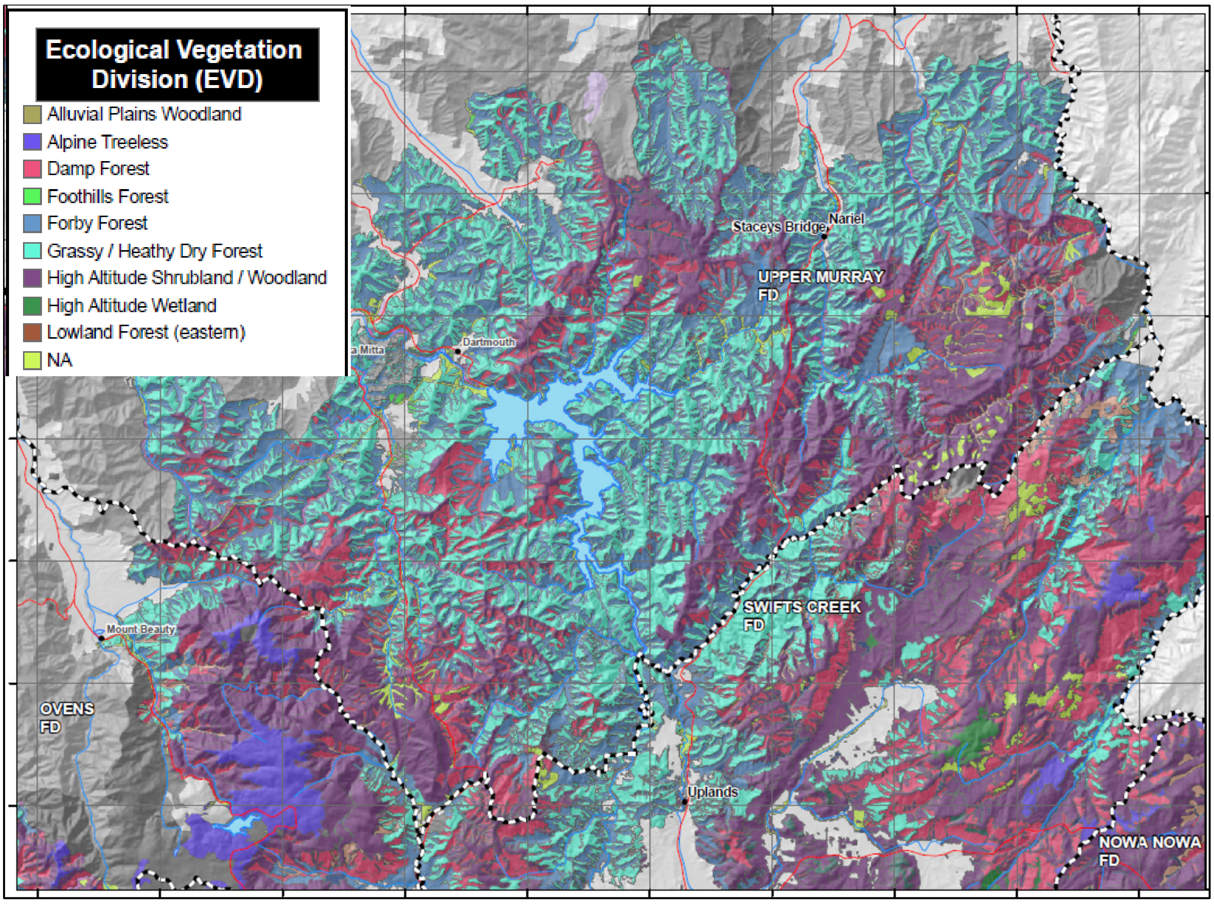
4.3 Planning of target fuels

Comprehensive spatial data is required to support LMB. High resolution EVC mapping is important, as is wildfire severity mapping if the area being treated has been recently impacted by wildfire. For the identification of target fuels, EVCs which are above their minimum tolerable fire interval are mapped and from those, the EVCs selected for burning are identified. After there has been a significant wildfire, as was the case with the Lake Dartmouth LMB, the first EVCs to become available for burning will typically be grassy systems because these have the shortest minimum fire interval.

Having identified the target EVCs, a critical next step in planning is to consider how fire can be contained to the target EVC, or conversely, restricted from spreading from the target fuels into the non-target fuels. This is where local knowledge, including fuel type and fuel moisture content at various locations and burning experience is a vital asset.

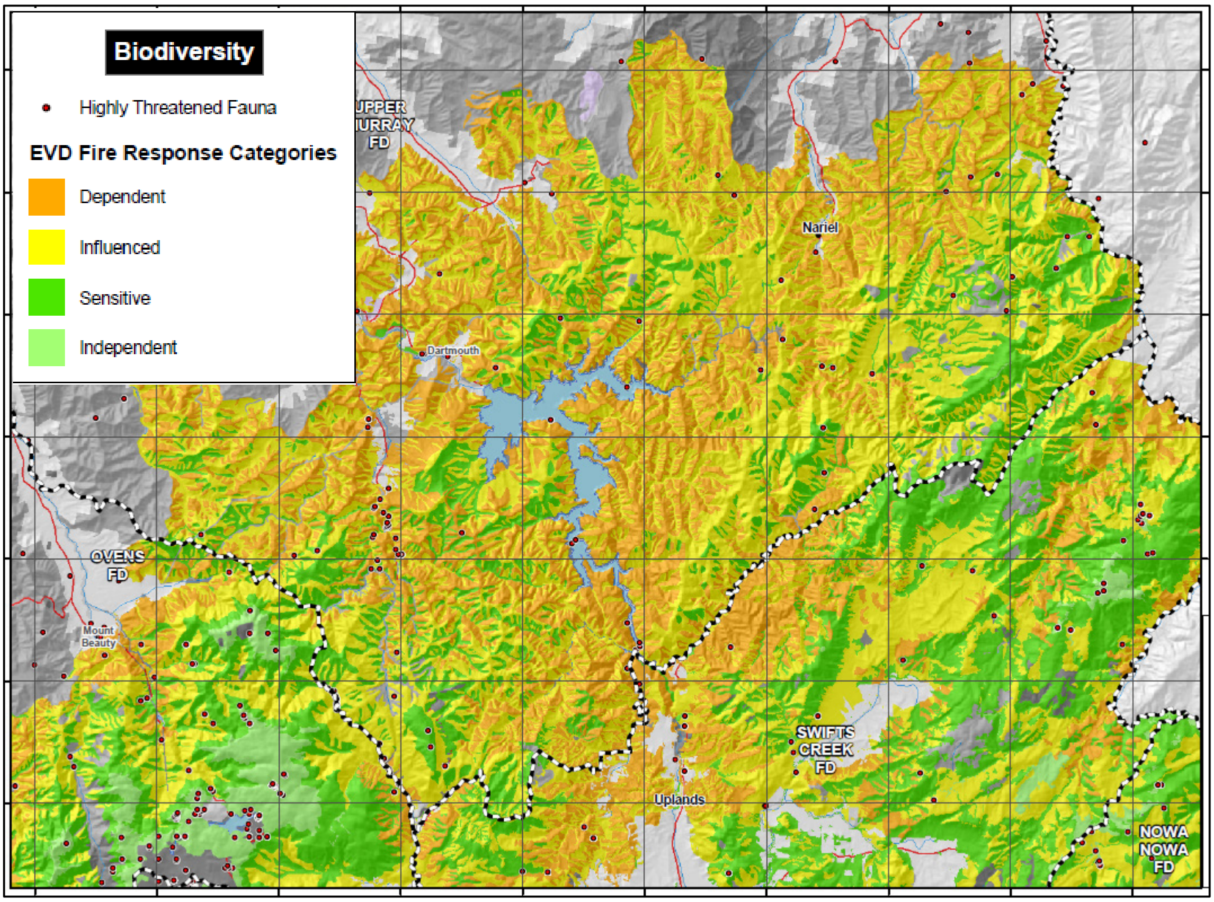
Mapping to clearly distinguish the target EVCs from the non-target EVCs is undertaken so lighting patterns can be planned that will apply aerial ignition only into the target EVCs. The size or extent of the target EVC patches, as well as their location in the topography will be considered in determining the optimal time to commence ignition, based on estimates of how long it will take fire to burn out from the ignition locations to the edges of the target EVCs. Identification of those proportions of EVCs that have burnt at lower intensities and therefore may have re-accumulated sufficient litter to carry fire can be assessed from fire severity mapping.

Figure 4 Ecological Vegetation Divisions present within the Lake Dartmouth LMB Unit



In Figure 4 it can be seen that the dominant vegetation types in the Lake Dartmouth LMB Unit are fire-dependent Grassy/Heathy Dry forest which occupy most north-eastern to western aspects and ridgetop areas. Fire-influenced Forby Forest tends to occupy south to easterly aspects and lower positions within drainage features. The most heavily sheltered sites in the steeper, deeper terrain features on southern and south-eastern aspects are occupied fire-sensitive ‘damp forest’ including montane forest.

Figure 5 EVD Fire response category mapping for the Lake Dartmouth LMB Unit



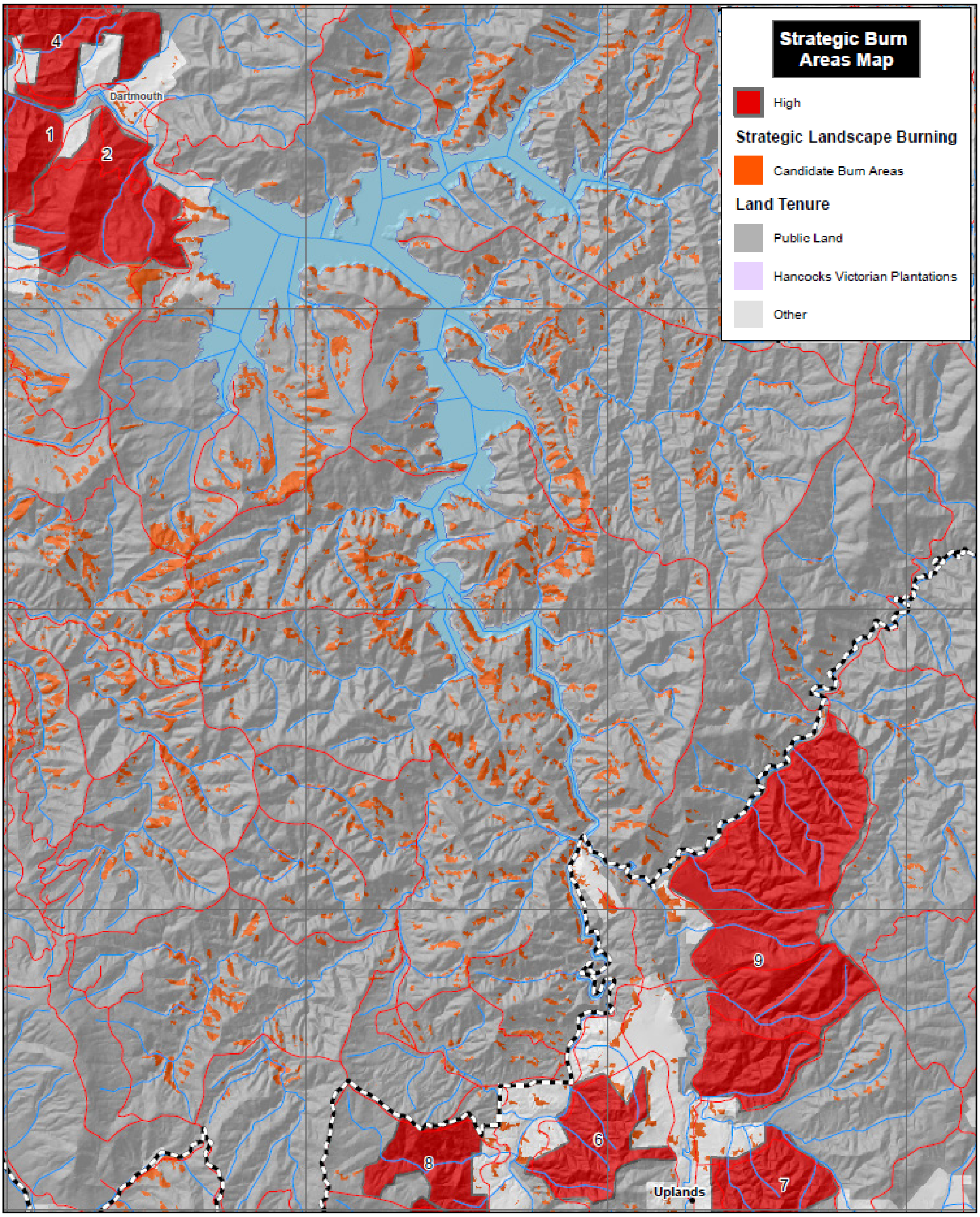
In Figure 5 fire-dependent category vegetation can be seen occupying higher parts of the topography. Across the majority of the landscape, fire-influenced vegetation occurs adjacent to fire-dependent vegetation. Fire-sensitive vegetation mostly occurs adjacent to fire-influenced vegetation, except in the steepest areas where fire-dependent and fire-sensitive vegetation occur adjacent to each other, either side of a major change in slope and aspect.

In the case of the Lake Dartmouth LMB case study, for the first-stage burn (planned for 2011) targeting grassy EVCs, exposed positions in the upper parts of the topography was mostly on the northern and western aspects (some grassy areas were low in the topography and less exposed to wind) so a light south-east wind was ideal. Burning was conducted in stable conditions when winds were light.

Mapping of the target EVC's for treatment in the first-stage burn was undertaken. As can be seen in Figure 6 the targeted areas (depicted in orange) represent only a small proportion of the landscape area. There are a high number of small patches, some connected along ridgelines or shoreline locations. Accordingly, there is a very large perimeter length associated with all the small patch size target burn patches. Successful fire containment to the target patch areas will generate a high extent of 'edge-effect' areas but equally these edges represent a potentially high number of smouldering ignition sources. Areas depicted in red in Figure 6 are strategic asset protection areas, situated near community or economic assets.

In the Lake Dartmouth LMB Unit a second stage burn was planned for 2015 targeting fire-influenced EVC's particularly those areas which were relatively lightly burnt during the 2003 wildfires, which retain intact canopies and have since accumulated sufficient litter fuels to carry a planned low intensity burn. These areas are more extensive than the relatively small areas treated in the first stage burn of 2011.

Figure 6 Patches selected on EVC basis, for first-stage LMB Unit (Lake Dartmouth) burning



5 Burn plan preparation

DELWP has a standard burn planning process which is supplemented by additional requirements in the case of landscape mosaic burning. These are summarised below:

5.1 Burn Planning Process

A multi-disciplinary burn planning team was assembled to undertake burn planning for the Lake Dartmouth LMB. The team included both Parks Victoria and DELWP personnel incorporating ecologists and experienced planned burning practitioners.

A planning process is identified on DELWP District Prescribed Burn Planning Maps. A sample of the planning process is reproduced at Figure 7.

Figure 7 Prescribed Burn Planning Process steps for Lake Dartmouth LMB Unit

Prescribed Burn Selection Process

Strategic Asset Protection –

- Select from the Strategic Asset Protection Areas before selecting candidate areas for strategic landscape burning.

Strategic Landscape Burning –

Step 1. Select from the candidate areas available for prescribed burning.

Step 2. Establish the type of Fire Dependent EVD's identified as candidates areas to burn.

Step 3. Use the provided EVD Fire Intervals in the table above &/or in Appendix 7 of the Guide to identify the EVD minimum interfire period. If EVD minimum interfire period is 8 years this EVD should be included in any FOP planning above 2010/11 FOP period.

Step 4. Define the specific objectives of the burn and check that they complement the objectives set out in relevant Fire, Parks & Forests Management Plan's.

Step 5. Identify any compounding issues, such as weed infestations after fire, and consider their response to fire.

Step 6. Ensure that the requirements of any threatened species and/or community Action Statements/Recovery Plans are addressed.

Step 7. Include conditions needed to protect specific values within a burn area (e.g. damp gullies, habitat trees, or soil erosion).

Step 8. Conduct the prescribed burn in accordance with the approved burn plan. Record the environmental conditions on the day and map the amount of burnt area.

Step 9. Monitor the response of key fire response species and other attributes identified in the burn objectives. Refer to current state pre and post burn monitoring protocols.

A range of map products were used, including site-specific maps produced using GIS applications, to inform burn planning. The following maps were prepared or obtained for the planning process:

- A general landscape map showing land tenures, roads and trails, major landscape features settlement and significant infrastructure locations, fire history and zoning and the LMB unit outer boundary location – this is used in identifying landscape burn context and potential issues;

- 'Consequence of Loss' mapping relevant to the LMB Unit and surrounding area – also used for considering the context of the risk associated with planning and conducting the burn;

- An EVC map showing those EVCs within the tolerable fire interval range, those outside the tolerable range, any other areas requiring fire exclusion, and the particular EVCs to be targeted for burning;

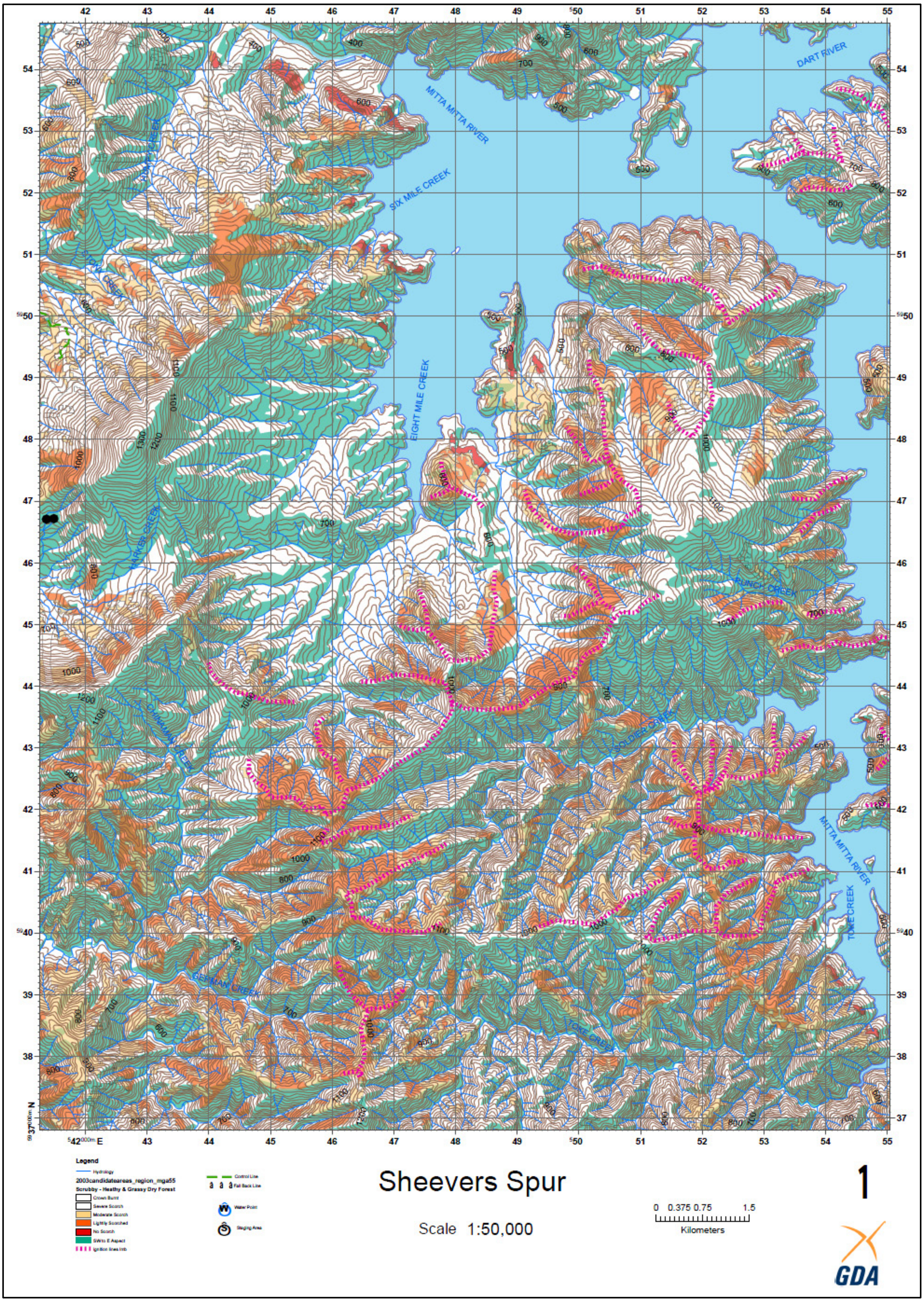
- Landscape fuel hazard mapping, taking account of vegetation types and fire history; and

- Detailed topographic mapping showing contours, vegetation type and landscape feature details sufficient for informing lighting pattern development.

Informed by the maps and relevant information provided by each member of the multi-disciplinary burn planning team, a Landscape Mosaic Burn Plan was developed using DELWP's standard procedures.

A sample map from the LMB Burn Plan depicting the proposed aerial ignition point locations is shown at Figure 8. Pink dotted lines show proposed ignitions lines, which correlate to target areas depicted in orange which are fire-dependant EVCs in which only light scorch occurred during the 2003 wildfire.

Figure 8 Proposed aerial ignition line map from lake Dartmouth LMB burn plan (2011)



6 Operational preparations

In the lead up to the Lake Dartmouth LMB operations, the focus was on monitoring fuel and weather conditions and organising aerial ignition teams and equipment for burn implementation. Leading up to selection of a burn date, with natural boundaries to be heavily relied upon, it was necessary to closely monitor how fuel moisture levels in target areas and non-target areas were tracking over time.

While drought indices can provide a coarse level guide for general drying pattern development, there is no substitute for direct sampling of fuel moisture levels. In DELWP, this is mostly done using a Wiltronics moisture meter, by taking afternoon FMC samples in fuels representative of target and of non-target fuel areas.

Monitoring of weather patterns is also undertaken, to identify when a period of suitably stable atmospheric conditions and weather is forecast to arrive over the LMB area. DELWP's operational practitioners and planners have found the Bureau of Meteorology's (BoM) 7, 3 and 1 day meteograms are a particularly useful product for the purpose of early identification of opportunities. Once a proposed burn date is identified, the use of meteograms is supplemented by liaison with the BoM's meteorologist in the State Control Centre.

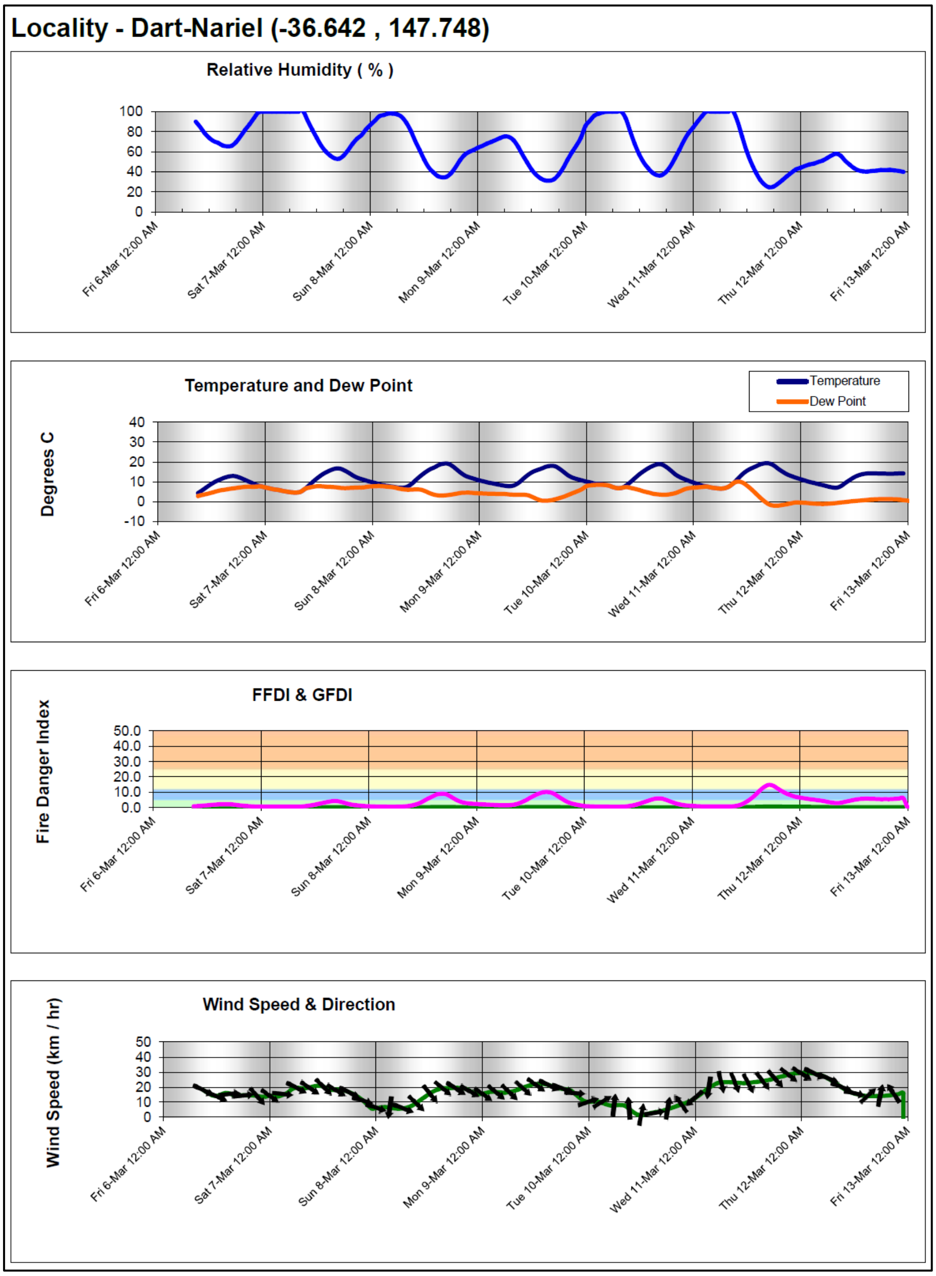
Once the window of opportunity to conduct the burn is confirmed, arrangements for aircraft and aerial ignition crews need to be made and standard notification and approval processes implemented.

Figure 9 is an example of the meteogram product used by DELWP. Meteograms are derived from the BoM's gridded weather forecasts, and are updated twice per day (6AM and 6PM). The meteogram is based on district forecast data, and thus represents the best possible information at a whole of weather district scale. Accordingly, it needs to be borne in mind that meteograms may not include local weather and terrain driven effects. Whilst not a site-specific product, meteograms do provide a useful indication at district scale of how forecast weather is expected to change over the forecast period. The meteograms used by DELWP include temperature, relative humidity, dew point, fire danger index (grass and forest) and wind speed and direction.

DELWP also run an internal computer-based application called Planned Burn Forecaster (PB Forecaster). The PB Forecaster application uses gridded weather forecast data from the BoM, and forest fuel quantity information entered by the DELWP user, to generate a range of indicative fuel moisture and fire behaviour potential calculations in time sequenced graphical format. Hourly forecast of dead fuel moisture content is calculated using a range of fuel moisture models including McArthur Mk 5, McArthur Leaflet 80, VESTA dry eucalypt and CSIRO Grass. Indicative forward rate of spread, fireline intensity and scorch height predictions (assuming afternoon spread on days with FFDI <12) for dry eucalypt forest are also provided based on McArthur's Leaflet 80 methodology. The use of these predictive service products is principally to identify windows of opportunity for burning and to highlight time periods when conditions are forecast to move outside prescription ranges. More detailed site-specific weather and fire behaviour assessment is required on the selected burn day.

Figure 10 shows a predicted fire behaviour output chart from DELWP's Planned Burn Forecaster application.

Figure 9 Sample meteogram product used for prescribed burning



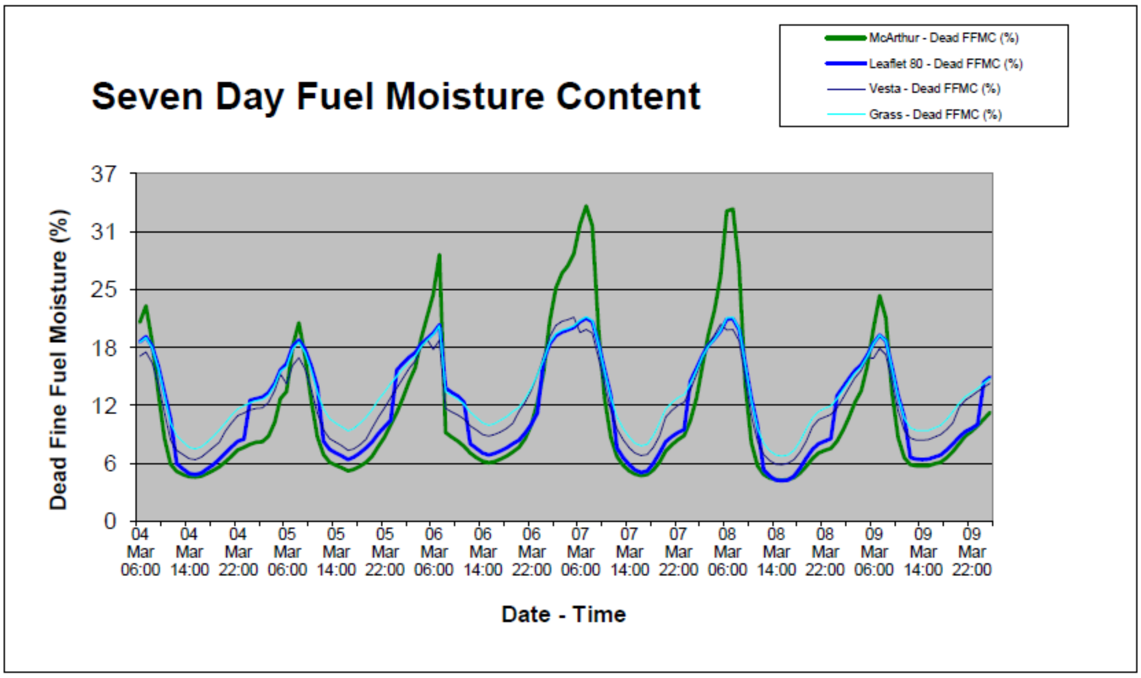
Note: When temperature equals dew point then condensation will occur. This produces dew if the temperature is above zero and frost if it below zero.

Note: Background colours indicate Fire Danger ratings
Low = green
Moderate = Yellow
Very High = Tan

GFDI is zero until curing % gets above 70%.

The arrows on the wind chart show the direction the wind is going. Down pointing arrow is Northerly (going south). Right pointing arrow is Westerly (going west).

Figure 10 Modelled fuel moisture content graph (from DELWP Planned Burn Forecaster)



7 Burning Operations Implementation

On the day of the burn, routine procedures for obtaining weather and smoke forecasts for the burn area are implemented. This includes taking into account the four day outlook for weather.

As ignition, patrolling and burn coverage mapping is undertaken by helicopter, routine pre-burn operations briefings are in the form of an aviation operations briefing, incorporating the lighting pattern, burn assessment and mapping work components.

In the case of the Lake Dartmouth LMB, due to the large ignition area involved, two helicopters were required to complete ignition the first day. On the second day, one helicopter undertook aerial reconnaissance, burn effectiveness assessment, and any in-fill ignition work deemed necessary to meet burn objectives.

Target burn areas and predetermined ignition patterns are uploaded into the helicopter's GPS.

Authorisation to proceed with ignition is requested and obtained from the appropriate manager.

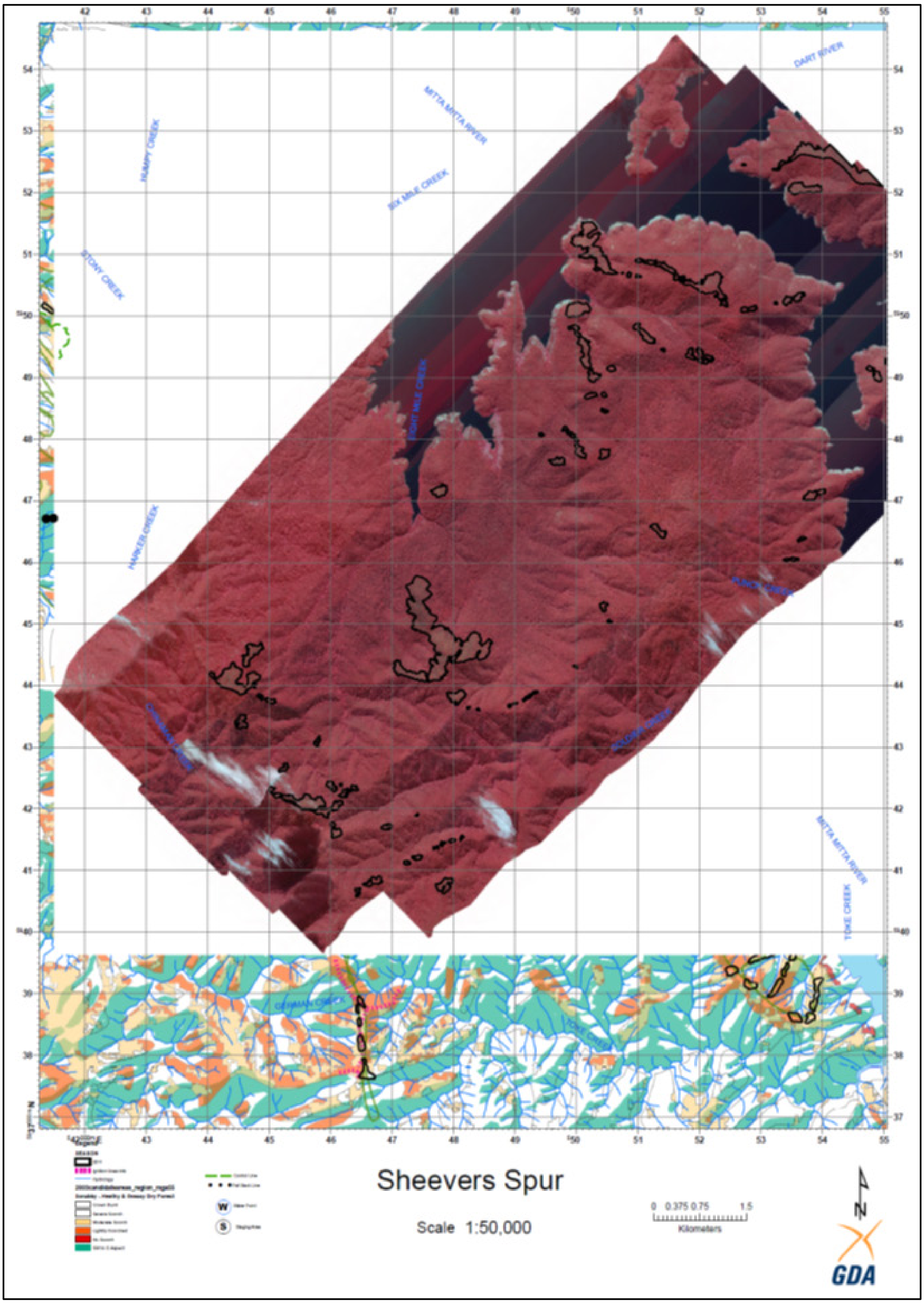
It is normal for a test aerial ignition to be conducted in a target fuel area to determine the appropriateness of the conditions prior to proceeding with further ignitions.

Lighting patterns are implemented, generally commencing with a conservative pattern on ridges to achieve a downslope spread pattern (see Figure 11). The resulting fire behaviour is observed and assessed. If spread is less than desired then additional lighting further downslope may be tested with the aim of achieving more desirable spread and behaviour.

As with most aerial ignition operations lighting sequence and pattern implementation needs to take account of wind direction and smoke dispersal patterns to, as far as possible, enable the helicopter to operate in suitable visibility conditions.

Figure 11 Aerial ignition at Lake Dartmouth LMB Unit first-stage burn

Figure 12 Planned burn patch extent map for Sheevers Spur section of Lake Dartmouth LMB



8 Appraisal (post-burn assessments and monitoring)

For monitoring and evaluation of LMB effects, a rigorous monitoring procedure is followed.

Burn extent and severity mapping is undertaken. Aerial photography is captured, in the case of the Lake Dartmouth LMB Unit burn using a Leica 80S80 camera which captures infra-red and colour images simultaneously. These are used to distinguish burnt patches within the LMB area (Figure 12).

For ecological monitoring, the procedure applied is documented in DELWP's *Guide to Monitoring Habitat Structure* (Treloar 2012).

The key features of the ecological monitoring approach applied within the Lake Dartmouth LMB Unit are:

8.1 Monitoring plot site selection

- Candidate areas for establishing monitoring plots are selected based on having minimal edge effects and being within a fire affected area from the 2003 bushfires; and
- Selected candidate areas are stratified by EVC, aspect and if possible, elevation as well, and then ground-truthed for accessibility and correct EVC. If appropriate, a 2 hectare plot is established.

8.2 Monitoring plot set up

- 50 metre transects, measured by belt and line transects, plus point assessments;
- 3 transects per plot oriented N, SE and SW;
- Metre belt transects for trees, saplings and stumps;
- Line transects for coarse woody debris and habitat structure (0 – 2m in height);
- Point assessments for fuel hazard and fire severity; and
- 2 cameras per plot – one herbivore and one carnivore located at opposite ends of the 2 hectare plot. Placed in the plot for 3 weeks.

8.3 Assessment schedule

- Performed pre burn, and the following spring post burn; and
- An assessment is done whenever there is any fire in the area.

8.4 Other resources used

- Line scans and aerial photography;
- Mapping products such as candidate area mapping showing areas that are available for ignition (i.e. within TFI); and
- Management plan to re-introduce planned burning appropriately.

Scientific analysis of monitoring plot data is undertaken by the Arthur Rylah Institute.

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10 References and further reading

DELWP (2009) Landscape Mosaic Burning Planning Guidelines. Working draft prepared for the Department of Environment, Land, Water and Planning (Victoria: Melbourne)

Treloar SM (2012) Guide to monitoring habitat structure. Department of Sustainability and Environment (DSE) report no. 85. (Melbourne: Victoria)