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Glossary

AWS - Automatic Weather Station
CBD - Central Business District
CSIRO - Commonwealth Scientific and Industrial Research Organisation
CEO - Chief Executive Officer
CFA - Country Fire Authority
DEPI - Department of Environment and Primary Industries
DTPLI - Department of Transport, Planning and Local Infrastructure
EVC - Ecological Vegetation Community
EVD - Ecological Vegetation Division
FEPO - Fire and Environment Program Officer
FFDI - Forest Fire Danger
FMZ - Fire Management Zoning
FOP - Fire Operations Plan
FSC - Fire Services Commissioner
HILI - Houseloss Ignition Likelihood Index
IFMP - Integrated Fire Management Planning
LGA - Local Government Area, also known as Shires or Municipalities.
MFEP - Melbourne Fire and Emergency Program
OFH - Overall Fuel Hazard
PV - Parks Victoria
TFB - Total Fire Ban
TFI - Tolerable Fire Interval
VFRR - Victorian Fire Risk Register
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This report is an output of the Dandenong Ranges Landscape Bushfire Project, which contributes to the broader Fire Services Reform Program. It describes a modelled understanding of bushfire hazard and risk to property in the Dandenong Ranges landscape.

The bushfire risk assessment outputs in this report were developed consistent with standard approaches employed by the Department of Environment and Primary Industries (DEPI). This includes the use of Phoenix Rapidfire: a computer model which can simulate fire behaviour using a wide range of inputs. There are key assumptions in the bushfire modeling process that place limitations on the application of the outputs of the risk assessment. Phoenix Rapidfire as a modelling tool is only as good as those inputs and like all models, it also comes with many assumptions. Key assumptions and limitations are described in the Data and Methods section of this report.

Just as risk changes over time so does our understanding of bushfire behavior and our knowledge of key inputs to the modeling process. For these reasons it is expected the information provided in this report about bushfire risk in the Dandenong Ranges landscape will be regularly reviewed. This will be done through DEPI’s strategic bushfire management planning processes, and risk assessment products shared with other land managers and agencies to support an integrated, cross-tenure, multi-agency approach to bushfire management.

It is intended that the recommendations in this report be considered and implemented through existing agency planning processes.
REPORT CONTEXT

Introduction

In October 2011, then Victorian Deputy Premier and Minister for Bushfire Response Peter Ryan launched the Dandenong Ranges Landscape Bushfire Project.

The Project was initiated by Craig Lapsley, Fire Services Commissioner, following a joint request from the CEOs of Yarra Ranges Shire Council, City of Casey, City of Knox and the Shire of Cardinia to address outstanding bushfire management issues across the Dandenong Ranges common to each of the four municipalities.

The Dandenong Ranges Landscape Bushfire Project reflects the desire of government and communities to enable shared responsibility for bushfire management. This has grown from the 2009 Victorian Bushfires Royal Commission and evolved to become a driving force in bushfire and emergency management.

Communities of the Dandenong Ranges are directly involved in the Project and provide advice and input that helps guide recommendations around future fire management in the area.

Communities, fire services agencies, local governments and land managers are being challenged to apply new ways of thinking, preparing and planning for bushfires. This project is an important part of building knowledge, capability, partnerships and resilience to bushfire and other emergencies in Victoria.

This report is broken into four sections

- Report Context: which explains why this report has been prepared, who it is for and how it relates to the broader Dandenong Ranges Landscape Bushfire Project
- Landscape Context: which defines the landscape, describe its key attributes, its fire history and expected future trends
- Bushfire Risk Assessment: which describes the level of bushfire risk in this landscape, the origin of major bushfires; modelled bushfire spread paths and bushfire behavior dynamics in the landscape. The assessment is based on the modeled consequences of major fires in this environment
- Key findings and recommendations

Purpose of the Broader OFSC Dandenong Ranges Landscape Bushfire Project

The Dandenong Ranges Project Landscape Bushfire Project aims to (Fire Services Commissioner, 2013):

- Reduce the likelihood and consequences of major bushfires on communities in the Dandenong Ranges;
- Develop cross boundary, strategies to inform other levels of planning and activity; Develop cross-boundary land management strategies that integrate with other planning activities/land managers?
- Develop methodologies that inform bushfire safety planning in high risk areas;
- Enhance the safety of people through a shared responsibility approach that engages agencies and community members to be accountable, and
- Build more sustainable communities.

A new fire management plan is not an output of the project; instead the findings and products of the project will inform and enhance existing fire management planning processes.

In order to meet the aforementioned aims, seven themes were developed within the project (Figure 1).

Each theme captures a priority area for bushfire management and includes issues affecting the communities of the Dandenong Ranges.

DEPI Role in the Project and Purpose of this Report

For each of the themes identified in the Dandenong Ranges Landscape Bushfire Project, an agency was identified to lead the development of ideas and to provide advice to the Fire Services Commissioner.

DEPI, in conjunction with Parks Victoria, was asked to lead discussion of theme 1 ‘Understanding the Hazard and Risk’. This report presents the outcomes of this work.

In 2010, DEPI, in conjunction with Parks Victoria, committed to undertaking risk-based bushfire management planning across Victoria. Victoria was split into seven Bushfire Risk Landscapes (BRLs), including the East Central BRL, of which the Dandenong Ranges landscape is wholly a part of. A key outcome of risk-based bushfire management planning is a DEPI Strategic Fire Management Plan, which will be produced for each bushfire risk landscape (BRL). Within each BRL, sub-landscapes have been defined. The Dandenong Ranges Landscape Bushfire Project area is one of these sub-landscapes, and therefore the basis of the risk analysis within this report has been sourced from the East Central BRL Risk Profile Report (DEPI, 2013a). Within the Strategic Fire Management Plan there will be many new and innovative products created that have not been seen in fire management anywhere in the world before.
Audience
This report is provided to the Fire Services Commissioner for consideration, it is understood the content of this report will be shared and discussed with both the Dandenong Ranges Landscape Bushfire Project Executive and Project Management Boards and that some of the information provided in this report may be used to inform the development of other themes and to produce information for the broader community.

Data and Methods
A detailed description of the data, methods and assumptions used to create the information contained in this report is provided in the following documents:

- East Central Bushfire Risk Landscape Risk Profile Report (DEPI, 2013a)

The risk analysis within this report is based upon modelling and as such has a range of assumptions that underpin the analysis. Any conclusions that can be drawn from the system must be referenced against the assumptions and any associated limitations of the modelling and models.

The key model underpinning this report is Phoenix Rapidfire. Phoenix is a research tool developed by the University of Melbourne (Kevin Tolhurst and Derek Chong). Phoenix has been used by DEPI and other fire agencies for both incident prediction (SCC Phoenix Firemap system) and as the key tool for bushfire risk assessment in a new strategic approach to fire management planning.

DEPI acknowledges that the model designed for research is being applied operationally. Use of Phoenix is coordinated through an agreement between DEPI, the University of Melbourne, and the Bushfire and Natural Hazards Cooperative Research Centre. Some of the models, assumptions, and settings within Phoenix are the subject of scientific papers (peer reviewed), although the system itself has not been extensively assessed. As a planning tool, it is generally acknowledged by many stakeholders in the field, including DEPI, that Phoenix is a state-of-the-art, world-leading tool, critical for helping us understand how to reduce risk to life and property from major bushfires.

The implication of using Phoenix is that actual fire spread may not be reflected in model guidance. There are several input layers and submodels within Phoenix. Each layer and submodel needs to be validated.

In addition to assumptions and limitations of Phoenix, a small number of assumptions have been made in the application of Phoenix to risk profile modelling and the results in this report (described later in this section).

One composite weather scenario was used in informing the analysis in this report (except for the indicative fire paths, where two scenarios are used). The limitation of this analysis is that actual fires may occur under different weather conditions to those modelled, which may influence the potential consequences of any future fire event. The priority in this project was modelling severe bushfires under conditions in which catastrophic fires have occurred in Victoria in the past, such as Black Saturday (7 Feb 2009), Ash Wednesday (16 Feb 1983) and Black Friday (13 January 1939), as these have been when the majority of bushfire impacts have occurred, with many fatalities and thousands of properties lost. A detailed, spatially explicit fire weather climatology is required for assessment of risk with a range of potential weather streams and this is already under development.

The house impact metrics used in Phoenix are currently threshold-based, which has the implication of simplifying the locations of homes and assuming a correlation between house loss and impact on human life. A shift to a continuous probability of house loss function (incorporating convection) is preferable and is being assessed by an independent program within DEPI (Fire Severity and Threshold Program).

Fuel treatability has been assessed by expert opinion of practitioners and in the analysis within this report, we use this opinion to describe treatability of individual Ecological Vegetation Classes (EVCs). Such work is an interim step and requires validation. The implication of this assumption is that we may underestimate the area of forest where fuel reduction burning may be possible. DEPI and Parks Victoria Risk Analysts and Fire and Environment Program Officers (FEPO’s) are continuing to review treatability and minor refinements are likely.

Spatial records of fire and logging history have been used to represent the historical fire disturbance in the landscape. These layers of information have uncertainties associated with them and the implication of that is that fire behaviour in any given part of the landscape may be not accurately captured by Phoenix. DEPI continues to refine and improve our monitoring, evaluation, and reporting framework to improve data certainty.

Phoenix Rapidfire has been developed and validated from analysis of real fire situations. Figure 2 shows the actual fire extent and timing of the 1983 Upper Beaconsfield fire (grey) and the Phoenix simulation (overlaid in orange/yellow) to demonstrate correlation of the model with known events.

Fire modelling provides a platform for scenario-planning and trade-off analysis to determine cost-effective strategies. It also enables more transparent and informed discussions about bushfire risk with stakeholders and community with the maps, graphs and animations that are possible. Scenario planning is important for managers facing uncertainty. It provides a disciplined method for imagining possible futures and better positioning a particular organisation or business for future events, which otherwise would occur as a surprise (Schoemaker 2005).

Phoenix best characterises fire activity when fire weather conditions (i.e. Fire Danger Ratings or FDRs) are at the upper end of the range (Severe/Extreme/Code Red). For analysis at the household level, tools such as the Wilson & Tolhurst’s House Ignition Likelihood Index (HILI) model are more appropriate.

It is important to note that many fine-scale, local factors - such as house-construction, how defendable the house is, garden design and plantings - can influence whether a house is impacted by fire. No models exist for predicting such dynamics, and Phoenix Rapidfire does not aim to represent the historical fire disturbance in the landscape. Spatial records of fire and logging history have been used to represent the historical fire disturbance in the landscape. These layers of information have uncertainties associated with them and the implication of that is that fire behaviour in any given part of the landscape may be not accurately captured by Phoenix. DEPI continues to refine and improve our monitoring, evaluation, and reporting framework to improve data certainty.

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One composite weather scenario was used in informing the analysis in this report (except for the indicative fire paths, where two scenarios are used). The limitation of this analysis is that actual fires may occur under different weather conditions to those modelled, which may influence the potential consequences of any future fire event. The priority in this project was modelling severe bushfires under conditions in which catastrophic fires have occurred in Victoria in the past, such as Black Saturday (7 Feb 2009),
Phoenix Rapidfire was used to simulate severe bushfires burning in a single day (i.e. 11am to 11pm) under catastrophic conditions one-by-one on a 5km and 1km systematic grid across the bushfire risk landscape (40,262 simulated fires in total). The 5km ignition grid was preferable for efficiency in running simulations, and the finer-scale (1km) grid was necessary for more detailed analysis of township risk. A basic “first attack” suppression model was included.

Limitations of the modelling undertaken in this report include:

- The risk analysis presented in this report represents the key recommended approach for ensuring fire modelling and bushfire risk assessment can be effectively incorporated into a strategic approach to fire management planning in a consistent, standard and organised manner. It is in a very early stage of development, and needs considerable work and support to further build its robustness and ensure it will be workable across all Regions of Victoria.

- Phoenix has had little scientific (peer-reviewed) validation of how well it performs, largely because there are no other models as sophisticated for reference so it is difficult for other scientists to understand and review it. Depending on perspective, in an academic sense it may be seen as having a weak scientific basis, but as a planning tool for fire managers, it is generally acknowledged by many stakeholders in the field, including DEPI and the developers themselves, that Phoenix is a state-of-the-art, world-leading tool, critical for helping to reduce risk to life and property from major bushfires.

- Some of the property impact metrics used in Phoenix are currently threshold-based and have significant limitations. A shift to a continuous probability of house loss function (incorporating convection) is preferable but requires some further development.

Potential impacts to properties by fires were estimated by intersecting a spatial layer of Victorian address points with modelled fire characteristics. It only measures the likelihood of a fire arriving at an address at a certain fire intensity and does not consider other potential contributors to risk including housing vulnerability, population behaviour and potential impacts to a neighbourhood, based on the severity level.

By measuring average modelled property impacts over each year of the fire history back to 1980, we were able to construct a profile of ‘residual risk’, revealing a temporal trend (green dashed line in Figure 3). This trend shows how the potential consequences of fires across the landscape have changed over time according to whatever mosaic of fuel-reduced patches exists at each year (from both bushfires and planned burns). Currently the residual risk is based on prescribed burning being the only treatment option.

In a similar manner, by defining potential future fuel treatments we can project the likely residual risk outcome or effectiveness of these treatments.

The residual risk profile graph becomes the main system for tracking how risk has changed in the past and for comparing the relative effectiveness of future fire management scenarios.

![Figure 2: A simulation of the 1983 Upper Beaconsfield Ash Wednesday fire using Phoenix Rapidfire. Grey shows the actual fire area, and orange/yellow shows the simulated fire area.](image)

![Figure 3: Measure of changing residual risk through time](image)
DANDELONG RANGES LANDSCAPE CONTEXT

Landscape Description

The Dandenong Ranges landscape is located on the north east urban fringe of Melbourne, starting on the western slopes leading to the Dandenong range and extending eastwards as far as Hoddles Creek and Pakenham Upper (Figure 4). It is bounded in the south by the Princes Highway. Major townships in the landscape include locations along the Dandenong range extending from Kalorama to Olinda, then extending east through Upwey, Belgrave, Emerald, Cockatoo and Gembrook.

The Dandenong Ranges landscape covers 103,000 hectares and is characterised by large areas of dense forests, interspersed with urban areas, hobby farms and primary industries such as berry and flower farms. As the closest mountain range to Melbourne CBD, the Dandenong Ranges is home to a large number of ‘tree change’ residents who commute to the city for work. Of the landscape, 82% of the land tenure is private land and 48% or 49,000ha is currently mapped as having tree cover. Of the tree-covered land approximately 60% is private.

This landscape incorporates parts of Yarra Ranges, Knox, Casey and Cardinia municipalities, and includes 8,900 ha of ‘built up’ urban land, and is home to 130,000 people. The Dandenongs is a popular tourist destination, particularly over summer months, with large numbers of people visiting attractions like Puffing Billy, Mount Dandenong, Bunyip State Park, Cardinia Reservoir and Emerald Lake.

Figure 4: General overview of the Dandenong Ranges landscape
Landscape Location and Local Government Areas
The Dandenong Ranges landscape includes parts of four Local Government Areas (LGAs): Cardinia, Casey, Yarra Ranges and Knox. A break up of the landscape by LGA is shown in Table 1 and Figure 5.

<table>
<thead>
<tr>
<th>LGA within Landscape</th>
<th>Total Area in LGA (hectares)</th>
<th>Total Area of LGA within Landscape (hectares)</th>
<th>Landscape Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Casey</td>
<td>39,690</td>
<td>5,077</td>
<td>12.8%</td>
</tr>
<tr>
<td>Cardinia</td>
<td>128,121</td>
<td>49,295</td>
<td>38.5%</td>
</tr>
<tr>
<td>Knox</td>
<td>11,386</td>
<td>2,587</td>
<td>22.7%</td>
</tr>
<tr>
<td>Yarra Ranges</td>
<td>246,818</td>
<td>45,925</td>
<td>18.6%</td>
</tr>
</tbody>
</table>

Table 1: The Dandenong Ranges landscape by Local Government Area (LGA)

Within the Dandenong Ranges landscape 19,348 hectares is public land, and 83,535 hectares is private property.

Demographics
Approximately 130,000 people live within the Dandenong Ranges landscape (Table 2) (DEPI, 2013d).

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<tr>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Casey</td>
<td>252,382</td>
<td>18,175</td>
<td>3,757</td>
<td>1,837</td>
</tr>
<tr>
<td>Cardinia</td>
<td>74,176</td>
<td>38,177</td>
<td>8,673</td>
<td>4,056</td>
</tr>
<tr>
<td>Knox</td>
<td>149,300</td>
<td>18,177</td>
<td>3,990</td>
<td>1,762</td>
</tr>
<tr>
<td>Yarra Ranges</td>
<td>144,541</td>
<td>54,574</td>
<td>10,963</td>
<td>5,857</td>
</tr>
</tbody>
</table>

Table 2: Population statistics by LGA within the Dandenong Ranges landscape
Cardinia has a relatively young population with 20% of the population below 17 and 15% over 60. Casey has an even younger profile with 28% of the population below 17 and 13% above 60. Yarra Ranges by contrast has 20% younger than 17 and 27% older than 60.

**Consideration:** Whilst Yarra Ranges has a stable population with good historic memory, the younger demographic and increasing populations in Cardinia and Casey require increased fire awareness education programs.

A large proportion of those relocating to the hilly and forested areas of Yarra Ranges and Cardinia shires are of retirement age. 30% of the Yarra Ranges population lives outside urban areas i.e. in rural interface housing.

**Consideration:** the population in the higher risk hilly forested areas is ageing and this may impact on their capacity for self-sufficiency in a fire situation.

There are 28,000 households in Cardinia shire and 87,000 in Casey, (most outside the Dandenong landscape footprint). There are 52,000 households in the Yarra Ranges shire. 75% of all households in the four shires have an internet connection and 90% have at least one car (84% for Melbourne in general).

**Consideration:** You cannot rely on electronic messaging to reach the entire community; there will be a need for other ways to keep people informed in a bushfire situation, particularly as mobile coverage is also patchy in this landscape.

50% of the workforce who live in the landscape travel outside their shire to work and 70% drive to work.

**Consideration:** A significant proportion of the population will not be at home during weekday bushfires and will need to be kept informed, and may pose a traffic issue in trying to return during a bushfire event.

Education standards in Yarra Ranges, Casey and Cardinia are lower than Greater Melbourne averages with respect to number of people with higher education degrees. All four shires are rated in the mid-range in terms of SEIFA Index of disadvantage rating of Victorian shires. The index is derived from attributes that reflect disadvantage such as low income, low educational attainment, high unemployment, and jobs in relatively unskilled occupations.

In Cardinia 7% speak a language other than English at home. In Casey, 30% of all residents speak a language other than English at home and overall there are over 200 languages, 150 cultural backgrounds and over 100 faiths in the shire. In Yarra Ranges 3.9% speak a language other than English at home.

Approximately 4% of people in the landscape report needing help in day to day lives due to a disability.

**Community Values and Assets**

Key infrastructure assets within the landscape include (VFRR, 2012):

- SP Ausnet Transmission Lines;
- Mount Dandenong Communications Tower Precinct;
- Cardinia and Silvan reservoirs;
- Cardinia and Silvan water catchments;
- Puffing Billy Railway line and station;
- Silvan Chlorine treatment plant;
- Dandenong Ranges tourism;
- Upper Beaconsfield and Gembrook water and communications towers;
- Hoddles Creek, Montrose and Yellingbo telephone exchange;
- Melbourne, Cardinia, Monbulk, Silvan and Silvan-Waverley water treatment plants;
- Kleenheat gas depot;
- 43 kindergartens and schools;
- 3 aged care facilities;
- Wandin North, Seville and Seville east repeater tower;
- Mount Dandenong, Belgrave South and Upwey Zone substations;
- Yellingbo Gas Bleedoff Valve; and
- Mount Dandenong Tourist Road, Burwood Highway, Princes Highway East, Warburton Highway, Wellington Road and the Princes Freeway.

Key environmental assets within the landscape include (VFRR, 2012):

- Dandenong Ranges National Park;
- Emerald Lake Park;
- Bunyip State Park;
- Helmeted Honeyeater population;
- Leadbeater’s Possum population;
- Southern Brown Bandicoot population;
- Beaconsfield Nature Conservation Reserve;
- Emerald Bushland Reserve;
- Wright Forest Bushland Reserve;
- Yellingbo Nature Conservation Reserve;
- Churchill National Park;
- Lysterfield Park; and,
- Dandenong Police Paddocks Reserve.
Fire History

Major Bushfires

An important part of understanding bushfire in the landscape is understanding its history. As Table 3 depicts, the area has a history of major bushfires that have led to significant loss of life and property.

<table>
<thead>
<tr>
<th>Year</th>
<th>Town/ area affected</th>
<th>Bushfire Area (ha) (private ha/public ha)</th>
<th>Human loss</th>
<th>Asset loss (Buildings)</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1939</td>
<td>Large area of Victoria</td>
<td></td>
<td></td>
<td></td>
<td>DEPI, 2013e</td>
</tr>
<tr>
<td>1962</td>
<td>Most of Dandenongs</td>
<td>4600 (9)</td>
<td>300+</td>
<td></td>
<td>VBRC, 2010b</td>
</tr>
<tr>
<td>1968</td>
<td>The Basin / Ferny Creek</td>
<td>1900 (53 houses, 10 other)</td>
<td></td>
<td></td>
<td>DEPI, 2013e</td>
</tr>
<tr>
<td>1983</td>
<td>Upper Beaconsfield</td>
<td>7153 (6579/955)</td>
<td>21</td>
<td>238</td>
<td>CFA, 1983</td>
</tr>
<tr>
<td>1983</td>
<td>Cockatoo</td>
<td>1084 (894/190)</td>
<td>6</td>
<td>307</td>
<td>CFA, 1983</td>
</tr>
<tr>
<td>1997</td>
<td>Ferny Creek</td>
<td>174 (27/145)</td>
<td>3</td>
<td>41</td>
<td>CFA and NRE, undated</td>
</tr>
<tr>
<td>2009</td>
<td>Quarry Road</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>VBRC, 2010a</td>
</tr>
<tr>
<td>2009</td>
<td>Harkaway</td>
<td>147</td>
<td>0</td>
<td>7</td>
<td>VBRC, 2010a</td>
</tr>
<tr>
<td>2009</td>
<td>Nixon Road</td>
<td>342 (166/176)</td>
<td>0</td>
<td>1 CFA tanker</td>
<td>VBRC, 2010</td>
</tr>
</tbody>
</table>

Table 3: Fire history in the Dandenong Ranges landscape
Fires in the Landscape

Figure 7 summarises the number of fires in this landscape over a 10 year period. On average the landscape experienced 95 forest or grass fires per year.

![Graph showing number of fires per year](image)

Whilst the landscape experiences a high number of fires per annum, most are quickly suppressed; analysis in Figure 8 suggests that in most years over 80% of fires on public land are extinguished at less than one hectare in size. For grassland and CFA fires, the percentage is much higher. Fire suppression remains one of the most important and effective bushfire strategies in this landscape.

![Graph showing percentage of fires controlled at less than 1 hectare](image)
Figure 9 summarises the causes of these fires. The analysis suggests a significant number are deliberately lit (26%) and many are due to human error. Both these causes can be managed by appropriate arson prevention and community education strategies but as 20% of fires have been caused by natural causes (i.e. Lightning), fire cannot be eradicated from the landscape, it is a natural process.

**Fire Ignition Points**

Figure 10 shows ignition points of all vegetation fires recorded by DSE and CFA over the past 10 years. The pattern of ignition is widespread but a very high density occurs in and around the west face of the Dandenong Ranges, and a high density in the Belgrave region, in private bush north of Cardinia reservoir and in areas south of Lilydale. These high density areas are shown as circles in Figure 10. The high concentrations that are not circled, such as those in Ferntree Gully, are in high density residential areas with little tree cover and continuity, and therefore fires are not expected to spread.

Figure 11, which shows all arson ignition points (irrelevant of whether they start in residential areas), indicates there is a high concentration of arson ignitions in the Belgrave area and on the west face of the Dandenongs.

Key insights to be drawn from the history of bushfires in this landscape are:

- Bushfires have been recorded to travel significant distances quickly, spreading at a rate of up to 8km per hour with significant spotting, recorded at up to 5km ahead of the fire front
- Even comparatively small bushfires (<500ha) in this landscape can have significant impacts, notably the 1997 Ferny Creek fire
- Whilst planning needs to consider the worst possible fire danger weather days (FFDIs of 100+), fatalities can and have occurred on lower fire danger weather days which can be expected to occur in most years (1997 Ferny Creek fire, FFDI 50)

**Consideration:** Fires in the Dandenongs on fire danger days that can occur every year can have significant impacts.

- Some of the largest bushfires have burnt mostly on private land (Upper Beaconsfield and Cockatoo fires of 1983)
- Significant bushfires occur on a 10-20 year cycle when both longer term dry climatic conditions and extreme on day weather conditions coincide
Figure 10: Ignition points from 1997 to 2009

Figure 11: Arson ignitions from 1997 to 2009 within and immediately surrounding the Dandenong Ranges landscape
Planned Burning

Planned burning programs run by DEPI on public land have treated on average 3% of the Dandenong Ranges landscape over the past 10 years (blue areas in Figure 12), however there are limited records or evidence of fuel treatment on private land, however it has been included where it is known.

Dandenong Ranges Area Fire History

Figure 12: Bushfire and planned burning history in the Dandenong Ranges landscape
Case Study of the 1983 Belgrave South Fire

The following case demonstrates many of the insights on fire in this landscape discussed in this section. The information provided is taken from a local newspaper report at the time and a CFA document of the event (CFA, 1983).

BELGRAVE HEIGHTS/BEACONSFIELD UPPER

**LOCATION**
- **General Area:** Belgrave Heights and South, Beaconsfield Upper
- **Point of Origin:** Bird's Paddock (Shire Reserve), Melways Edition No. 14 — 84 C4

**TIME OF OUTBREAK:** 1524 hours

**SUSPECTED CAUSE:** Unknown

**RESPONSIBLE AUTHORITY**
- **For Suppression:** C.F.A.
- **For Support:** Forests Commission

**MUNICIPALITIES INVOLVED**
- Shires of Sherbrooke, Pakenham, City of Berwick

**FATALITIES**
- **No.:** 21

**ESTIMATED LOSSES**
- **Area:** 9,200 hectares
- **Houses & Other Buildings:** 238
- **Sheep:** 526
- **Cattle:** 452
- **Fodder:** —
- **Fencing:** 650 kms.

**SITUATION PRIOR TO THE FIRE**

Prior to the start of this fire Region 13 Brigades had attended six fires and there had been one fire in Region 8.

By 1400 hours the temperature at Dandenong had reached 40.5°C with a relative humidity of 14%. The wind at this time was north to north westerly at 25 km/hr.

**OUTBREAK AND CAUSE**

The Belgrave South/Beaconsfield Upper fire was first reported at 1524 hours on Wednesday, 16th February, 1983.

It is suspected to have been deliberately lit in ‘Bird’s Paddock’ off Hazel Vale Road, Belgrave Heights.

This was a very destructive fire, causing the deaths of twenty-one people, (including eleven C.F.A. volunteer firefighters and one casual firefighter), razing 238 buildings and burning 9,200 hectares of grass, scrub and forest.

Most of the fire was in the country area of Victoria.

**PROGRESS OF THE FIRE**

The fuel load in the light eucalypt floor near the point of origin was in excess of 3 tonnes/ha. The fuel moisture at this point was very low, being approx. 9% (Over Dry Weight), Drought Index at Kalista — 363; fire danger rating extreme.

After ignition, the fire rapidly entered heavy fuels, and houses in the Mt. Morton Road area became involved within the first four minutes.

By 1528 hours the fire had crossed Mt. Morton Road and involved further houses. First units in attendance noted that there were many spot fires and that they appeared to be burning in many different directions. The fire continued into the Mt. Morton reserve and up the slopes of Mt. Morton, where very heavy spotting occurred.

At 1602 hours it crossed the Belgrave-Hallam Road, again with very heavy spotting activity; and at 1608 hours it crossed Wellington Road. Spotting activity was so intense that, between 1620 hours and 1640, spot fires were recorded as far away as Tooradin, some 30 km.

Sparsely fuel in Wellington Road and Belgrave-Hallam Road areas varied in some pasture paddocks between 0.87 tonnes/ha and 1.75 tonnes/ha, consequently a mosaic of burnt and unburnt areas appeared.

There appeared to be no main head of the fire, but instead there was a series of rapidly developing spot fires. At 1630 hours another spot fire developed about 5 km south of the main series of fires, and by 1735 hours had crossed the Beaconsfield-Emerald Road.

Further spotting activity continued from all parts of the fire and at 1621 hours another spot fire occurred north of the Princes Highway and west of Officer.

This fire crossed the Princess Highway, but was fairly easily contained because of light grass fuels. After this time, spotting became less intense to the south of the main fire. Spotting occurred in the Pakenham Upper area from 2015 hours from the Cockatoo fire before the wind change. However, spotting was still occurring within the main fire area. An overall average rate of spread for the north south run of the fire was 5.07 km/hr. At 2050 hours a violent south westerly wind change, with winds between 70 and 80 km/hr hit the fire area.

**Fire After the Wind Change**

With the exceptions of the areas from the point of origin south east towards Wellington Road and areas to the north west of Officer, the eastern flank was lost on the wind change. After the change there was severe spotting activity and a front of the fire entered the township of Beaconsfield Upper at approximately 2100 hours.

Fire destroyed the Beaconsfield Upper General Store and other buildings at 2100 hours. “Fire storm” activity was reported by many witnesses as the fire progressed in a generally ENE direction in a series of spot fires. For this reason reliable rates of spread calculations are not valid.

Fuel loads on the forest floor in Pakenham Upper were measured in the vicinity of 7, 14 and 16 tonnes/ha. The latter fuel loads in the gullies, which were abnormally dry, coupled with the slope and aspect of the land and extreme weather conditions, resulted in very intense fires in these localities.

Once into the grassland the fire began to slow down and there was evidence of a very patchy burning pattern to the east of Beaconsfield Upper, in some grassland areas the fire was “blown out” by the force of the wind and its easterly spread was finally halted at about 0430 hours.

Because of the excessive spotting activity the fire was still active within the general perimeter for several days.
THE FIREFIGHT
The initial turnout to this fire was four units from the Dandenong Ranges Group. Because of the very fast build up of the fire, extra vehicles were requested, and within ten minutes there were 14 units on Mt. Morton Road. As the situation developed, with houses burning, panic among residents, and traffic leaving the area, co-ordination of forces was difficult, therefore units concentrated on attempting to save individual houses and property.

The East Central Zone aircraft was on the scene within minutes and, as its reports were discouraging, virtually the whole of the Dandenong Ranges, Knox and Pakenham Groups were committed. As the situation continued to deteriorate units from Region 26 were also committed and Regional Officers began organising supports from other Groups in Regions 13 and 8 and from other Regions.

In an endeavour to provide forward control, the Dandenong Ranges Group set up a Forward Group Headquarters at the Belgrave South school. With this very quick build up of both fire and vehicles, and the difficulties of command and co-ordination becoming obvious, it was decided to divide the fire into two distinct sectors of responsibility.

1. North of Wellington Road — Region 13 — Control to be maintained by the Dandenong Ranges Group from both the static headquarters at Belgrave and the Forward Headquarters at the Belgrave South school.

2. South of Wellington Road — Region 8 — Control to be maintained by the Pakenham Group from the static headquarters at Beaconsfield Upper. This division allowed a more effective use of resources and the opportunity to work the fire on two radio channels.

However, some difficulties were encountered. Support vehicles from the south were not reaching their destination as they were encountering the fire on route. This situation crested difficulties in determining "which unit was where".

The Dandenong Ranges Group made a decision to concentrate efforts on the eastern flank of the fire and not to have vehicles make individual efforts to save houses. Whilst this no doubt resulted in the loss of some homes, the decision proved to be correct as, on the wind change, only one significant breakaway occurred north of Wellington Road. Had this area not been secured prior to the change losses may have occurred in the Belgrave South-Selby areas.

As the amount of support coming to the fire was becoming impossible for the Pakenham Group to control, a Forward Regional Headquarters was established at Akoona Park, Berwick, to relieve the Group of this responsibility and provide a liaison point for assisting organisations. Because of the rapid spread and heavy spotting of the fire, both Groups had great difficulty in assessing its progress.

Units were having little trouble containing the fire in grasslands but were finding it an impossible task in timbered areas, although the north-south run of the fire was checked prior to the wind change. A concentrated effort was made on the south eastern edge of the fire to secure this area before the expected change. With limited time and vehicles, excellent work was done and the area held during and after the change.

Unfortunately, despite much hard work in difficult conditions and terrain, much of the eastern flank was lost on the change. During the initial stage of the change fire conditions were such that firefighting was not possible because of the strong winds which gusted up to 70 km/hr.
Landscape Attributes Affecting Fire Behaviour

Forest Cover
The landscape comprises approximately 103,000 ha of land, of which 20% is forested public land and 25% is forested private land. Approximately 60% of the forested land is on private property. Of the 30,000 hectares of forested land in the landscape which is suitable for fuel reduction burning, 66% is on private property and is a significant bushfire risk factor in the Dandenong Ranges landscape.

A significant factor influencing bushfire risk in the Dandenong Ranges landscape is the forested areas of public and private land, and for this reason effective fuel management must consider the whole landscape.

Figure 13: Tree Cover with Crown Land

Climate
The landscape has a history of bad fire weather days. Analysis of data suggests that over the last 25 years the landscape has averaged six total fire ban (TFB) days per year with a maximum of 18 in 2009. By comparison the North East TFB District has averaged eight and the South West TFB District six over the same period. Anecdotal knowledge however suggests that there is much variation across the Central TFB District and many of the declared TFB days for Central would be much more benign in the Dandenong Ranges, with perhaps only 50% being genuine TFB days.

By comparison in Figure 14, the area has experienced on average eight TFB days per year over the past decade.
Analysis of weather conditions on Black Friday, Ash Wednesday and Black Saturday show that there are two predominant conditions which, when combined, can result in extreme fire weather days. These two conditions are:

- Long term dryness
- A synoptic pattern characterised by a cold front or trough moving into Victoria from the west and high pressure in the Tasman Sea. This pattern can result in very hot, dry air moving into Victoria with strong north westerly winds, and a gusty south westerly wind change usually late in the day.

**Typical Fire Weather Conditions for the East Central Bushfire Risk Landscape**

Hourly Forest Fire Danger Index (FFDI) observations from Automatic Weather Stations (AWS) (Figure 15) within East Central BRL during summer from 1 Dec 1997 to 28 Feb 2009 was analysed to provide localised fire weather conditions.

The results show the maximum hourly FFDI recorded (Figure 12), the likely highest FFDI for each AWS each year (Figure 18), and the likely fifth highest FFDI for each AWS each year (Figure 14).

For this area, FFDI peaks at Kilmore Gap AWS for both the maximum FFDI and the highest each year. This is likely due to the funnelling effect at Kilmore Gap that results in an increase in wind speed and a subsequent increase in FFDI compared to other locations. The influence of coastal weather patterns is clear in all three figures, with FFDIs being milder at Rhyll and Cerberus compared to most inland locations. Mount Baw Baw AWS consistently records the lowest FFDI observations throughout the observation period. This AWS is located 1561 metres above sea level, so the very mild FFDI observations are likely due to the cooler, milder weather conditions at high elevation. Each of the maximum FFDIs recorded during the observation period occurred on Black Saturday, except Mount Baw Baw. However Mount Baw Baw is missing observation for both 15:00 and 18:00 on this day.

**Consideration:** The Dandenongs can expect a severe fire danger day every year, but only a few days a year would be above Very High. A Code Red rating day is very rare.
Future Trends

Changing climate
The CSIRO and Bureau of Meteorology State of the Climate 2012 report for Australia found that since 1950 annual-average daily mean temperatures have increased by 0.9°C. The rainfall for south eastern Australia has been decreasing in late autumn and winter over the last decade.

The Report on Climate Change and Greenhouse Gas Emissions in Victoria (As required under Section 17 of the Climate Change Act 2010) (DSE 2012) estimates the following projected changes for Victoria's weather:

- Average annual rainfall to decrease, predominantly in winter.
- Stream flow reductions likely to be greater than changes in rainfall.
- The number of days over 35 degrees Celsius in Melbourne may increase from 9 days in 1990, to 11-13 days by 2030, and to 15-26 days by 2070.
- There may be fewer and heavier rainfall days, and more consecutive dry days.
- The extent and frequency of droughts may more than double by 2050.
- The frequency of very high fire danger days may substantially increase. Melbourne’s extreme fire danger days may double to five per year.

The report cites research undertaken by Lucas et al (2007) that shows a recent increase in fire danger and the length of fire season for Victoria in recent decades. This increase in fire danger is linked to the recent drought in 1997-2007, which was accompanied by higher maximum temperatures. It is also expected that there will be more dry lightning, which is currently the cause of 20% of ignitions.

In 2006, Hennessy et al. at CSIRO, the Bureau of Meteorology and Bushfire Co-operative Research Centre (CRC) released a study on ‘Climate Change Impacts on Fire-Weather in South-East Australia’. The study built on climate change projections from 2001 (CSIRO) which indicated that south eastern Australia would become warmer and drier into the future. Hennessy et al. (2008) used climate change models to create projections for 2020 and 2050, and calculated FFDI (McArthur Mark 5) and Grass Fire Danger Indices (GFDI) (McArthur Mark 4) for these projections. The results were:

- The number of days with very high or severe FFDI ratings are likely to increase by 15-70% by 2050.

While we may expect an increase in the potential for bushfire as drought and severe to extreme fire weather conditions become more common, the exact effect on intervals between bushfire events depends on a number factors, such as fuel availability.

Overall the analysis suggests that:

- Fires are happening more often and this will increase.
- Fire severity is increasing.

Urban and Population Growth
According to the Growth Areas Authority report “Growth Corridor Plans: Managing Melbourne’s Growth” (2012) Melbourne’s population is projected to grow from 4 million to 6 million over the next 30-40 years. Draft Growth Corridor plans have been released in four precincts including the South East Corridor which includes Casey and Cardinia.

Cardinia Shire’s population has grown by on average 5.3% over the past 5 years, which equates to 17,000 new residents. The shire population in the area from Beaconsfield to Pakenham, which is within the Dandenong Ranges landscape pilot, is expected to increase from 16,000 in 2010 to 80,000 by 2021. Similarly the Shire of Casey has experienced a 33% population growth in the period 1997 to 2007 and the overall shire population is expected to double by 2036. While population increase is important, but almost more important is the fact that current planning regulations mean that housing density and tree clearing is limited in most of the fire prone areas. The majority of the expected population increase within the Dandenongs landscape will be in high density urban areas with a lower fire risk.

Population growth is important in an analysis of fire risk for both risk likelihood and risk consequence reasons.

Increased population leads to increased ignitions both of human error caused fires and arson.

Increased population leads to a higher urban forest interface and hence an increased consequence of house loss from a major bushfire.

Consideration: Urban Growth will have an increasing impact on bushfire risk especially in Cardinia Shire which lies within the Urban Growth Area.
RISK ASSESSMENT

Risk Definition
The International Standard for Risk Management (ISO 31000) defines risk as the effect of uncertainty on objectives. In a bushfire context this would include the effect of uncertainty on our objective of protecting human life and property.

Risk is often characterised by reference to potential events and the consequences of these events. In the Victorian bushfire context this is associated with reference to major historic bushfires, such as Ash Wednesday or Black Saturday when most of the historic life and property loss has occurred. In planning for risk mitigation, it is standard practice to consider the worst case scenario, for this reason consideration of bushfire risk in this paper will primarily consider a major bushfire of Black Saturday proportion with an FFDI of 130 (Code Red Fire Danger Rating) which is a low likelihood.

Historically such events occur every 10-20 years. Typically, the highest FFDI expected to occur in any given year is approximately 50 (Very High to Severe Fire Danger Rating) therefore a high likelihood. This FFDI will be used in a small number of products in this assessment.

Bushfire risk is expressed in terms of a combination of the consequences of an event and the associated likelihood of that event happening. Where a scenario has a low likelihood and a high consequence, it would be a significant event that impacts on a large area and/or many people but is not likely to happen often. Where a scenario has a high likelihood but a low consequence, it would be a frequent event that has a low level of impact, we need to consider all of these scenarios when planning for community safety.

Factors affecting likelihood are:
- Likelihood of a fire starting
- Likelihood of a fire reaching a specific point in the landscape
- Likelihood of a weather scenario occurring

The level of consequence of an event is dependent on the vulnerability of the asset or value that you wish to protect. Whilst protection and preservation of human life is paramount, other values to be protected include critical infrastructure and community assets, residential property, individual livelihoods and economic production, biodiversity, environmental and water production assets.

Factors affecting the consequence of people and their property in the Dandenong Ranges landscape are:
- Assets at risk (PIPES), namely: people, infrastructure, public administration, economic and social.
- Population density, demographics, awareness of the risk, level of preparedness and resilience.
- Community preparedness: the response capability, house preparation, warning systems etc.

Many tools exist to identify assets at risk including the Victorian Fire Risk Register (VFRR) analysis at a municipal level, State significant asset registers and industry profiles. Many tools exist to assess risk, and all have their strengths and weaknesses. In many cases they complement each other and provide a broad picture of the risk. The main tool used in this analysis is Phoenix Rapidfire modelling, as described in the data and method sections of this report. Other tools which are used include the CFA VFRR and HILI.

Residual Risk Profile
The residual risk profile of a landscape will fluctuate with availability and accumulation of fuel, which is influenced by planned and unplanned (bushfire) events. However, the Dandenong Ranges landscape has shown an historically high level of residual risk. The lowest risk level captured in the analysis is around 80%, and follows the Ash Wednesday fires which included severe fires in Upper Beaconsfield and Cockatoo. These fires did not affect large areas of the landscape, and therefore the residual risk of 80% meant there was still potential for other bushfires to cause significant impacts. After this time, the residual risk had risen to 93% by 1998, reaching its maximum level (100%) in 2009. Currently the residual risk remains at its maximum of 100%.

As shown in Figure 19, when we project DEPI’s public land planned burning program as detailed in the Draft Fire Operations Plan for 2013/14 – 2015/16, the modelled risk is predicted to slowly decrease, but only to around 90-95%. There is no discernable difference in modelling between the highly treatable and moderately treatable vegetation. This analysis suggests the current planned burning program will have some effect in reducing risk but this is limited due to the high proportion of the forested area which is too wet to effectively burn under safe conditions (Ash forest) and the high proportion of highly fragmented forested private land. Figure 31 indicates that the absolute minimum residual risk that can be obtained through public land burning is around 75% so a reduction of 5 to 10% of risk over three years would be a good result.

There may be an opportunity to target the public land planned burning program to areas which will more effectively reduce the risk, however there will still be a high residual risk which must be managed by other strategies including planned burning or fuel reduction measures on private land.

Planned burning can contribute to safer communities but on its own it will not reduce risk to acceptable limits.

It is notable that risk modelling does not currently account for the contribution of other fuel reduction programs such as strategic fuel breaks, community education, etc in the reduction of risk. Whilst DEPI and its partner Parks Victoria currently burn approximately 3% of the park area per annum, they also slash a similar area. Given the limited potential of planned burning this is a sensible complementary program to reduce risk.
The residual risk profile in Figure 19 is only relating to the residual risk to property assets. There are other types of risk that in the future may be modelled for example infrastructure.

Impact Risk: Relative Risk in the Landscape
Phoenix Rapidfire can overlay the modelled fire spread paths created from the ignition grid to give an indication of the areas that are more likely to be frequently impacted by fires. We can use the modelling to determine the impact to the localities within the Dandenong Ranges area.

The impact risk to properties in the Dandenong Ranges landscape is shown in Figure 20. Impact risk is developed by weighting the number of properties impacted per 180m cell, by the amount of times that cell is impacted by the grid of fires. This is just one of the methods that DEPI is investigating and can be used to compare with other methods of determining risk such as the CFA’s VFRR.

Within the Dandenong Ranges landscape, the areas of highest modelled impact risk include Yarra Junction and Launching Place along the Warburton Highway, Cockatoo, Maryknoll and Monbulk. There are also other areas which have a high modelled impact risk, including Belgrave, Emerald, Upper Beaconsfield and Gladysdale.

To put the risk in the Dandenong Ranges landscape into context, the neighbouring Warburton Valley has areas with a much higher impact risk.

Impact Risk - Dandenongs Ranges

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To put the risk in the Dandenong Ranges landscape into context, the neighbouring Warburton Valley has areas with a much higher impact risk.
**Ignition Threat**

The ignition threat map for the Dandenong Ranges landscape (Figure 21) shows that any ignition starting on or adjacent to the western face of the Dandenong Ranges will cause many thousands of house losses based on the worst case scenario. It is immediately obvious that fuel treatment works carried out in this area will have substantial benefits, not just in the local area but the wider Dandenongs area where fires are likely to spread.

**Ignition Threat - Dandenong Ranges**

![Image: The Dandenong Ranges landscape modelled ignition threat](image)

Fires from as far away as Kinglake are able to reach the Dandenong Ranges landscape, these fires would impact on the eastern side of the Dandenong Ranges area. There is a strip of modelled ignition points with moderate ignition threat (when modelled, these ignition points cause a moderate level of house loss) between Lilydale and Healesville where fires are able to spread into the Dandenong Ranges landscape (Figure 21). To the south of the landscape along the Princes Freeway in the built up area, fires ignited do not impact on houses. Fires starting in the west of the Dandenongs near the west face of Mt Dandenong are the worst ignition locations for impacts to life and property, as seen in the orange dots in Figure 21. The ignition threat does not consider the likelihood of something occurring at a specific location including increased likelihood due to populations nearby or a reduction in likelihood due to arson prevention as well as rapid detection and suppression.

**Fire Impact Frequency**

Figure 22 shows the result of impact frequency modelling for the Dandenong Ranges landscape. Within the landscape the fire impact frequency is generally low, however moving from west to east the frequency increases towards moderate, meaning that from the 1km ignition grid the further east in the landscape, the more likely a fire will impact on an area based on the worst case scenario.

The modelled loss level impact frequency is also low for the majority of the landscape (Figure 22), however for a small amount of the landscape the loss level spread frequency does increase above the lowest level: near Silvan Reservoir, Cockatoo and Upper Beaconsfield. The loss level impact frequency increases rapidly in Bunyip State Park.
Indicative Fire Path

Figure 23 and Figure 24 show an indicative fire path for the Dandenong Ranges landscape. This is the one of the worst fire spread paths based on the worst case scenario over a 12 hour Phoenix Rapidfire simulation. The scenario was run at both FFDI 50 (severe fire weather, annual event) and FFDI 130 (worst case scenario).

For a fire on a day of FFDI 50 (severe fire weather, annual event), igniting south of Doongalla Road The Basin at 11am, with no fuel treatment or fire suppression, a fire has the potential to:

- Reach up to 600 ha;
- Impact on 750 houses/properties;
- Impact on the townships of The Basin, Olinda and Sassafras;
- Will reach The Basin within 0-2 hours, Sassafras within 1-9 hours and Olinda within 2-10 hours of ignition (Note that due to the slower movement of the FFDI 50 fire, there are variations as to when fires impact different areas of the towns, for example some parts of Sassafras were impacted within an hour, but other parts of the town were not impacted until many hours later)
- Causes traffic disruption and the closure of Mountain Highway, the Mount Dandenong Tourist Road and Olinda-Monbulk Road; and
- Impact upon: five human settlements, three schools and the Mount Dandenong Tourist Road (no critical assets).
Figure 23: Indicative fire path within the Dandenong Ranges landscape on a day of FFDI 50

Figure 24: Indicative fire path within the Dandenong Ranges landscape on a day of FFDI 130
For a fire on a day of FFDI 130 (catastrophic fire weather), igniting south of Doongalla Road The Basin at 11am, with no fuel treatment or fire suppression, a fire has the potential to:

- Reach up to 39,400 ha;
- Impact on 11,500 houses/properties;
- Impact on the Basin within 0-3 hours, Sassafras within 1-3 hours, Olinda within 1-8 hours, Sherbrooke within 1-2 hours, Kallista within 2-3 hours, Ferny Creek within 2-5 hours, Selby within 2-7 hours, Belgrave within 2-8 hours, Menzies Creek within 3-4 hours, The Patch within 3-5 hours, Emerald within 4-6 hours, Clematis within 4-7 hours, Dewhurst within 5-7 hours, Monbulk, Nar Nar Goon and Pakenham Upper within 6-7 hours, Mount Burnett within 6-8 hours, Maryknoll and Tynong North within 7-8 hours, Silvan, Cockato and Avonsleigh within 7-9 hours, Mt Dandenong within 7-12 hours, Macclesfield within 8-9 hours, Kalorama within 9-10 hours;
- Causes traffic disruption and the closure of the following main roads: Beaconsfield – Emerald Road, Emerald Monbulk Road, Sherbrooke Road, Sassafras Creek Road, Monbulk Road, School Road, Storyford Road, Reservoir Road, David Hill Road, Macclesfield Road, Bessie Creek Road, Morrison Road, Dore Road, Belgrave Gembrook Road, Kallista Emerald Road, Healesville-Koo-Wee-Rup Road, Pakenham Road, Bourkes Creek Road, Mount Dandenong Tourist Road, Pakenham Road, Wellington Road, Woori Yallock Road and Tynong North Road; and
- Impact on the following critical assets: 47 Human Settlements, St Mathews Anglican Church, Puffing Billy Railway and Stations, Silvan Water Catchment, Cardinia Reservoir Drainage WPS, Belgrave, Selby and Yarra Valley Water Towers, Belgrave South Zone Substation, US Buslines, Yellingbo Gas Bleedoff Valve, Silvan Waverly WTP, Silvan WTP, Monbulk WTP, Melbourne WTP, Kallista WTP, Helmeted Honeyeater and Leadbeater's Possum populations, 13 kindergartens/schools, Kadampa Buddhist Temple, one childcare center, three aged care facilities, Beaconsfield – Emerald Road, Belgrave Gembrook Road, Healesville-Koo-Wee-Rup Road, Mount Dandenong Tourist Road, Pakenham Road, Wellington Road, Woori Yallock Road, eight transmission lines, Emerald Lake Park and the Cardinia Water Catchment.

In addition to this example, a number of other indicative fire paths have been developed and run at FFDI 130 and 50 across the landscape and provided to project team members to assist in other aspects of the Dandenong Ranges Pilot including traffic modelling and community behavioural modelling. These include: Belgrave South, Wandin East, Monbulk and Kalorama.

**Fire Ecology**

The current measure to determine the status of an ecosystem is Tolerable Fire Interval (TFI), the state of the vegetation in relation to time since fire and it’s susceptibility to a future fire event. This is based on plant fire responses and the natural fire regime for an Ecological Vegetation Community (EVC). There are several hundred EVCs mapped in Victoria and due to lack of knowledge of all of these EVCs and a similar reaction to fire, for the purposes of fire planning, EVCs have been aggregated into larger groups called Ecological Vegetation Divisions (EVDs) (Cheal 2010). These EVDs capture the variation in a particular ecological landscape and have a recognizable set of characteristics, for example, the large range of coast EVCs dominated by salt-tolerant shrubs are grouped as coastal. To understand the natural fire regimes for EVDs, DEPI has taken the approach first outlined by Noble and Slatyer (1980) to put together a database of vital attributes of plant species.

The majority of the land tenure within the Dandenong Ranges landscape is private land. In relation to private land within the sub-landscape, Figure 25 shows 36% of the total sub-landscape has no recorded logging or fire disturbance and 26% is above maximum Tolerable Fire Interval (TFI), both of which are likely to be overestimates due to the lack of logging history and fire history for prescribed burning on private land.
In looking at this measure of landscape risk, this graph shows that there are more ecological communities below the minimum tolerable fire interval on public land (6%) compared to private land (2%). This is not unexpected due to the Government’s prescribed burning within the public land estate to reduce bushfire risk to community and due to lack of information on fire history for private land.

8% of the EVDs within the Dandenong Ranges landscape are below minimum TFI (Figure 26 and Figure 27). Figure 27 shows that most of the EVDs that are below minimum TFI are those that are fire dependent and fire influenced, with only a very small amount of the fire sensitive EVD, Closed-forest below minimum TFI. It is also not surprising that there is Tall Mist Forest below minimum TFI as its tolerable fire interval is 80 years and in this time there have been the wildfire events, of 1962, 1983 and 1997 that burnt areas of Tall Mist Forest.

Only 3% of the public land is above maximum TFI compared to private land at 26%. These areas above maximum TFI on public land are often targeted for prescribed burning and therefore it is not surprising that only 3% of the public land is above maximum TFI. Figure 27 shows that most of the vegetation that is above maximum TFI is fire dependent EVDs.

The Dandenong Ranges landscape has many fire sensitive and fire dependent vegetation communities that are not treatable by prescribed burning. These are mostly wetter communities such as the wet forest, tall mist forest and closed forests communities. Although normally not able to be burnt through prescribed burning due to being too wet, in hot dry summers are capable of carrying fires of catastrophic proportion. Many of these EVDs are near to human communities and assets, which presents a fire protection problem for the community to reducing the residual risk of bushfire to the Dandenong Ranges landscape through fire management.

Figure 26: Area below minimum TFI in the Dandenong Ranges landscape
A large proportion of the Dandenong Ranges landscape is made up of forest vegetation communities and these are very close to human assets. As the closest mountain range to Melbourne this landscape has a high population, high amount of assets and high visitation. The landscape provides aesthetically appealing landscapes, biodiversity and natural values, such as clean water, clean air, recreation, tourism and many other values. The Dandenong Ranges landscape has a number of townships with a high bushfire risk and trying to manage this bushfire risk by management of the vegetation on public land using prescribed burning is very challenging. Figure 28 shows that the landscape has a large amount of vegetation within TFI, with most EVDs having a limited amount of vegetation below minimum TFI (aside from Tall Mist Forest), and only Heathlands Sands having a large amount above maximum TFI.
Fuel Management and Residual Risk

Scenario Testing

Scenario testing can be used to attribute the landscape residual risk to either public land or private property.

This section discusses how this analysis was undertaken at a broader level across East Central BRL and may be undertaken in future analysis for the Dandenong Ranges landscape.

Public versus Private land

Two hypothetical scenarios were created: (1) where all treatable public land was fuel-reduced at once and (2) where all treatable land on both private property and public land was fuel reduced at once. The grid of fires was re-run over the landscape to see the difference to how major bushfires might spread and impact properties. The results of this modelling is shown in Figure 29.

The light green bar in Error! Reference source not found. shows that 80% is the minimum residual risk that could be achieved by burning all highly treatable public land in the Dandenong Ranges landscape. The light red bar demonstrates that if all highly treatable private land were treated as well, the minimum residual risk could be reduced to near 15%. If moderately treatable fuels were also able to be treated, the minimum residual risk we could achieve through fuel management on public land only is just under 75%, but on all tenures it is between 0 and 5%. The remaining residual risk reflects potential property impacts that are not related to treatable public or private land, most likely from grassfires that impact properties through fireline intensity from grassfire flames.

Overall it appears that to successfully reduce impacts to properties in the Dandenong Ranges landscape, fuel management strategies that integrate private and public land fuel hazard along with public land planned burning, would be most effective. Purely focusing on public land planned burning has a limited effect.

It is important to note that these are purely theoretical tests of the absolute limits. Actual contemporary burning regimes would never reach these levels.

Figure 29: Residual risk graph and treatment and tenure modelling for The Dandenongs
Treatment level analysis

A second type of scenario testing was used to understand how much planned burning should be conducted in the landscape. Figure 30 shows the effectiveness of different burning levels, on different land tenures in the landscape. Again for this analysis, the covered geographic area was the East Central Bushfire Risk Landscape, which goes from Puckapunyal to Wilsons Promontory and wholly includes the Dandenong Ranges. For instance, if 5% of the treatable public land in the landscape was burned every year, the residual risk would be 85-90%. If 5% of all treatable land across any land tenure (all tenure) was burned every year then the residual risk would drop to 70-75%. Similar to the result from the previous scenario testing, residual risk is significantly lower at all treatment levels when burning all tenures, rather than just public land. Again, planned burning strategies in the East Central BRL should be integrated across both land tenures in order to have the greatest effect on residual risk. Both graphs of treatment level show that the residual risk decreases exponentially as the treatment level increases. There is an area from burning 2% every year to burning 10% every year, where there are the greatest efficiencies are to be gained. Above this point, the decrease in residual risk is minimal for every additional treatment level. It is important to note that this analysis was done with the grass fuel load at 5t/ha which was an older methodology while the previous analysis in Figure 29 was done at 2t/ha. Both analyses are still scientifically valid, however this explains variations in the results where they would be expected to be the same.

![Figure 30: Planned burning treatment level analysis for the East Central BRL](image-url)
CONCLUSION

Key Findings and Recommendations

Key findings

1. The Dandenong Ranges is a high bushfire risk area
   - The Dandenong Ranges landscape is a very small proportion of the overall State of Victoria (0.45% of the area), yet analysis suggests it contains about 3% of the State’s overall exposure to bushfire risk.

2. It is not all about the ridge line
   - Although we traditionally think of and define the Dandenong ranges as the immediate ridgeline, in a fire sense, we need to think of a broader definition which considers not just where fires start, but where they spread and impact upon. Major fires that start around the Dandenong Range, can in fact impact as far away as Pakenham Upper, hence we need to define a broader landscape for effective planning.

3. The bushfire risk cannot be eradicated, there has been and will be major fires in the landscape
   - History shows this area has been subject to major fires and the residual risk profile shows even in times of significant fuel reduction, the area maintains a high risk.

4. The level of risk is dynamic, it varies each year
   - The level of risk will vary from year to year dependant on such things as fuel loads and how they accumulate and also in terms of fuel availability. The area contains significant areas of wet forest which in normal years are less available to burn than in years following protracted or severe drought conditions.

5. Future risk likely to increase with population pressures and climate change
   - Climate change suggests that we are less likely to get ‘normal fire seasons’ as experienced in the past and more likely to get bad fire seasons, predictions suggest we could experience 20% more severe fire weather days in the future than we have in the past. Population increases will impact on the likely consequences of such fires, and can also increase the number of fire ignitions. Arson, for example, is closely linked to human settlement / forest interfaces.

6. There is only so much that can be achieved with fuel treatment
   - Firstly, fires are more ‘fuel driven’ for FFDIs up to 50 and more ‘weather driven’ for FFDIs above this. Fuel treatments will have a greater impact on a total fire ban day of FFDI of 50 but will be less effective on a catastrophic day.
   - Second, there are some major impediments to effective fuel treatment in this landscape. There are a high proportion of wet Ash forests on public land which carries high fuel loads but is difficult to treat.
   - Third, of the treatable forest area, 60% is actually on private not public land and coordinating and managing the effective treatment of this has many practical difficulties.

7. Risk mitigation requires a combination of strategies, treatments and is best achieved in an integrated manner across the landscape
   - A range of strategies, coordinated across the landscape, is needed to address priority risk treatment areas. For example high consequence ignition areas can benefit from targeted arson prevention programs, community education and planned burning. Priority fuel treatment areas may have a composite of strategies from roadside slashing to fire prevention notices, land use planning restrictions to planned public and private land burning. It may also include strategies such as shelter options, suppression, relocation, evacuation or warnings.

8. If a location or asset is at risk, the best mitigation treatment may not be in the immediate area
   - The risk may be more effectively treated at the ignition source, which could be 20 kilometres away
   - The risk may be treated in the landscape to break up the fire spread path and stop the build-up of convective energy
   - The risk may be treated at the point of impact, around the home, or township or asset at risk
   - The risk may be treated by methods other than prescribed burning
   - The risk may best be treated with a combination of these approaches

9. Understanding the risk and fire behaviour can improve or enhance all strategies within the Dandenong Ranges Project

10. The risk is not evenly spread across the landscape, it is possible to identify priority areas for risk treatment
    - Whilst the landscape is a high risk environment it is possible to identify key areas for treatment which will reduce the overall risk level and to prioritise these. This report indicates some of these areas however this will be explored in more detail in the fuel management paper.

11. Residents and the community are part of the solution so they need to understand the nature of the risk and be able to act
    - Not all of the risk can be managed by fuel treatment or other agency actions; it requires residents to assume some responsibility for their safety. A community that understands its risk exposure will be more resilient, and a resilient community will respond and recover from a major bushfire better than an ill prepared one.
Recommendations

1. Risk is characterised by reference to potential events and the consequences of these events. In the context of the Dandenongs, the Dandenong Bushfire Risk Landscape Project should plan for:

   · More days of severe to extreme fire danger ratings with consequently more damaging fires, more often,
   · Fast running fires with the potential to spread at up to 8km per hour and spot for more than 10 kilometres,
   · One day fire events which have the potential to spread up to 30 kilometres in that time period,
   · Fires being characterised by strong NW winds up to 70km /hour (but gusting higher) ahead of strong SW changes which will cause the greatest threat to life and property,
   · Climatic conditions which shall see dry cycles that increase fuel availability and risk every 10-20 years,
   · Ember attack and loss of visibility extending significant distances ahead of the actual fire zone with potential to start new fires and cause house loss.

2. The project will need to continually improve understanding of the landscape and the fire behaviour and risk models used in planning, examples of improvements on the analysis which could be undertaken include:

   · Use of more representative and localised weather data,
   · A method of weighting the likelihood of ignition sources in the analysis,
   · More analysis of fuel availability,
   · Testing of risk at differing levels of FFDI.

3. The project should consider both the risk to the Dandenong Ranges from neighbouring areas, and the risk to neighbouring areas from the Dandenong Ranges, such as the Warburton Catchments and Latrobe Valley areas.

4. The project should adopt a science and an evidence based approach in discussions with the community.

5. Reporting on the level of risk and reviews of knowledge and model inputs should be undertaken regularly.

6. A common understanding of bushfire risk should inform all themes of the Dandenong Ranges Landscape Bushfire Project.

7. A data and mapping platform should be established to allow sharing of information across agencies and the community.
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NOTES