Department of
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The impacts, losses and benefits sustained from five severe bushfires in south-eastern Australia

Fire and adaptive management

report no. 88

State Government Victoria

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Please be advised that the information contained in this report comprises statements based on the data available. The reader is advised and needs to be aware that such information may be incomplete and will therefore need to reference back to the original source to fully understand the information in its original context.

Photo: Front cover: Catherine Stephenson

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Summary

Whether started by natural means (e.g. lightning) or deliberately lit (e.g. fire authority prescribed burns), bushfires are a frequent ecological disturbance in many parts of Australia. In some cases, however, they can impact on numerous economic, social and environmental elements, causing widespread destruction and disruption. To better understand these impacts and associated costs, the objectives set out at the beginning of this project were to:

1. Establish a framework for a more efficient capture and representation of severe fire impacts, and
2. Determine the economic, social and environmental impacts of major Victorian bushfires.

Once the costs associated with economic, social and environmental impacts were estimated, the results could be used to inform land and emergency management departments' policies and strategies associated with prevention, preparedness, response and recovery (PPRR).

While researching and reviewing relevant existing frameworks for establishing a framework as set out in objective 1 above, several that suited the requirements of this project were found and fourteen of these were assessed against 13 selection criteria (worth 3 points each), resulting in two frameworks receiving the highest score of 38 out of a possible 39 points. Given that both frameworks focused on different aspects of an economic loss assessment, both were used at different stages of this report's assessment.

The Disaster Loss Assessment Guidelines (Handmer, Reed and Percovich 2002) were used first, as they contained practical steps to ensure that good economic principles were being followed. An important step was to define the spatial and temporal boundaries of the assessment. The spatial boundary was defined as the boundaries of local government areas that had been burnt to some extent, while the temporal boundary was defined as two years after the fire was declared safe.

Following from this, The Development of a Socio-Economic Impact Assessment Model for Emergencies (or SEIA-Model) (Office of the Emergency Services Commissioner (OESC) 2008a) was used as the template to enter and value the bushfire data. When valuing environmental impacts, the ecosystem services method used by Costanza et al. (1997) was employed.

The five bushfires studied in this report were the:

- 1983 Ash Wednesday Fires (Victoria only)
- 2003 Alpine Fires
- 2005–06 Grampians Fires (including Deep Lead and Mount Lubra)
- 2006–07 Great Divide Complex Fires (Great Divide Complex North, Great Divide Complex South, Tatong–Watchbox Creek, Tawonga Gap and Coopers Creek fires)
- 2009 Black Saturday Fires (including Beechworth–Murmungee, Bunyip Ridge Track, Churchill–Jeeralang, Coleraine–Glenelg Highway, Delburn Complex, Horsham–Remlaw Road, Kilmore East–Kinglake Complex, Maiden Gully–Bracewell Street (Bendigo), Murrindindi Mill–Marysville Complex, Redesdale–Coliban Park Road, Weerite–Danedite Road and Wilsons Promontory National Park–Cathedral).

Both the losses sustained by the community and benefits gained after the event (i.e. government aid) were included, with the net economic loss of the five fires (i.e. losses minus benefits) being very high. The net losses were (in 2008 Australian dollars): Ash Wednesday Fires – \$795 million, Alpine Fires – \$2.691 billion, Grampians Fires – \$407 million, Great Divide Fires – \$2.002 billion and Black Saturday Fires – \$925 million. Not all losses could be valued at the time of writing, which will therefore push the net loss even higher once they are. Although these values may seem excessive, they are comparable with several other studies from Australia, USA and New Zealand that consider the full range of economic, social and environmental impacts or parts thereof.

The use of an economic loss assessment gives a good indication of the high-priority requirements when accounting for bushfires, with the preservation of life always being the top priority. Other impacts that generally resulted in the highest loss values across the five fires were the costs associated with the loss of ecosystem services, losses in harvestable natural and plantation timber and the loss of agricultural assets.

Fire and land managers have the task of managing bushfire threats by using different methods to minimise economic, social and environmental losses with limited human and financial resources. The results of this analysis will increase the amount of information available and enable more informed decision-making, such as a more efficient allocation of fire resources. Similarly, policy-makers will also find this information useful, as it provides a common basis for valuing impacts. Applications include comparing losses and benefits to aid in creating policies that minimise losses and understanding the impacts on regional and remote communities.

Some problems were encountered whilst obtaining the data and it became clear that the establishment

of a systematic recording and reporting framework would make the job of collecting, collating and valuing bushfire impacts more efficient. The first proposal was that either a central online database be established or an online tool that retrieves information from its original source be developed, thereby making bushfire information and data more accessible. The advantage of either option would be that all the information would be centrally located, and with the addition of information from many fires over time, trends in data might be seen, thereby providing decision-makers with valuable information.

The next two proposals were to ensure that indirect economic and social impacts were accounted for, and, if possible, valued in dollars, and ecosystem service values were created specifically for Australian conditions. Even though collecting this information may be relatively time-consuming and difficult compared with collecting direct economic impacts, these impacts are as important and should at the very least be accounted for in the framework as qualitative data.

This report intended to find the costs of five severe fires to improve government's assessment and understanding of future bushfire impacts. The results gained from this study hopefully demonstrate the importance of incorporating sound economic principles and an economic loss assessment to capture and analyse the data. Until the economic losses associated with bushfires are estimated, policies and strategies incorporating bushfire information will not be fully informed.

Photo: Catherine Stephenson ▶

Fire and adaptive management

1

One: Introduction

1.1 Background and Objectives

Fire is a familiar sight in many Australian natural environments, being a necessary element (under the most appropriate fire regime) for the ongoing survival of ecological communities (Burrows 2008; Flint and Fagg 2007). In rare cases, however, bushfires cannot be controlled in time and impact on a diverse range of economic, social and environmental assets. A number of these impacts have been explored in the literature review completed prior to this report, titled *'A literature review on the economic, social and environmental impacts of severe bushfires'*.

Although 'severe' can have many meanings, the word is defined here as '*causing very great pain, difficulty, worry, damage, etc.; very serious*' (Cambridge University Press 2010), and refers to the severity of the impacts, and not to the severity (e.g. intensity) of the actual bushfire. This is because a fire can be very intense, but burn in a remote area and thus not cause adverse impacts for humans. Conversely, a less intense fire may begin close to major infrastructure or economic sectors (e.g. tourism, agriculture) and cause widespread impacts. Therefore, it is the severity of the impacts that are commonly used to characterise a bushfire, and not its fundamental components.

The economic, social and environmental impacts of severe bushfires have been felt extensively throughout south-eastern Australia in recent decades. The losses associated with these impacts extend beyond the clearly visible suppression activities and building losses to include less obvious direct and immediate costs (e.g. commercial timber losses), as well as indirect (e.g. soil erosion) and long-lasting (e.g. psychological trauma) impacts. A large number of government and non-government organisations collect economic, social and environmental impact information directly relating to their business. A consolidated assessment of the impacts of major bushfires that incorporates this information, however, has not been undertaken previously on such a large scale. Importantly, few assessments consider broader and long-term impacts on communities.

To better understand these impacts and associated costs, the objectives of this project were to:

1. Establish a framework for a more efficient capture and representation of severe fire impacts, and
2. Determine the economic, social and environmental impacts of major Victorian bushfires.

To ensure that the final framework provided a fair and accurate account of the impacts, while allowing comparability across the fires being studied, an appropriate loss assessment framework using sound economic principles was required. The word 'establish' is used at the beginning of the first objective, but when reviewing relevant existing frameworks, it was found that several already suited the requirements of this project, so this objective became more about selecting a framework rather than establishing one The rationale for focusing on economic principles when choosing a framework is explained in section *1.3 Measuring Bushfire Impacts using an Economic Loss Assessment*.

In relation to the second objective, this report has collated, costed and summarised in a consistent format an extensive range of economic, social and environmental impacts relating to severe bushfires. The five bushfires nominated for inclusion at the beginning of the project were the:

- 1983 Ash Wednesday Fires (Victoria only)
- 2003 Alpine Fires
- 2005–06 Grampians Fires (Deep Lead and Mount Lubra)
- 2006–07 Great Divide Complex Fires (Great Divide Complex North, Great Divide Complex South, Tatong–Watchbox Creek, Tawonga Gap and Coopers Creek)
- 2009 Black Saturday Fires (Beechworth–Murmungee, Bunyip Ridge Track, Churchill–Jeeralang, Coleraine–Glenelg Highway, Delburn Complex, Horsham–Remlaw Road, Kilmore East–Kinglake Complex, Maiden Gully–Bracewell Street (Bendigo), Murrindindi Mill–Marysville Complex, Redesdale–Coliban Park Road, Weerite–Danedite Road and Wilsons Promontory National Park–Cathedral).

It is important to note that the Royal Commission's interim report was used when collecting impact information for the 2009 Black Saturday Fires (Teague, McLeod and Pascoe 2009) instead of the final report (released 31 July 2010) because the current report was written before the Commission's final report was released. This means that the changes made to some impact information when the Commission's final report was written (e.g. number of housed destroyed increased for the Delburn Fire in the final report) were not included in the current analysis and therefore final costs.

While this report and the associated database holding each bushfire's impact, loss and benefit data fulfil the objectives, the broader purpose of this exercise was to estimate the costs associated with previous bushfires and use the information gained to inform land and emergency management departments' future policies and strategies associated with prevention, preparedness, response and recovery (PPRR). It does this by highlighting the high-priority requirements when accounting for bushfires and proposing steps for establishing a systematic recording and reporting framework based on lessons learnt. This report and associated database would be most useful to government staff involved in creating policies and PPRR strategies for bushfire risk management, managers creating risk frameworks and treasury officials providing financial assistance to the community and funding to emergency management agencies.

1.2 Terminology used in this Report

To ensure that there is a common understanding of the terminology used throughout this report, the following words have been defined:

- **Impact**: The broadest term; includes both market-based (i.e. tangible) and non-market (i.e. intangible) effects[1]. Individual impacts can be either negative or positive.
- **Direct Impact**: Impacts that result from direct contact with the event[2].
- **Indirect Impact**: Impacts that arise as a consequence of the direct impacts of the event[3]. For example, disruption to the flow of goods and services in and out of the affected area.
- **Tangible Impac**t: Impacts on items that are normally bought or sold and that are therefore easy to assess in monetary terms[4]. In the context of the 'triple bottom line' approach used in this study, economic impacts (defined below) are considered to be tangible.
- **Intangible Impact**: Impacts on items that are not normally bought or sold[5]. In the context of the 'triple bottom line' approach used in this study, social and environmental impacts (defined below) are considered to be intangible.
- **Economic Impact**: Although not desirable, the word economic has two meanings in this report. In the field of economics, 'economics' refers to the study of the economy as a whole and measures all losses and benefits to that economy[6]. In this sense, all impacts, including environmental and social impacts, are included, regardless of whether they can be valued in monetary terms or not. The phrase 'economic, environmental and social impacts' is commonplace, with many government policies advocating the use of the 'triple bottom line' approach[7].
  In the context of the project brief, 'economic' refers to the impacts on tangible assets, both direct and indirect, as shown in Table 1.

  When reading this report, 'economic' means impacts to the whole economy when used in reference to an economic loss assessment, whereas it refers to tangible impacts when used in all other cases.
- **Social Impact**: Impacts relating to people, such as health (e.g. fatalities, injuries, mental health)[8] and items or places of personal (e.g. memorabilia) or cultural (e.g. heritage buildings or sacred sites) significance. It also includes impacts to the broader social fabric of the community[9].
- **Environmental Impact**: Impacts on the natural environment, including assets such as the soil, water, air, fauna, flora, habitat, and flows such as ecosystem services.
- **Loss**: A measure of the negative impact to a specific economy. It is taken as being equal to the resources lost by the specific area as a consequence of the disaster. The resources can be expressed in time, money or as an intangible loss[10].
- **Benefit**: Any benefit the economy receives as a result of the disaster, such as government aid (e.g. recovery packages) and insurance payouts (Handmer, Reed and Percovich, 2002). These are usually measured in terms of the money flowing across the spatial boundary of the selected economy into the assessment area. Flows such as government aid within a defined economy would usually be viewed as transfers. Enhanced business activity is another potential benefit. Enhanced business activity is another potential benefit.

Cost is another term associated with natural disasters and emergencies, defined by Emergency Management Australia (EMA) (1998, p. 26) as '*direct and indirect, involving any negative impact, including money, time, labour, disruption, goodwill, political and intangible losses*'. However, for the purposes of this report, cost refers to dollar values, and can either be a negative (e.g. cost of a destroyed house) or positive (e.g. amount raised in donations) value.

1 Commission on Geosciences, Environment, and Resources 1999
2 Handmer 2003, Parker, Green and Thompson 1987
3 Handmer 2003, Parker, Green and Thompson 1987
4 Handmer, Reed and Percovich 2002
5 Handmer, Reed and Percovich 2002
6 Handmer, Reed and Percovich 2002
7 Suggett and Goodsir 2002
8 Middelmann 2007
9 Middelmann 2007
10 Handmer, Reed and Percovich 2002

Including the benefits to a community after a bushfire or any natural disaster may sound strange, since the first thing we think of is destruction; however, this is a fundamental part of any economic loss assessment. It is especially important when measuring the impacts on a small scale (i.e. regional or smaller), as the money flowing into an economy partially offsets the losses flowing out of it (Handmer, Reed and Percovich 2002).

1.3 Measuring Bushfire Impacts using an Economic Loss Assessment

Assessing a wide range of impacts resulting from severe bushfires is important at all levels of government. Without a rigorous method to assess the impacts and costs sustained from bushfires, decision-makers would not have the objective information they need on which to base mitigation strategies (e.g. policies, programs) for the prevention or reduction of future disaster effects (Handmer, Reed and Percovich 2002).

1.3.1 Types of Impacts in an Economic Loss Assessment

Table 1 presents several economic, social and environmental impacts, illustrating where they lie within the direct, indirect and intangible categories. In general, economic impacts fit within the (tangible) direct or indirect categories, whereas social and environmental impacts are traditionally classified as intangibles.

In reality, the impacts associated with bushfires and other disasters or emergencies do not fit neatly into a box as shown in Table 1. They are in fact very complex and can be categorised in more than one category simultaneously. For example, the disruption to transport with the closure of the main road into a town for prolonged periods leads to a large range of impacts in its own right. It can lead to disruptions in moving commercial products out of the affected area, thereby increasing the cost of transportation when drivers are forced to seek alternative routes, or the loss of orders being placed with companies in the affected area. Depending on the boundaries of the affected area, these can be considered economic impacts. In addition, social impacts stemming from the road closure are just as significant. As a result of losing business for example, a company may lay off some of its employees, leading to a large strain on household budgets, and importantly, affecting other local businesses as people have less to spend and these businesses in turn experience their own stress. If the disruption is longer-term, the local economy may contract permanently, and people may limit health and education expenditure with further negative consequences. Some townspeople may also feel isolated and trapped, causing them to become increasingly anxious.

While it is important to understand that the impacts associated with disasters are more complex than shown in the table above, using simple tables and diagrams captures the basic impacts, thereby making

Table 1 Types of loss and measurement (Uncertainty in both identification and valuation increase from the top left to the lower right of the table)

Eco – Economic Impact **Soc** – Social Impact **Env** – Environmental Impa

Can the loss be bought or sold?	Direct Loss (Loss from direct contact with the natural event)		Indirect Loss (No contact – loss as a consequence of the event)	
Yes – Tangible	Buildings and contents	**Eco**	Disruption to transport	**Eco**
	Cars	**Eco**	Disruption to production	**Eco**
	Livestock	**Eco**	Legal costs associated with lawsuits	**Eco**
	Crops	**Eco**		
No – Intangible	Lives and injuries	**Soc**	Stress and anxiety	**Soc**
	Loss of memorabilia	**Soc**	Disruption to living	**Soc**
	Loss of cultural structures	**Soc**	Loss of community	**Soc**
	Ecological damage – burnt vegetation	**Env**	Ecological damage – erosion, air pollution	**Env**

Source: Handmer 2003, p. 93

assessment relatively straightforward and the results easy to interpret. It must be kept in mind, however, that this does not give the full picture, which is effectively impossible to capture without an extensive case study over an extended period (i.e. up to many years).

Impacts will be referred to as economic, social or environmental and not direct, indirect or intangible throughout the remainder of this report in order to meet its second objective, despite loss assessments generally using the latter impacts.

1.3.2 Key Features of an Economic Loss Assessment

A loss assessment process based on sound economic principles is a very useful tool for providing rigorous and unbiased information. It not only estimates the costs of the bushfire being studied, but uses consistent values that allow comparability across multiple fires. Economic loss assessments essentially add up all the losses and benefits resulting from the event and find the net loss (i.e. losses minus benefits).

Another key feature of an economic loss assessment is that it places a geographical and temporal boundary around the assessment area. Apart from giving the assessor a clear boundary in which to work, it is critically important when measuring indirect effects (Commission on Geosciences, Environment, and Resources 1999). The geographical boundary enables the flow of goods and services (and the costs of these) to be accounted for and identifies what is a loss, benefit or transfer. Losses can be viewed as the loss of goods and services within the assessment boundary (e.g. crops, buildings, loss of business), while the benefits can be measured by the flow of goods and services (inc. money) into the assessment area. The exchange of goods, services or money wholly within the assessment boundary (i.e. does not move across the boundary) is considered a transfer effect and not an economic loss or benefit to the assessment area (Handmer, Reed and Percovich, 2002). Losses and benefits attributed to a bushfire will change depending on the geographical scale. That is, in many cases, losses at a local level will 'disappear' at a state or national level because losses to the local economy will be compensated by increased productivity in other regions, thereby producing no net loss (Merz, Elmer and Thieken 2010). Therefore, assessing the local economy actually affected by the bushfire will produce meaningful results specific to that economy, where the effects of mitigation strategies and policies can be most effectively measured. Handmer, Reed and Percovich (2002) recommend that a loss assessment be conducted at least six months after the event. This is to ensure that indirect and intangible impacts not immediately obvious are accounted for. For example, the trauma and other psychological impacts felt by those in the community are often not known until well after the fire when people have to rebuild their lives. Conversely, losses to some products and services may be recovered to some degree over the coming months to years, such as timber salvage operations and the construction industry.

An economic loss assessment measures the impact of an event on the economy of the area selected for analysis and not individual businesses (Handmer 2003). A financial assessment is undertaken when a business wants to assess the impact of the event on their own profits, and does not consider impacts directly unrelated to their business, such as all intangible losses, disruption to the wider economy and impacts to residential and government sectors (Handmer 2003).

1.3.3 Valuing Economic, Social and Environmental Impacts

Where possible, economic loss assessments place a dollar value on economic, social and environmental impacts, thereby enabling them to contribute to the net impact. All values given in this report are in 2008 Australian dollars. Any dollar values published before or after this time were adjusted to 2008 dollars using the Reserve Bank of Australia's (RBA) Inflation Calculator[11]. The consumer price index (CPI), on which the inflation calculator is based, measures the change in the prices paid by households for goods and services to consume over time (Pink 2009).

Economic Impacts

Direct economic impacts are comparatively easy to measure and cost, as the assets and flows they refer to are readily bought and sold in existing markets. As part of assessing direct economic losses, the depreciated (or market) value of the asset is used rather than the replacement value, which more accurately reflects its actual value (Handmer 2003). The value of the replacement item is generally higher than the value of the asset lost, thereby producing an overestimation of the total economic loss. Indirect economic losses are harder to value, as they are a consequence of the event and can be more difficult to measure and confirm (Rose and Lim 2002).

11 Inflation Calculator available at: http://www.rba.gov.au/calculator/

Social Impacts

While many social impacts are important e.g. psychological trauma, loss of memorabilia and family photographs), it is currently not possible to value them in dollar terms; nevertheless, they are included in an economic loss assessment as qualitative data.

Two social impacts that are routinely valued are the loss of life and injuries. Most recently, Abelson (2008) valued a statistical life at $3.652 million, which is a measurement of society's willingness to pay to avoid '*an immediate death of a healthy individual in middle age (about 50) or younger*' (Abelson 2008, p. 21). As part of the study, Abelson (2008) found that values from research around the world varied widely, from $3.131 to $15.653 million. The values obtained depended greatly on the method used and the way it was applied. An injury was valued as a proportion of the value of a statistical life year ($158,000), depending on the type of injury sustained. For example, a short-term burn to less than 20% of the body received a proportional weighting of 0.158 (Mathers, Vos and Stevenson 1999). Therefore, the value of a year of life free of this injury would be $24,964 (i.e. $158,000 × 0.158). The proposed values have now been adopted by the Australian Government's Office of Best Practice Regulation (OBPR) (2008). Another approach is the human capital or cost of illness method, which views people as a labour source and the '*value to society of preventing an injury is the saving in potential output or productive capacity*' (Bureau of Transport Economics (BTE) 2001, p. 129). The BTE (2001) developed values for use in natural disaster cases, which are (in 2008 dollars): $1.769 million per fatality, $431,000 per serious injury (i.e. patient admitted to hospital) and $14,400 per minor injury (i.e. patient may be treated in, but not admitted to hospital). Abelson (2008) highlights many limitations with the human capital approach, the most fundamental being that it measures the amount lost post death (e.g. value of labour lost, funeral expenses, legal costs). For society as a whole and more specifically from a policy-maker's point of view, the amount people are willing to pay to prolong a life is a more constructive method (Abelson 2008).

Environmental Impacts

Natural environments provide amenities to society in the form of ecosystem services, such as water purification, carbon sinks and sources of new medicines. They also provide tourism and recreational values, as well as being valued for their very existence. Estimating these values in a common unit (i.e. currency) is important for use in policy decision-making, particularly in relation to environmental impact assessments and cost–benefit analysis.
The Total Economic Value (TEV) approach allows economists to categorise ecosystem goods and services according to how they are used, being divided into two sub-groups: use value and non-use value (Pagiola, von Ritter and Bishop 2004). Use value is further divided into direct use value, indirect use value and option value (Figure 1).

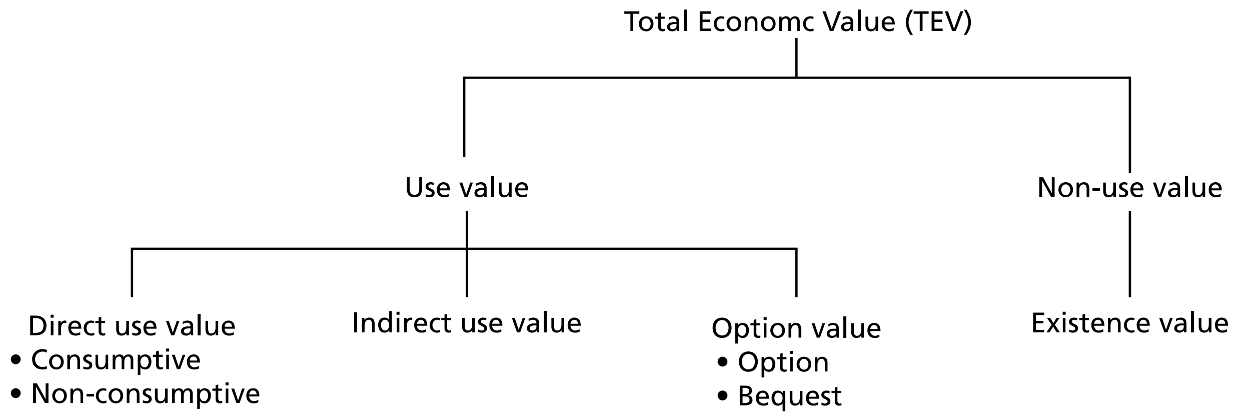


Figure 1 Typologies of ecosystem services: total economic value (Pagiola, von Ritter and Bishop 2004, p. 9)

The terms from Figure 1 are described as follows (Pagiola, von Ritter and Bishop 2004):

Use values refer to ecosystem goods and services that are currently being used, or may be used in the future.

- **Direct use value**: the value of ecosystem goods and services that can be consumed, such as food or timber products, as well as non-consumptive goods and services such as recreational amenity. Direct use value generally benefits people at the ecosystem site.
- **Indirect use value**: the values of ecosystems that are enjoyed outside the ecosystem site, such as water filtration and protection from storm surges.
- **Option value**: the value derived from preserving the ecosystem for a future use not currently being carried out.

Non-use values refer to the enjoyment people may feel in the knowledge that the ecosystem is present. It is also known as the existence value.

Direct use values, particularly consumables, are generally the easiest to value because they are often associated with goods and services that have a price in the market place. Similarly, for tourism and recreation, values can be estimated by examining the costs incurred by visitors travelling to the site. Indirect use values are more difficult to estimate because actual quantities of the good or service are difficult to measure, are often not traded, and in some cases can be enjoyed alongside other uses and by many people. Estimating non-use values is the hardest to measure, requiring practitioners using surveys to ascertain people's willingness to pay for a certain service or asset (Pagiola, von Ritter and Bishop 2004). For example, people may be asked what they would pay to conserve vulnerable ecosystems in remote areas, knowing that they will probably never use or experience the area directly. A table summarising several methods for estimating environmental, or more specifically, ecosystem service values is presented in Appendix 1. Social impacts, such as health impacts and community wellbeing, can also be valued using these methods.

1.4 Report Structure

A profile of the fires and the affected areas is presented in Chapter 2. This provides the context for the selection of each fire, by describing their duration, weather conditions before and during the fire, major impacts and basic socio-economic activity in the affected areas. Maps are also included to illustrate each fire's size and location. The methodology is described in Chapter 3, which explains the process used to select the most appropriate frameworks for valuing economic, social and environmental impacts. It also gives details on data sourcing how the data were collated to produce the final net economic loss for each fire and the limitations when analysing the data and monetary values. The losses, benefits and net loss and an analysis of the results are presented in Chapter 4. In the discussion in Chapter 5, the results are compared with similar studies, high-priority outcomes are identified, the implications for fire managers and policy-makers are discussed and the steps for establishing a framework are proposed. Chapter 6 presents a conclusion. A list of appendices follows in Chapter 7, and the references in Chapter 8.

Two: Profile of the bushfires and impacted regions

The five fires studied were chosen because they are significant in Victoria's fire history. They caused widespread destruction, leading to numerous economic, social and environmental impacts. Each fire's statistical information is presented in this section, including their total area, source of ignition, significant fire dates and major impacts. A brief profile of the assessment area's demographics is then shown. Information on the New South Wales (NSW) part of the Alpine Fires and the Canberra Fires, which were started by the same series of thunderstorms as the Victorian Alpine Fires, is included in *2.2 2003 Alpine and Canberra Fires*, but given that this report focuses on Victorian impacts, all other information relating to the NSW component of the Alpine Fires and the Canberra Fires is described in Appendix 2. This includes statistical information (fire areas, ignition sources, major impacts, socio-economic profiles) and the costs of the fires.

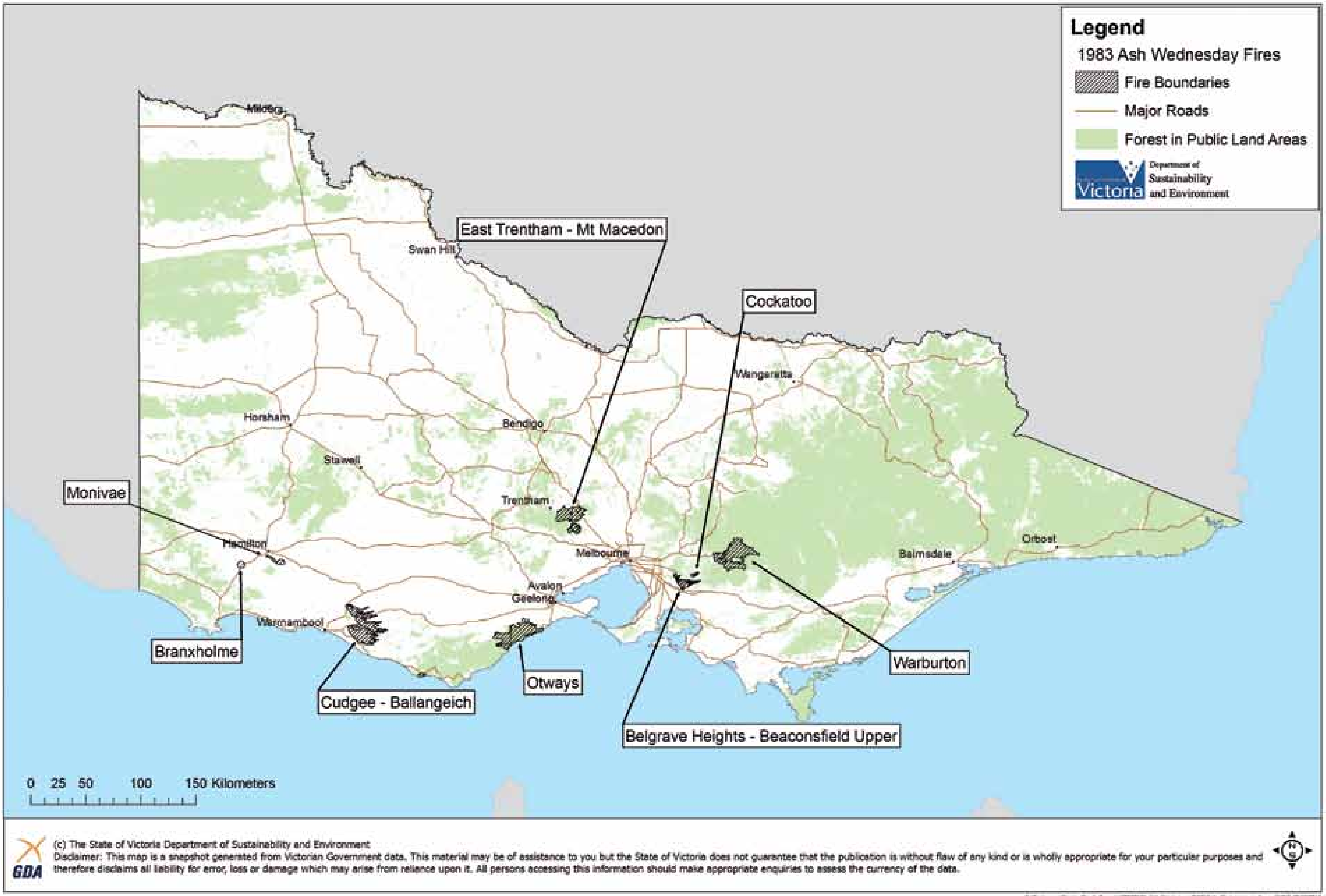
2.1 1983 Ash Wednesday Fires

Prolonged drought, less than 60% average rainfall in the six months leading up to February 1983 and three days of 40°C and over in February 1983 meant that the land was extremely susceptible to fire during the 1982–83 season (Rawson, Billing and Duncan 1983). On 16 February, which came to be known as Ash Wednesday, the conditions were just as severe. Temperatures were over 40°C for much of Victoria, the relative humidity was very low (below 10% at Melbourne Airport) and winds were strong (Oliver, Britton and James 1984).

A total of 180 fires were attended by the Country Fire Authority (CFA) on this day alone, with a CFA report (1983) highlighting eight as being of major significance. The CFA (1983) could not identify the cause for half of the fires, and suspected sparks from powerlines for ignition of the other half. Once a fire had begun, it was very hard to bring under control. In total, approximately 180,000 ha were burnt from fires beginning on Ash Wednesday, with 47 Victorians (including 12 CFA volunteers and 1 casual firefighter) losing their lives (CFA 1983). Other impacts include the loss of around 2,100 homes, 20,000 sheep, 9,000 cattle and 2,300 ha of soft- and hardwood plantations (CFA 2003).

A map illustrating the locations of the Ash Wednesday Fires, as well as other large bushfires from the 1982–83 season, is shown in Figure 2. The fires labelled with a box are the eight fires described in the CFA (1983) report.

Figure 2 Area burnt by the1983 Ash Wednesday Fires (DSE 2010)



2.2 2003 Alpine and Canberra Fires

Over 95% of Australia experienced below-average rainfall in the period of March to December 2002, and in Victoria, the highest seasonal mean maximum temperature was recorded for autumn, winter and spring (Sullivan 2004). Fires were ignited by a series of lightning strikes on the evening of 7 January and on 8 January. These strikes were created when a cold front and associated pre-frontal trough passed over south-eastern Australia, forming upper-level thunderstorms as the front passed over the Alpine region (Sullivan 2004). As a result, 87 fires were ignited in Victoria, and more than 40 in NSW and the Australian Capital Territory (ACT) (Department of Sustainability and Environment (DSE) 2005). Firefighters moved quickly to extinguish the fires; however, the large number of ignitions and difficult terrain meant that in Victoria, nine fires could not be brought under control and spread quickly, eventually merging to burn through approximately 1.1 million ha in 59 days (Sullivan 2004). For operational and administrative purposes, the Victorian Alpine Fires were divided into two complexes of approximately equal size: Bogong Complex North and Bogong Complex South (Figure 3). Fires ignited by the same thunderstorms also burned through approximately 600,000 ha of NSW vegetation and 160,000 ha of rural land, plantation forests and residential areas in the ACT (Canberra Fires) (Figure 3) (Sullivan 2004).

Five people died during the Alpine and Canberra Fires. A firefighter drowned during a flash flood in Victoria (DSE 2005), and four Canberra residents could not escape the fire when it raced into the outer suburbs on 18 January 2003 (McLeod 2003). The impacts to buildings and infrastructure were high in the ACT, in which approximately 800 homes and other buildings were either destroyed or damaged (McLeod 2003). Mount Stromlo Observatory, located in the hills overlooking Canberra, also suffered losses of great cultural significance, including six historically significant telescopes, the oldest of which dated back to 1911 (Orchiston 2003).

For Victoria and NSW, the fire was mainly restricted to the Alpine forests and grasslands. A DSE report (2005) highlighted that 60% of the Alpine National Park and 81% of the Mount Buffalo National Park were burnt to some degree. These impacts had large implications for the tourism industry and associated retail and accommodation industries.

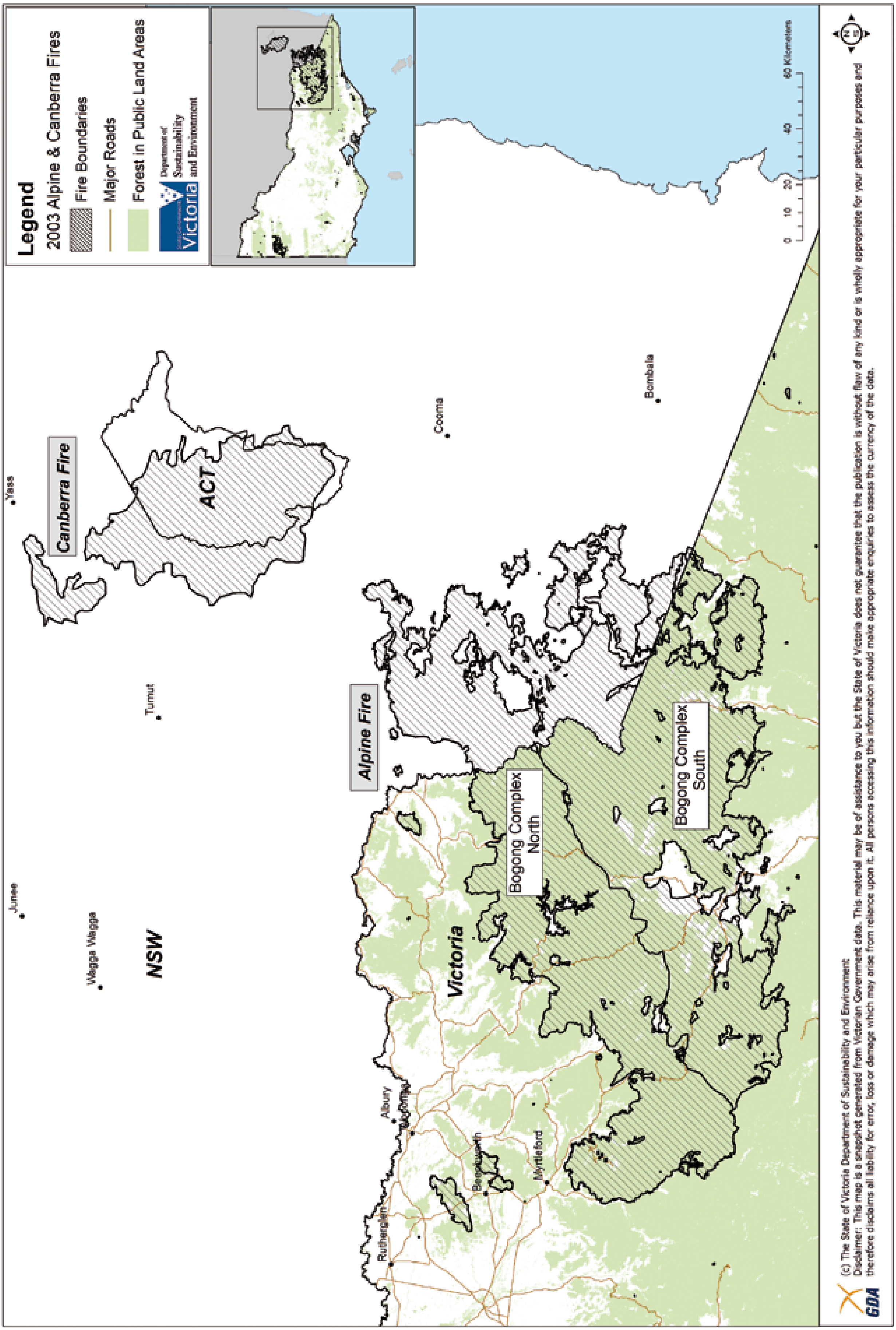


Figure 3 Area burnt by the 2003 Alpine and Canberra Fires (DSE 2010)

2.3 2005–06 Grampians Fires

The Deep Lead Fire and Mount Lubra Fire were included under the Grampians Fires. The Deep Lead Fire primarily caused agricultural impacts, while the Mount Lubra Fire caused significant agricultural and natural vegetation losses. The Deep Lead Fire was detected from a fire tower at 1644 hrs on 31 December 2005 (Smith 2006). It was caused by lightning on private property, and with temperatures around 43°C, a relative humidity of 10% and a NNW wind of 65 km/hr, it expanded quickly (Smith 2006). By the time it was contained 49 hours later, it had burnt through approximately 7,500 ha of state forest and 6,100 ha of farmland (Figure 4). Eleven homes were also lost (Fleming et al. 2007).

The Mount Lubra Fire had already grown to 10 ha when spotted at 0745 hrs on 20 January 2006 inside the Grampians National Park (Fleming et al. 2007). It was assumed to have started at approximately 2300 hrs the previous night by lightning (Smith 2006). Steep terrain, extreme weather conditions, continually changing wind directions and short-distance fire spotting made it exceptionally difficult to contain the fire (Fleming et al. 2007). By the time it was contained on 3 February, it had burnt approximately 85,000 ha of the Grampians National Park and 45,000 ha of farmland (Figure 4) (Fleming et al. 2007). Losses were high, with two people dying while attempting to flee the fire in their car. As the fire burnt through 47% of the Grampians National Park, tourism was significantly affected. Agricultural losses were also high, with around 63,100 livestock (mostly sheep) killed, 2,500 hives lost and 10,300 tonnes of hay destroyed (Fleming et al. 2007).

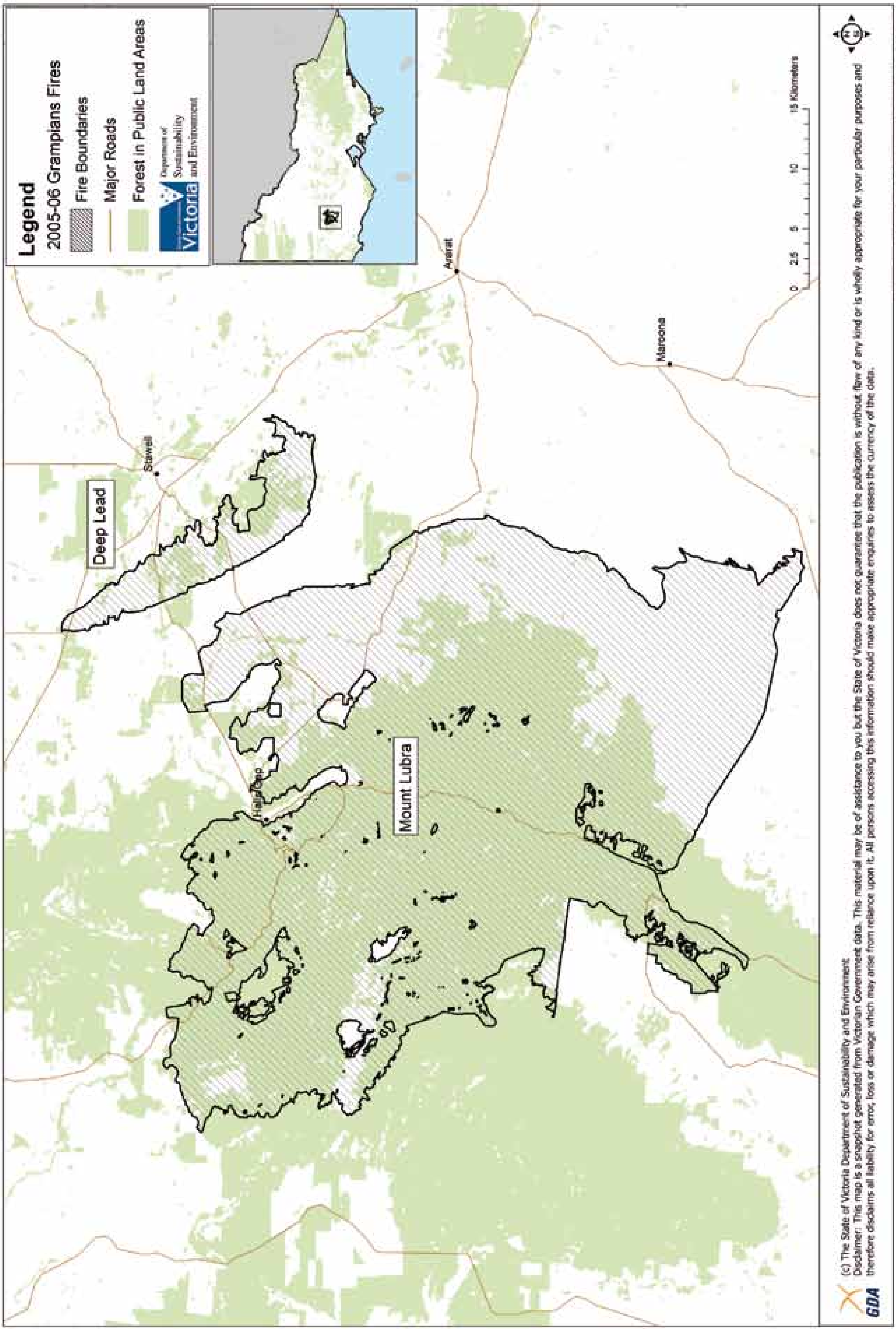


Figure 4 Area burnt by the 2005 Deep Lead and 2006 Mount Lubra Fires (DSE

2.4 2006–07 Great Divide Fires

Like the 2003 Alpine Fires, the 2006–07 Great Divide Fires were started by a series of dry lightning strikes from a thunderstorm passing over the Alpine area of Victoria on 1 December 2006 (Flinn, Wareing and Wadsley 2008). As a result, 70 separate fires were confirmed as going in extremely dry vegetation (Smith 2007). While many were extinguished quickly, some grew continually and eventually merged to become the Great Divide Complex North and Great Divide Complex South Fires. In addition, three other fires ignited within the Alpine area at later stages became part of the Great Divide Fires. The first was the Tawonga Gap Fire, which started on 10 December and which was suspected to have been deliberately lit. Extensive fire suppression activities were used to contain the fire and stop it from merging with the large Complex Fires, as towns such as Mount Beauty, Falls Creek and Bogong Village were under threat. It was eventually contained on 27 December (Flinn, Wareing and Wadsley 2008). Another fire suspected of being deliberately lit was the Coopers Creek Fire, which started on14 December. Extreme weather conditions and changing winds meant that this fire spread quickly and went on to destroy large areas of agricultural land and assets. This fire merged with the Great Divide Complex South Fire on 6 January (Flinn, Wareing and Wadsley 2008). The Tatong–Watchbox Creek Fire began on 11 January from lightning. Under extreme fire weather conditions, it spread quickly, growing to approximately 6,000 ha in the first 12 hours (Flinn, Wareing and Wadsley 2008). Like the Coopers Creek Fire, this fire merged with the main Complex Fires (Flinn, Wareing and Wadsley 2008).

The total area burnt was just over 1.1 million ha in 69 days (Figure 5).Tragically, a CFA volunteer was killed in a motor vehicle accident while trying to help a Seaton property owner defend his property in the Coopers Creek Fire (Flinn, Wareing and Wadsley 2008). Even though the fires threatened many towns and agricultural properties, losses to the immediate area were relatively low. This was attributed to some breaks in the extreme weather that the firefighters could take advantage of and the tireless efforts of the DSE and CFA.

One major indirect impact was the tripping of the key powerline connecting Victoria to NSW when fire entered the easement on 16 January during the Tatong–Watchbox Creek Fire (The Nous Group 2007). As a result, large areas of Victoria including Melbourne lost supply for up to 4.5 hours. In total, 685,000 residential, commercial and industrial customers lost power. Problems were further exacerbated because it occurred at 1600 hrs on a weekday, leaving 175,000 peak-hour train commuters stranded as a result of delays and cancellations (The Nous Group 2007). Although the fire was too intense for firefighters to control on this occasion, they successfully prevented the fire from entering the Victorian Thompson Dam catchment. Recognising the impacts on Melbourne's long-term water supply if the fire did enter this catchment, i.e. more then 250 years in the worst-case scenario (assuming 100% tree mortality in the catchment) (Feikema, Lane and Sherwin 2008), fire personnel constructed a 107-km control line using backburning operations and bulldozers between the fire and the catchment (Flinn, Wareing and Wadsley 2008).

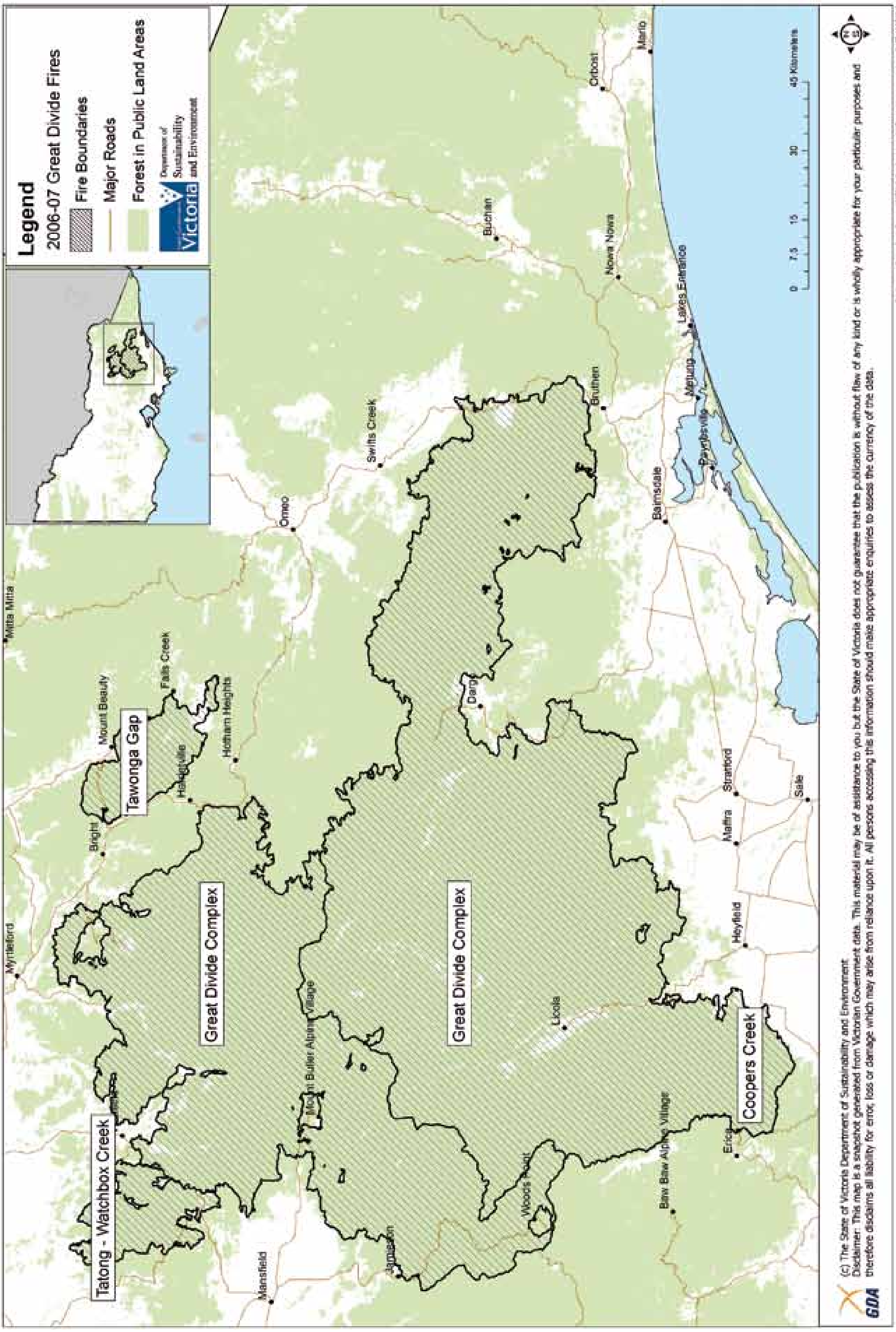


Figure 5 Area burnt by the 2006–07Great Divide Fires (DSE 2010)

2.5 2009 Black Saturday Fires

The weather during January and February 2009 was extreme. Even though many parts of Victoria experienced near-average to above-average rainfall during the last three months of 2008, January 2009 was characterised by below-average to record-low rainfall (Teague, McLeod and Pascoe 2009). Making the landscape even more conducive to fires was the onset during the last week of January of the most severe, prolonged heatwaves in south-eastern Australia's history (Teague, McLeod and Pascoe 2009). A new record was set in Melbourne with three consecutive days over 43°C (Teague, McLeod and Pascoe 2009).

In the days leading up to Black Saturday (7 February 2009), fire activity was very high. The Delburn Complex fire began on 29 January (Figure 6), burning 30 homes and approximately 6,500 ha of forested and agricultural land before being contained on 3 February (A. Haywood, Policy Officer, Land and Fire Management Division, Department of Sustainability and Environment, Victoria, pers. comm. 2009). One day later, the Bunyip Ridge Track Fire began in the Bunyip State Park. This fire could not be contained before 7 February, sweeping through the forest into cleared land and heading for the towns of Bunyip, Drouin and Warragul (Teague, McLeod and Pascoe 2009). This fire was largely controlled by the night of 7 February and by the time it was contained on 4 March (A. Haywood, pers. comm. 2009), 26,500 ha of forested and agricultural land (including a large amount of stock, pasture and feed) had been destroyed (Figure 6) (DSE 2009, Victorian February 2009 Fire Severity Area Statements, unpub.[12])

Much hardship had already been felt throughout many communities this fire season; however, Saturday 7 February 2009, 173 people lost their lives in what will forever be known as Black Saturday (Franklin 2009). Hundreds of fires were reported to fire authorities on this day, with the CFA recording 592 grass and bushfires (Teague, McLeod and Pascoe 2009). Many of these were extinguished or brought under control while still small, but some became major fires, causing widespread destruction and chaos that directly impacted on 78 communities and left entire towns unrecognisable (DSE 1996a). The major fires beginning on 7 February studied in this assessment were (in order of when they were reported to authorities and using the fire names recorded by DSE) the Kilmore East–Kinglake Complex, Horsham–Remlaw Rd, Coleraine–Glenelg Highway, Weerite–Danedite Road, Churchill–Jeeralang, Murrindindi Mill–Marysville Complex, Redesdale–Coliban Park Road, Maiden Gully–Bracewell Street (Bendigo) and Beechworth–Murmungee Fires. The locations of these fires are shown in Figure 6.

The Kilmore East–Kinglake Complex and Murrindindi Mill–Marysville Complex were the most destructive by all measures (Figure 7). One hundred and twenty-one people died in the Kilmore East–Kinglake Complex. In addition, 1,244 homes, many other buildings including community centres, schools, shops and emergency facilities, and hundreds of farms and their infrastructure and stock were destroyed (Teague, McLeod and Pascoe 2009). The total area burnt was 86,500 ha (DSE 2009, Victorian February 2009 Fire Severity Area Statements, unpub.). During the Murrindindi Mill–Marysville Complex, there were 38 fatalities, with an ACT firefighter also losing his life on 17 February from a falling tree branch (Teague, McLeod and Pascoe 2009). Again, many hundreds of buildings and farms were destroyed, including 590 homes. In all, approximately 171,600 ha were burnt (DSE 2009, Victorian February 2009 Fire Severity Area Statements, unpub.).

While authorities were still battling these fires, another large fire was started by lightning on 8 February on the western side of Wilsons Promontory National Park (Parks Victoria (PV) 2010a). As that fire could not be easily accessed by fire crews and there was a chance of winds bringing the fire to a major holiday destination, all campers at Tidal River (camping grounds on the east side of the promontory) were evacuated on 9 February (ABC News 2009). The fire was difficult to control, but was eventually contained on 14 February. It burnt through 24,500 ha (DSE 2009, Victorian February 2009 Fire Severity Area Statements, unpub.), or almost 50% of the park, and came very close to Tidal River in the process (PV 2010b).

Overall, these fires burnt approximately 388,000 ha (DSE 2009, Victorian February 2009 Fire Severity Area Statements, unpub.). A majority of the fires were not declared safe until March and April, with the Bunyip Ridge Track Fire and Kilmore East–Kinglake Complex the last to be declared safe on 15 May 2009 (A. Haywood, pers. comm. 2009).

12 This document is believed to give the most accurate area for each fire, as it used post-fire aerial imagery interpretation to map the exact boundary.

While fires are a natural part of Victoria's ecology, the fires of Black Saturday had significant adverse effects on some plant and fauna. The Leadbeater's Possum lives in small pockets of Mountain Ash forests in central Victoria; however, since their habitat sustained heavy damage during the fires, their species is on the brink of extinction (Victorian Bushfire Reconstruction and Recovery Authority 2009). One plant species that would have become extinct if not for the collaborative contingency planning between government agencies and other organisations was the Shiny Nematolepis *(Nematolepis wilsonii*). The only known wild population of this plant, consisting of 500 plants, was completely destroyed in the Yarra Ranges National Park. In 2008, cuttings had been taken and cultivated at the Melbourne Royal Botanic Gardens and were replanted into the park after the Black Saturday Fires (Victorian Bushfire Reconstruction and Recovery Authority 2009). The only other population is found at Melbourne Museum's Forest Gallery (Melbourne Museum 2009).

Figure 6 Area burnt by the 2009 Black Saturday Fires (DSE 2010)

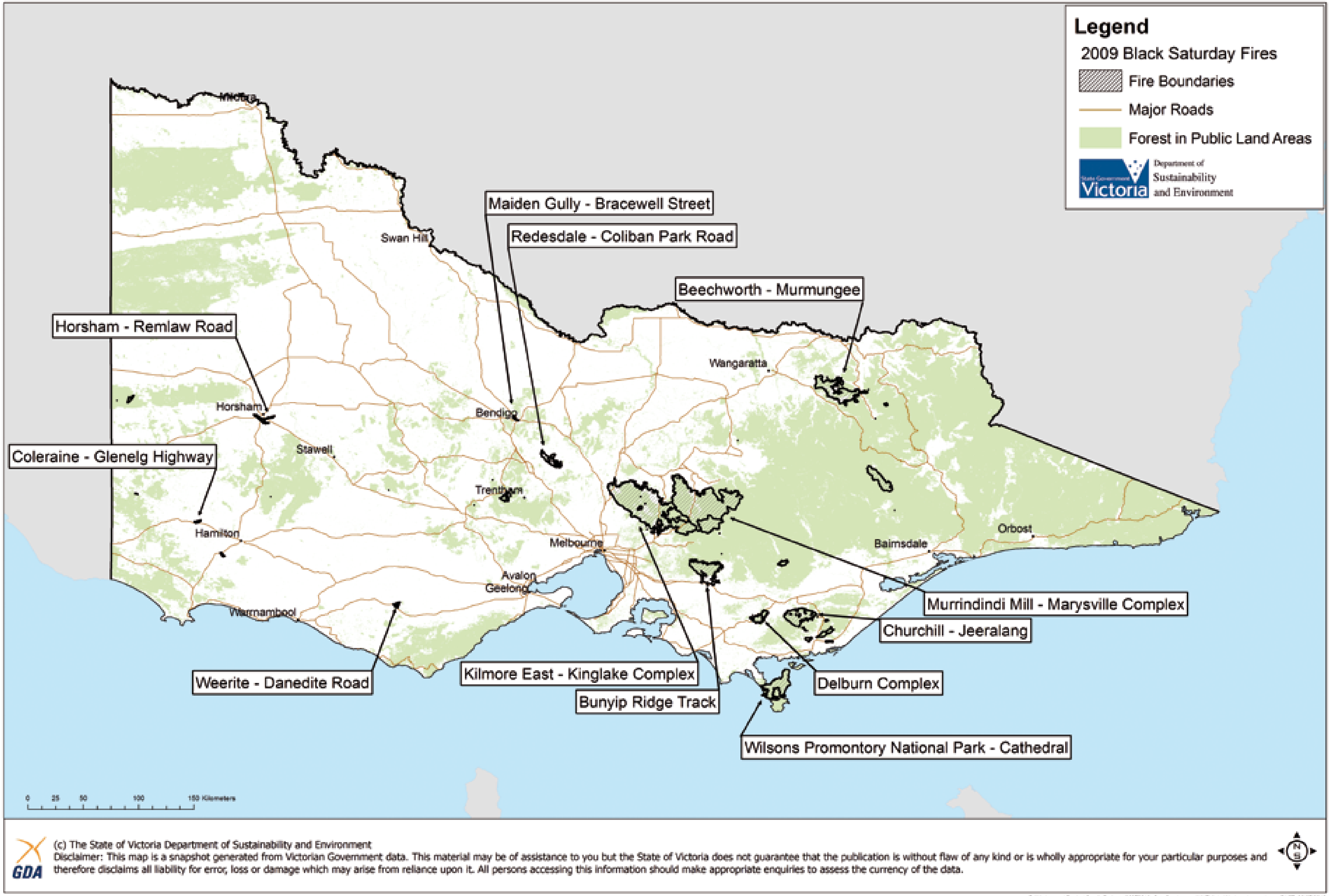
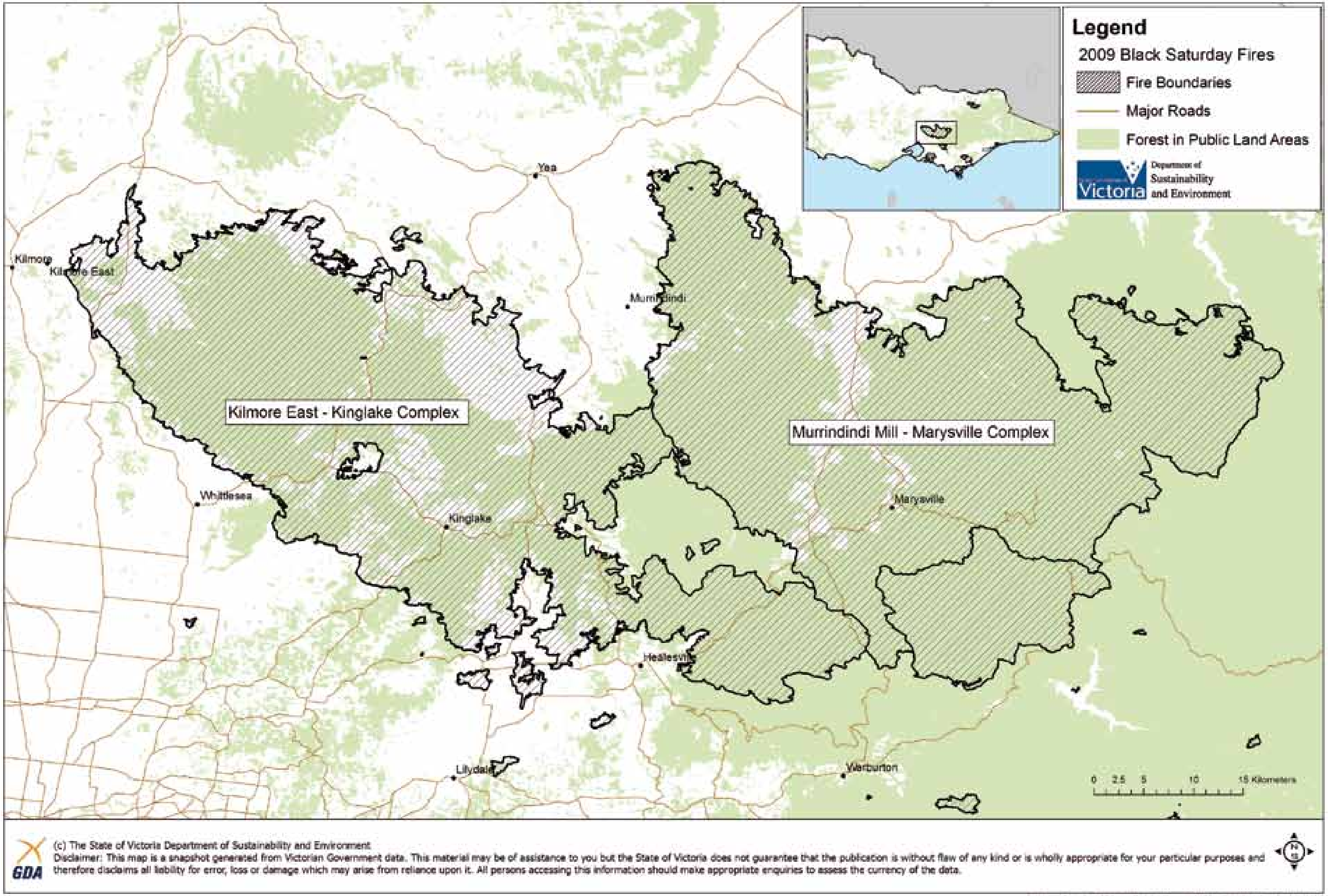


Figure 7 Area burnt by the Kilmore East–Kinglake and Murrindindi Mill–Marysville Complexes (DSE 2010)



2.6 Fire Statistics

Data were collected for a majority of the fires (Table 2). 'Unknown' denotes that no data were available, and sources of the data are described below the table.

Table 2 Fire areas, sources of ignition and significant fire dates

Fire	Area (ha)	Source of fire (Suspected or known)	Going*	Contained#	Safeø
1983 Ash Wednesday Fires†	**179,615**	**Various**	**16.02.83**	**21.02.83**	**Unknown**
Cudgee–Ballangeich	50,000	State Electricity Commission (SEC) line on private land/ unknown	16.02.83	17.02.83	Unknown
East Trentham–Mount Macedon	29,500	SEC line arcing in contact with trees	16.02.83	17.02.83	Unknown
Otways	41,000	Unknown	16.02.83	17.02.83	Unknown
Belgrave Heights–Beaconsfield Upper	9,200	Unknown	16.02.83	Unknown	Unknown
Cockatoo	1,800	Unknown	16.02.83	17.02.83	Unknown
Monivae	3,181	Clashing SEC conductors – private line	16.02.83	16.02.83	Unknown
Branxholme	200	High-voltage SEC pole snapped at base and fell to ground	16.02.83	17.02.83	Unknown
Warburton	40,000	Unknown	16.02.83	21.02.83	Unknown
2003 Alpine Fires	**1,092,421**	**Lightning**	**07.01.03**	**07.03.03**	**30.04.03**
Bogong Complex North	1,080,893	Lightning	08.01.03	07.03.03	30.04.03
Bogong Complex South	(both fires)	Lightning	08.01.03	07.03.03	30.04.03
2005–06 Grampians Fires	**142,885**	**Lightning**	**31.12.05**	**02.02.06**	**01.05.06**
Mount Lubra	129,275	Lightning	20.01.06	02.02.06	01.05.06
Deep Lead	13,610	Lightning	31.12.05	03.01.06	21.04.06
2006–07 Great Divide Complex Fires	**1,113,251**	**Various**	**01.12.06**	**07.02.07**	**02.05.07**
Great Divide Complex North	370,354	Lightning	01.12.06	19.01.07	07.03.07
Great Divide Complex South	638,065	Lightning	01.12.06	07.02.07	02.05.07
Tatong–Watchbox Creek	32,360	Lightning	11.01.07	22.01.07	07.03.07
Tawonga Gap	33,587	Malicious	10.12.06	27.12.06	07.03.07
Coopers Creek	38,885	Malicious	14.12.06	06.01.07	04.02.07
2009 Black Saturday Fires	**388,261**	**Various**	**29.01.09**	**14.03.09**	**15.05.09**
Beechworth–Murmungee	33,845	Power transmission lines	07.02.09	16.02.09	27.04.09
Bunyip Ridge Track	26,445	Lightning	04.02.09	04.03.09	15.05.09
Churchill–Jeeralang	24,460	Malicious	07.02.09	19.02.09	15.04.09
Coleraine–Glenelg Highway	776	Unknown	07.02.09	07.02.09	08.02.09
Delburn Complex	6,460	Malicious	29.01.09	03.02.09	31.03.09
Horsham–Remlaw Road	2,240	Power transmission lines	07.02.09	08.02.09	30.04.09
Kilmore East–Kinglake Complex	86,525	Unknown	07.02.09	04.03.09	15.05.09
Maiden Gully–Bracewell Street (Bendigo)	594	Pipe, cigarette, match	07.02.09	08.02.09	03.03.09
Murrindindi Mill–Marysville Complex	171,625	Malicious	07.02.09	05.03.09	27.04.09
Redesdale–Coliban Park Road	9,511	Unknown	07.02.09	09.02.09	17.03.09
Weerite–Danedite Road	1,280	Unknown	07.02.09	07.02.09	08.04.09
Wilsons Promontory National Park–Cathedral	24,500	Lightning	08.02.09	14.03.09	17.04.09

* Refers to the date on which a fire has been reported. A fire will remain 'going' while it is spreading in any direction (DSE 1996b)
# Refers to a fire whose spread has been halted, and may be burning freely within the parameter (DSE 1996b)
ø Refers to a fire that can be left without further patrols. It may be completely out, or pose very little threat of flaring up again (DSE 1996b)
† The CFA's report *The major fires originating 16th February, 1983* (1983) singled out eight significant fires, which are shown in this table. The 'Area' value also includes locations not included in the CFA's report.

1983 Ash Wednesday Fires: The first, third and four columns sourced from CFA (2003); second column sourced from CFA (1983) and Forests Commission Victoria (1983); last two columns from Jude Kennedy (CFA, East Burwood, Victoria, pers. comm. 2009).

2003 Alpine Fires: Victoria – CFA (2003), DSE (2003), Wareing and Flinn (2003), unpublished Department of Primary Industries (DPI) data and FireWeb (DSE internal fire management system); NSW – Sullivan (2004); ACT – Bushfire Recovery Taskforce report (2003).

2005–06 Grampians Fires: Fire size and source sourced from Fleming et al. (2007); dates from FireWeb.

2006–07 Great Divide Fires: All columns from Flinn, Wareing and Wadsley (2008); areas sourced from this and unpublished DPI data.

2009 Black Saturday Fires: All information sourced from FireWeb; areas sourced from this and unpublished DPI data.

Table 3 highlights some of the impacts caused by each fire. The information in this table was collated from published and unpublished sources and every attempt has been made to collect the most reliable data available. Some of the data have been extrapolated from information available in the literature (especially for the Ash Wednesday Fires) and some values may not include impacts from all the separate fires that make up the five fires studied. An '–' indicates that data could not be obtained, but the impacts are expected to be minimal.

Table 3 Summary of the major impacts caused by each fire

Asset type destroyed or damaged	1983 Ash Wednesday	2003 Alpine	2005–06 Grampians	2006–07 Great Divide	2009 Black Saturday
Fatalities	47	1	2	1	174*
Major injuries	66	–	–	–	130
Minor injuries	400	–	–	–	670
Homes	2,090	41	77	51	2,298
Agricultural buildings	985	250	307	213	1,411
Fencing (km)	8,939	3,338	2,244	1,436	8, 618
Sheep	19,751	9,185	58,636	71	4,449
Cattle	8,763	3,689	160	907	3,673
Pasture (ha)	3,381	–	39,246	11,778	65,065
Softwood plantation timber (ha)	2,310	1,927	–	3,622	12,416
Native forest on public land (ha)	106,155	967,500	91,860	1,008,274	269,030

* 17 Total includes fatality on 17 February of an ACT firefighter killed by a falling branch. This fatality was not included in the analysis because the firefighter resided outside the assessment boundary.

2.7 Socio-Economic Profile of the Affected Areas

Mapping the economic, social and environmental status of an area affected by a bushfire (or any other disaster) is a critical step, as it places the impacts, losses and benefits in context. This step typically collects information on the study areas demographics, such as population, age, gender, employment status, employment by industry sector, income and main economic industries within the area. It may also contain information on a range of assets located within the study area, such as significant public buildings and infrastructure, cultural and heritage-listed objects and sites, and environmentally sensitive areas, including populations of endangered flora and fauna.

Given that presenting baseline profiles for all the above-mentioned categories for the five fires studied would be very lengthy, only basic socio-economic statistics have been included: age and gender, family composition and number employed per industry sector for each fire.

Data shown in Table 4 to Table 6 were collated from the Australian Bureau of Statistics (ABS) census data[13] and include all local government areas (LGAs) within each fire's study area (refer to Appendix 3, Step 3, for list of LGAs impacted). Data from the 1981 census were used for the Ash Wednesday Fires. The Alpine and Grampians data were taken from the 2001 census, while the Great Divide and Black Saturday Fires used 2006 census data. A '–' in Table 4 and Table 6 indicates that data were not available for these categories. Table 4 demonstrates the population of the LGAs affected during each fire. The LGAs affected by the Black Saturday Fires contained the highest population, approximately three times higher than LGAs affected by the Great Divide Fires, four times higher than the Ash Wednesday and six times higher than the Alpine Fires. Given that approximately 50% of the Grampians Fire burnt through a national park and much of the other area was agricultural land, the population was understandably the lowest in comparison. The large difference in population between those LGAs affected by the Black Saturday and Ash Wednesday Fires is to be expected, as the Ash Wednesday Fires occurred 26 years earlier.

13 Australian Bureau of Statistics census data available at: http://www.abs.gov.au/websitedbs/D3310114.nsf/home/census+data?opendocument#from-banner=LN

Table 4 Population of the areas affected by each fire by age and gender

Age bracket	1983 Ash Wednesday			2003 Alpine			2005–06 Grampians			2006–07 Great Divide			2009 Black Saturday		
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
0–9	–	–	–	9,436	8,870	18,306	4,148	3,869	8,017	16,503	15,846	32,349	59,620	56,769	116,389
10–19	–	–	–	10,440	9,878	20,318	4,355	3,938	8,293	19,604	18,712	38,316	67,345	64,247	131,592
20–29	–	–	–	6,530	5,820	12,350	2,886	2,739	5,625	12,486	12,408	24,894	47,278	46,445	93,723
30–39	–	–	–	8,478	8,946	17,424	3,473	3,855	7,328	14,694	15,774	30,468	54,801	59,600	114,401
40–49	–	–	–	10,367	10,621	20,988	4,248	4,289	8,537	18,712	19,942	38,654	64,290	68,224	132,514
50–59	–	–	–	9,255	8,922	18,177	3,764	3,646	7,410	18,992	19,028	38,020	59,305	59,752	119,057
60–69	–	–	–	6,753	6,647	13,400	2,824	2,777	5,603	13,881	13,625	27,506	38,523	37,611	76,134
70–79	–	–	–	5,107	5,628	10,735	2,190	2,681	4,871	9,075	9,915	18,990	22,832	25,056	47,888
80–89	–	–	–	1,682	2,817	4,499	776	1,405	2,181	3,802	5,958	9,760	9,150	14,444	23,594
90–99	–	–	–	224	506	730	88	296	384	402	1,121	1,523	1,104	2,977	4,081
100+	–	–	–	7	14	21	0	6	0	15	32	47	35	97	132
Total	103,709	101,753	205,462	68,279	68,669	136,948	28,752	29,503	58,255	128,166	132,361	260,527	424,283	435,222	859,505

Sources of information were: for the Ash Wednesday Fires, Bagnall (1983); for all other fires, census tables were created from the Australian Bureau of Statistics census data website according to usual place of residence and age and population distribution information.

Family composition, shown in Table 5, was relatively consistent across the four fires for which information was available. The Alpine and Grampians Fires contained a higher proportion of couples with children; however, there was a lower proportion of couples without children compared with the Great Divide and Black Saturday Fires. Sources of information: census tables were created from the Australian Bureau of Statistics census data website according to people's location on census night and family formation and dissolution information.

Table 6 illustrates the number of people employed by industry (excludes people who do not fit into these categories, such as children). All industry categories are listed according to the 2006 census information; a '–' indicates that these categories were not differentiated in the 2001 census information used. Across all fires, the main industries in which people were employed were agriculture, forestry and fishing, manufacturing, retail trade, and health care and social assistance. In relation to bushfires, those industries most susceptible to direct or indirect impacts are the agriculture, forestry and fishing sector and retail trade. This was particularly significant for the LGAs affected by the Grampians Fires, as the proportion of people employed in these areas was higher than for any other fire. Sources of information: census tables were created from the Australian Bureau of Statistics census data website according to usual place of residence and industry of employment information.

Table 5 Family composition of the areas affected by each fire

	2003 Alpine		2005–06 Grampians		2006–07 Great Divide		2009 Black Saturday	
Family Composition	**No. of families**	**%**	**No. of families**	**%**	**No. of families**	**%**	**No. of families**	**%**
Couple family with children	61,994	58	27,038	59	28,859	41	112,026	48
Couple family with no children	30,296	29	13,156	29	29,743	42	82,851	36
One-parent Family	13,205	12	5,147	11	10,738	15	34,553	15
Other family	812	1	390	1	783	1	2,550	1
Total	**106,307**		**45,731**		**70,123**		**231,980**	

Table 6 Number of people employed per industry

Industry	2003 Alpine Fires Total	2003 Alpine Fires %	2005–06 Grampians Fire Total	2005–06 Grampians Fire %	2006–07 Great Divide Fires Total	2006–07 Great Divide Fires %	2009 Black Saturday Fires Total	2009 Black Saturday Fires %
Agriculture, forestry and fishing	7,831	14	4,684	19	10,027	9	22,179	6
Mining	403	1	232	1	1,227	1	2,432	1
Manufacturing	6,675	12	2,089	8	11,972	11	50,409	13
Electricity, gas, water and waste services	634	1	224	1	2,860	3	5,439	1
Construction	3,540	6	1,368	5	9,862	9	38,371	10
Wholesale trade	1,981	4	1,165	5	3,208	3	17,040	4
Retail trade	8,237	15	3,934	16	13,881	12	47,575	12
Accommodation and food services	3,617	6	1,152	5	7,463	7	21,419	5
Transport, postal and warehousing	1,799	3	664	3	3,953	4	17,304	4
Information media and telecommunications	534	1	299	1	1,103	1	6,100	2
Financial and insurance services	810	1	456	2	1,899	2	10,244	3
Rental, hiring and real estate services	3,124	6	1,354	5	1,241	1	4,503	1
Professional, scientific and technical services	–	–	–	–	3,594	3	17,478	4
Administrative and support services	–	–	–	–	2,918	3	11,041	3
Public administration and safety	2,059	4	753	3	6,986	6	21,798	5
Education and training	4,300	8	1,694	7	9,044	8	30,287	8
Health care and social assistance	6,256	11	3,058	12	12,870	11	42,403	11
Arts and recreational services	950	2	395	2	1,162	1	4,973	1
Other services	1,996	4	961	4	3,987	4	15,491	4
Inadequately described	326	1	84	0	1,154	1	4,493	1
Not stated	1,033	2	479	2	1,637	1	5,593	1
Total	**56,135**		**25,045**		**112,048**		**396,518**	

Three: Methodology

The steps involved in determining the economic, social and environmental impacts, losses and benefits of the five bushfires studied are described below.

3.1 Choosing the Framework

The first step was to select the most appropriate framework for the collection, collation and costing of impact data from the fires studied. This was achieved by firstly understanding what types of frameworks should be excluded from the selection process. Once this was clear, those selected were reviewed against a set of criteria to determine the most appropriate framework(s) for valuing the impacts, losses and benefits for the bushfires studied.

3.1.1 Types of Assessments Excluded from Selection

Two common forms of loss assessments were not considered in the selection process, the first relating to insurance losses. Insurance losses are typically seen as indicative of disaster losses, but insurance is partially in the hands of the private sector and is not concerned with the impact of a disaster on the local economy but interested in claims against insurers. Insurance is usually only partial; not everyone is covered and many assets, such as those held by government, and activities are normally uninsured. Furthermore, household insurance usually replaces lost items with new ones, resulting in a much higher value for such items. In the approach reported here, a depreciated (or market) value is used to better reflect the actual value of the lost asset.

The other approach excluded from selection was general equilibrium modelling, which attempts to estimate the impact of an event on a specified economy by modelling the impact on the total economic flows of goods and services. This approach would appear to make sense in disaster loss assessment when it is concerned with the impact of an event on an economy; however, there are a number of reasons why this approach is not widely used in disaster loss assessment. A good model of the economy is needed, which in turn requires very detailed data on all sectors and how they respond to different impacts. Such models exist at national and state levels, but at these levels, most disasters have very small impacts. At local levels, the impacts may be large but the models tend to be more basic. A computable general equilibrium model has been developed by The Centre of Policy Studies (Monash University, Clayton) to measure the impacts of events at a regional level (among other applications) (Horridge, Madden and Wittwer 2003); however, this and other models like it require specialist expertise to develop and run and can be expensive. For these reasons, general equilibrium modelling was considered inapplicable in the present study because of its emphasis on robust approaches that can run with limited data at a wide range of scales.

3.1.2 Frameworks Selected to Value Economic and Social Impacts and Benefits

Internet searches, references from reports and recommendations by colleagues resulted in 14 natural disaster-related loss assessment frameworks being identified. To ensure that a framework was selected in a fair and transparent way, 13 framework selection criteria and a simple scoring system were developed to compare them (Appendix 4). Of the 14 selected frameworks, two received 38 out of a possible 39 points. These were the Disaster Loss Assessment Guidelines (Handmer, Reed and Percovich 2002) and the Socio-Economic Impact Assessment Model for Emergencies (SEIA-Model) (Office of the Emergency Services Commissioner (OESC) 2008a) (scores and comments for all 14 frameworks are given in Appendix 5). Given that each framework scored very highly against the criteria and focused on different aspects of a loss assessment, both were selected for the collection, collation and costing of data.

The Disaster Loss Assessment Guidelines were applied first, as they outline the process to ensure that important economic steps are followed. This resulted in a clear understanding of the temporal and spatial boundaries for the collection of data, the types of impacts that should be included and where this impact data could be sourced. The SEIA-Model template was then used for the actual collection, collation and costing of the data. The SEIA-Model assesses the impacts associated with a natural disaster (or other emergency) to the economy in question, dividing the impacts into their direct, indirect and intangible components. The SEIA-Model also factors in the benefits resulting from a disaster, such as government aid and insurance payments. To reflect the requirements set out in objective two of the present study, however, the template was separated into the following sections: economic losses, social losses, environmental losses and benefits.

The Disaster Loss Assessment Guidelines contained 12 steps, whereas the SEIA-Model contained eight. Given many of the steps in both frameworks have already been discussed in this report, actions taken to address them in assessing the five fires are listed in Appendices 3 (Disaster Loss Assessment Guidelines) and 6 (SEIA-Model).

An important step in both frameworks was to state the spatial and temporal boundaries of the current assessment. The spatial boundary in which the impact of each bushfire event on the economy was assessed was within the LGAs that were burnt to some extent. This ensured that as well as accounting for direct destruction and damage, indirect impacts in the areas surrounding the fire were also included. By using the LGAs as the assessment boundary, data relating to each LGA could be easily tracked.

Although this boundary may be convenient for some things, state government departments and agencies and other organisations have their own regional boundary lines. This meant that impact data gathered from these sources needed to be, as best as possible, aligned with LGA boundaries (Step 3 in Appendix 3 identifies the impacted LGAs for each fire).

Information was collected from the day the fires began to two years after the fire was declared safe. This ensured that indirect losses could be sufficiently accounted for, as they may only become known months after the event has passed.

3.1.3 Framework Selected to Value Environmental Impacts

The SEIA-Model uses the contingent valuation method (CVM) (described briefly in Appendix 1) to value environmental impacts. This involves surveying a number of people to understand their maximum willingness to pay for a particular good or service by using open-ended questions (e.g. how much are you willing to pay for 'X' good(s) or service(s)?), asking people to choose between a list of increasing values or by a referendum (i.e. survey of whether people would vote, with the amount they are willing to pay, for or against an environmental proposal (Mogas, Riera and Bennett 2006; Morrison, In press)). The SEIA-Model uses the second method and in the OESC (2008a) report, those surveyed were asked what they were willing to pay for the preservation or restoration of the natural environment. There were 13 values to choose from between $0 and $100.

Using the contingent valuation survey as outlined in the SEIA-Model or conducting a separate survey was not practical for the current analysis for a number of reasons. Firstly, the survey conducted as part of the case study in OESC (2008a) asked people to state how much they were willing to pay to restore or preserve three specific areas affected by the Great Divide Fires. As the current study covers fires that burnt over large areas at different times, the questions asked would not be as specific and therefore produce different results. Secondly, to be truly meaningful, a contingent valuation survey requires a very carefully planned, well-written set of questions and post-survey analysis, which this study did not have the resources to complete. Furthermore, if a contingent valuation survey does not contain enough information for the respondent to provide meaningful and well thought-out answers, then there is a large chance that respondent biases will distort valuation results (Barkmann et al. 2008).

The key to valuing the environment for the purpose of the present study was that the values placed on its services were the same across each fire, thereby allowing consistency and comparability in the results. Given this requirement, the framework proposed by Costanza et al. (1997) was employed, which focuses on use values (Figure 1). This approach had the advantage of placing a consistent monetary value on 17 ecosystem services required for human well-being (e.g. atmospheric gas regulation, water supply), thereby making the damage to environmental assets comparable across the fires and to losses sustained by commercial markets (Costanza et al. 1997) (the full set of ecosystems services, their functions and price per hectare is described in Appendix 7). Two of these ecosystem services did not contribute to the final ecosystem service cost used in the current assessment, Food Production and Raw Materials, as the costs associated with these were accounted for in the loss of agricultural (including horticultural) crops and timber. Conversely, the values given to Recreation and Cultural ecosystem services were used to measure the loss to tourism and cultural heritage values. Many types of biomes (e.g. ocean, coastal, deserts) were valued by Costanza et al. (1997), with Forest, Swamps and floodplains, Grasslands and Cropland being singled out for use in the present assessment. The areas of pasture lost to the fires contributed to the grasslands total. This method does, however, posses a number of critical limitations, which are discussed in *3.3 Limitations.*

Costanza et al. (1997) used a dollar value per hectare per year. A bushfire usually burns through an area in a mosaic pattern (i.e. there will be areas of unburnt and burnt vegetation; the amount of vegetation burnt may range from some scorching of the understorey to complete incineration of the understorey and crowns of the trees) (Lindenmayer and McCarthy

2002). During the Alpine Fires for example, Williams et al. (2008) found that approximately 50% of the Bogong High Plains (i.e. non-treed grass and shrublands) within the fire boundary was not burnt. In another study measuring the spatial patterns of fire behaviour, Hammill and Bradstock (2009) measured the percentage of landscape burnt in two bushfires during extreme (FFDI[14] ≈ 100) and moderate (FFDI ≈ 20) weather. During extreme weather, 71% of the landscape was burnt by either an intense understorey fire (51%) or a crown fire (20%). During moderate weather, 53% was burnt by either a patchy understorey fire (30%) or a low-intensity understorey fire (23%). The area unburnt in each fire was 1% for extreme and 2% for moderate. Based on these studies, 70% of the vegetation was assumed to be burnt.

The scope of the current loss assessment was to account for bushfire impacts over two years; however, as vegetation regrows, an estimate of what proportion of each ecosystem service is 'restored' by the second year cannot be given with any degree of confidence at present. Therefore, the final environmental impact value was chosen as 70% of the first-year loss value. Costanza et al. (1997) did not take into consideration the many beneficial impacts of fires on the ecosystem, such as stimulating seed germination via heat or smoke (Gill 1981; Auld 1996).

3.2 Collecting and Collating the Data to Produce the Net Loss

Data were collected from primary sources where possible, such as relevant government agencies and other organisations (as identified in Step 6 of the Disaster Loss Assessment Guidelines in Appendix 3). Other sources used were inquiries, books and reports (brief list shown in Appendix 8). Collecting data for the Ash Wednesday Fires proved relatively difficult, as government agencies and other organisations that were approached had very little information. Therefore, impacts and costs were largely sourced from literature.

Once the data were collated, they were entered into a database containing the (slightly modified) SEIA-Model template. A list of assets that could potentially be impacted already existed in the template provided by the SEIA-Model, as well as the principles used to estimate the value of the impacts (Table 7).

14 (McArthur) Forest Fire Danger Index: forecasts the influence of weather on fire behaviour. Index values range from 0 to 5 for low to 50+ for extreme (Luke and McArthur 1986).

Unit values (e.g. price used per house destroyed) were used as per the literature and no discount rates were applied or sensitivity analysis conducted. These economic concepts could be applied to the analysis at a later stage.

Quantifying Economic Costs

Residential, commercial, industrial and public premises, stock and contents, infrastructure and public assets were valued according to the following formula: X% of the replacement cost (i.e. depreciated value) or cost of repairs if damaged multiplied by the number of assets destroyed or damaged. The percentage value ranged from 85% for residential, commercial, agricultural and park buildings to 50% for many park structures (e.g. tables and seats, park signage). Agricultural livestock and feed were valued according to their market value at the time of the fire, apart from pasture, in which the cost of restoration was used. For crop and timber losses, the market price at the time of the fire less input costs avoided was used.

Many of the dollar values used to find the unit cost of an impact (e.g. replacement cost per park sign, cost of pasture restoration per hectare) came from the OESC (2008a) report, but other reports were also used (Buchan 2007; Office of Best Practice Regulation 2008; Read Sturgess and Associates 2000). In some cases, the unit costs of assets were researched by the author, particularly for agricultural buildings (e.g. woolsheds, dairy sheds, hay sheds). In other cases, the total amount lost for an entire group of assets was given in the literature, with no break-down of the impacts to specific assets (e.g. number of fire towers destroyed, kilometres of track damaged). This was especially evident when gathering information for the Ash Wednesday Fires. For example, the total loss to the Forests Commission Victoria, which at the time managed parks, reserves and forestry (timber) operations, was given for park and reserve assets (e.g. signage, roads, tracks) as well as the loss in timber production to the State.

Quantifying Social Costs

The three social impacts to be quantified were fatalities, injuries and cultural heritage. The statistical cost of a fatality followed the recommendation made by Abelson (2008), being valued at $3.652 million (in 2008 dollars). Injuries were not valued as a proportion of a statistical life year ($158,000) as suggested by Abelson (2008) because this would require the cause of every injury sustained for each fire to be known in order to apply the correct proportional weighting.

Table 7 Types of impacts and the appropriate means of quantifying their costs

Potential impacts	Estimation principle
Economic	
Direct	
• Residential buildings and contents	Depreciated economic value
• Commercial (inc. agricultural) and industrial buildings and contents	Depreciated economic value
• Public (inc. park) buildings and contents	Depreciated economic value
• Infrastructure (e.g. roads, fencing)	Depreciated economic value
• Livestock, feed	Market price at time of loss*
• Crops, timber	Market price at time of loss less input costs avoided
Indirect	
• Business disruption (i.e. loss of production, clean-up costs)	Loss of value added not taken up in the region within specific timeframe
• Transport network disruption	Increased operating costs, time value of delays, value of freight lost
• Disruption of public services	Cost of provision of public services not received
• Household disruption	Household survey
• Disaster response and relief	Marginal cost of response to bushfire, cost of alternative accommodation
Social	
• Fatality	Value of a statistical life – measured in OESC (2008a) using the human capital approach, but could also use the willingness to pay approach
• Serious injury (i.e. admitted to hospital)	Refer to *Fatality* entry
• Minor injury (i.e. may be treated in but not admitted to hospital)	Refer to *Fatality* entry
• Other health effects (stress, anxiety, etc.)	Lost time approach
• Memorabilia	Qualitative only
• Cultural heritage (sites and artefacts)	Contingent valuation method (could also use Choice modelling)
Environmental	Contingent valuation method (or Choice modelling; either can be used to value ecosystem services)

* Pasture is the only exception, which uses the cost of restoration.

Source: OESC 2008a, p. 66

Instead, the values developed by the BTE (2001) were employed (in 2008 dollars): $431,000 per serious injury and $14,400 per minor injury. Even though other studies have placed dollar values on injuries (Ashe, McAneney and Pitman 2007; Department of Justice 2010), the BTE (2001) values were considered to be the most representative and transparent. Impacts on cultural heritage were valued in the Costanza et al. (1997) framework.

Quantifying Environmental Costs

Reasons for choosing the Costanza et al. (1997) framework are described in *3.1.3 Framework Selected to Value Environmental Impacts*. Even though this is far from ideal (Pagiola, von Ritter and Bishop 2004), it was the only framework to provide a single value per hectare for each type of biome, e.g. forest, grasslands, to the author's knowledge, thus allowing consistency and comparability across the separate fires studied. Estimating these services in a common unit allows the services provided by the ecosystem to be compared with economic services and manufactured capital (Costanza et al. 1997). If these ecosystem services are not valued in dollar terms, TEEB (2009) points out that their overall value in terms of their weighting in policy decisions would be grossly underestimated.

When converting the ecosystem services values (i.e. for the environmental losses) from 1994 US dollars (as used in Costanza et al. 1997) to 2008 Australian dollars, an additional step had to be taken. This was achieved by multiplying each ecosystem service value by the average exchange rate for 1994 (73c (i.e. AU$1 = US$0.73[15]), and then using the RBA's inflation calculator to convert it to 2008 dollars. As an example, the value of erosion control in grasslands was originally valued at US$29 ha^{-1} yr^{-1}, which equates to AU$59 ha^{-1} yr^{-1} in 2008 dollars.

3.3 Limitations

As a result of using existing frameworks, data and costs per impacted asset from a range of sources, inherent limitations will exist. These are:

- Any deficiencies in the rigour of methodologies and in the data or costs were passed on to the current loss assessment.
- Impacts that result in reports quoting different loss or benefit values meant that certain assumptions had to be drawn as to the 'correct' figure. A good example of this was four reports listing the loss of houses in Victoria during the Ash Wednesday Fires as the following:
  - 1,511 houses destroyed; Healey 1985
  - 1,719 houses destroyed; Cain1983
  - 2,080 homes destroyed or damaged; Miller, Carter and Stephens 1984
  - 2,076 homes and other buildings destroyed; CFA 1983
- The above limitation exposes a related limitation – a lack of detailed data for some impacts. In the above examples, all authors may have given the correct number of houses lost or destroyed according to their assessment parameters or knowledge at the time. Some of the above authors may have included losses from fires across the 1982–83 season, or used loss figures available at different stages of their impact assessment, before the final losses were known.
- The degree to which the information could be analysed and conclusions drawn was limited by the amount of information used in the analysis. That is, not all impacts that could be valued were valued for all five fires. Reasons for this were that the impact data no longer appeared to exist (evident for Ash Wednesday Fires) or had not been found, or the information requested had not been returned to the author at the time of publication.
- The lack of a complete data set to measure the full extent of environmental impacts underestimates their total value. As described in section *3.1.3 Framework Selected to Value Environmental Impacts*, Costanza et al. (1997) valued 17 different ecosystem services for a range of biomes (Appendix 7). Not all 17 ecosystem services were valued for each biome however. Costanza et al. (1997) estimated values for ecosystem services within a Temperate/Boreal Forest and a Tropical Forest. The value for each ecosystem service (e.g. water regulation) produced by each biome was averaged to produce a value for Forest. Temperate/Boreal Forest contained values for nine ecosystem services, seven of which were used in the current study. The other eight ecosystem services were not valued by Costanza et al. (1997). Thirteen ecosystem services were valued for Tropical Forest. Even though Temperate/Boreal Forest values would have been more appropriate in this study, the ecosystem services values for Forest were used, as critical services such as erosion control and nutrient cycling that were not valued in Temperate/Boreal Forest

15 See Reserve Bank of Australia: http://www.rba.gov.au/statistics/hist-exchange-rates/index.html

were now accounted for because they were valued under Tropical Forest.

- Using the Costanza et al. (1997) framework itself had several limitations. These are explained by Pagiola, von Ritter and Bishop (2004):
  - The Costanza et al. (1997) study collected the results of other studies that valued ecosystem services at specific locations around the world and extrapolated them to give one value for each service across the earth. This is known as a benefit transfer, whereby the values estimated in one context are used in another context. For instance, the value of the ecosystem services provided by the Amazon is transferred to Kakadu National Park. Using this example, it is clear that simply applying one set of values derived in one location will produce unreliable results for another completely different landscape due to the wide variation in ecosystem service values across different sites.
  - The value for the world's ecosystem services produced by Costanza et al. (1997) exceeds the sum total of global income (global gross national product). Many of the studies (but not all; refer to Appendix 1 for other methods) used by Costanza et al. (1997) to derive their total were based on people's willingness to pay for these services, but people cannot realistically pay more than what they earn.
  - The values estimated in the Costanza et al. (1997) study are treated as being able to generate total economic values when they are mostly capable of generating marginal (i.e. incremental) values. That is, non-market valuation techniques in particular are good at valuing a change from X to Y, but not at identifying the total value of Z. For example, a person would be willing to pay a greater price per unit to save a remnant patch of eucalypt forest if there were only 10 such areas left in Victoria, as opposed to 100 areas left. Instead, Costanza et al. (1997) ascribed an average price per hectare for an ecosystem service regardless of how large the assessment area was or how many ecosystems with similar components there were to derive the total value.

These are significant limitations (which are not disputed by Costanza et al. (1997)), but, as stated before, this framework provided consistent values for a range of ecosystem services that allowed comparability across the five fires. Furthermore, no Australian study was found that provides a consistent range of values.

4

Four: Results

The Results section is divided into two parts. The results of the current study are presented first, showing the losses, benefits and net loss resulting from those impacts that could be quantified, and these results are then analysed. Owing to constraints in the current assessment, qualitative data could not be obtained using surveys. Instead, the results of three previous studies, in which qualitative impacts from the Ash Wednesday, Alpine and Great Divide Fires were measured, are included in the second part, in order to highlight the significance of these impacts as equal to those for which a dollar value has been allocated, and that decisions made regarding bushfires should place as great an importance on these types of impacts.

4.1 Qualitative Impacts and the Estimated Losses, Benefits and Net Loss

The losses, benefits and net losses for each fire are shown in Table 8. Not all impacts included in the SEIA-Model were valued, including health impacts (other than fatalities and injuries) and the indirect disruption to businesses, transport networks, essential service provision, public services and households. Identifying indirect costs can be difficult, as detailed business and household surveys are the best ways to obtain information on which calculations can be made and much of this information could not be collected by surveys owing to the large time-span over which the fires occurred and the resources available to conduct the assessment. As a result, the cost of emergency response and smoke taint in viticulture crops were the only indirect impacts estimated. The costs associated with the NSW component of the 2003 Alpine Fires and the Canberra Fires are shown in Appendix 2.

Table 8 Losses, benefits and net economic loss for each fire

Asset	Value (2008 AU$)				
	1983 Ash Wednesday Fires	2003 Alpine Fires	2005–6 Grampians Fires	2006–07 Great Divide Fires	2009 Black Saturday Fires
Total area (ha)	179,615	1,080,893	142,885	1,113,251	388,261
Economic losses	**946,581,042**	**1,715,286,629**	**124,372,271**	**1,077,615,049**	**1,826,197,051**
Residential buildings and contents	556,112,500	7,841,250	14,563,250	13,578,750	611,842,500
Commercial and industrial buildings and contents	33,542,149	2,613,750	0	0	37,223,605
Park buildings, contents and infrastructure	118,102,953	34,736,687	10,785,439	28,592,624	33,392,225
Public infrastructure	0	82,802,000	0	0	6,885,000
Agriculture	195,994,896	60,767,501	62,467,446	165,582,348	720,102,519
Timber	29,850,197	1,391,993,388	0	692,461,833	78,900,464
Emergency response operations	12,978,346	134,532,053	36,556,136	177,399,494	337,850,738
Social losses	**205,883,954**	**3,652,000**	**7,304,000**	**3,652,000**	**701,857,540**
Fatalities	171,644,000	3,652,000	7,304,000	3,652,000	631,796,000
Major injuries	28,470,354	0	0	0	56,077,970
Minor injuries	5,769,600	0	0	0	13,983,570
Environmental losses	**77,933,627**	**1,094,975,092**	**315,166,022**	**1,095,619,252**	**359,139,365**
Benefits	**435,620,794**	**122,565,903**	**39,938,160**	**174,819,572**	**1,962,284,227**
Payments by government	12,526,700	99,911,542	11,532,945	144,206,744	507,758,230
Donations	64,891,732	2,904,405	213,573	350,562	382,046,329
Insurance	358,202,362	19,749,956	28,191,642	30,262,266	1,072,479,668
Total losses	**1,230,398,623**	**2,813,913,721**	**446,842,293**	**2,176,886,301**	**2,887,193,955**
Total benefits	**435,620,794**	**122,565,903**	**39,938,160**	**174,819,572**	**1,962,284,227**
Net loss from bushfire	**794,777,829**	**2,691,347,818**	**406,904,133**	**2,002,066,729**	**924,909,728**

References for total area values in Table 8:

- Ash Wednesday Fires– CFA (1983) and Forests Commission Victoria (1983)
- Alpine Fires – CFA (2003), DSE (2003), and Wareing and Flinn (2003), unpublished DPI data
- Grampians Fire – Fleming et al. (2007)
- Great Divide Fires – Flinn, Wareing and Wadsley (2008), unpublished DPI data
- Black Saturday Fires – DSE (2009), unpublished DPI data

Table 8 provides a large amount of information, and the tables and graphs below have been created to better understand the important relationships within and between each fire.

Table 9 shows the total loss and net loss of each fire per hectare. The most expensive fires per hectare using total loss were the Black Saturday Fires, closely followed by the Ash Wednesday Fires. These high values can be attributed to the large housing, agricultural and social losses sustained in relatively small areas. The Grampians Fires had the next highest value, with total losses of $3,127 per hectare. This can be attributed to the high agricultural and environmental losses over the smallest area of the five fires studied. The Alpine and Great Divide Fires produced the lowest total losses per hectare. Although the timber and environmental losses were very large for both, the total size of the fires meant that the cost per hectare was spread over a much larger area than the other three fires.

When taking into account the financial benefits received post fire, the net losses were reduced across all five fires. The greatest change was seen in the Black Saturday Fires. The amount spent by the government in aid, community initiatives and environmental recovery works was 40 times greater than for the Ash Wednesday Fires. In addition, donations were almost six times greater and insurance payouts three times greater. As a result of this assistance and the comparatively low benefits received after other fires, the net loss was greatly reduced.

Figure 8 demonstrates what proportion of losses makes up the final total losses for each fire. The proportions of economic losses compared with environmental losses give some clues as to where each fire occurred. The Ash Wednesday and Black Saturday Fires, for example, burnt through many residential areas and agricultural land compared with the amount of forests burnt, resulting in higher proportions (%) of economic losses. Conversely, the 2006 Mount Lubra Fire (part of the 2005–06 Grampians Fires) burnt through a large area of national park compared with the number of houses destroyed and agricultural losses, therefore resulting in 71% of the total losses being attributed to environmental losses for the 2005–06 Grampians Fires. Although social losses account for a large proportion of the total losses in only the Ash Wednesday and Black Saturday Fires they are very important during any fire.

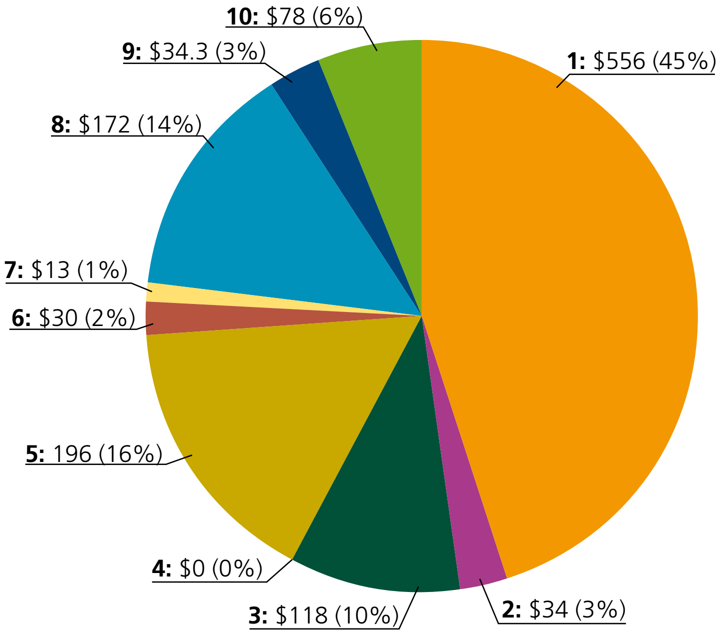
Table 9 Total loss and net loss for each fire per hectare

Comparison measurements	Value (2008 AU$/ha)				
	1983 Ash Wednesday Fires	2003 Alpine Fires	2005–06 Grampians Fires	2006–07 Great Divide Fires	2009 Black Saturday Fires
Cost per hectare – total loss/area	6,850	2,603	3,127	1,955	7,436
Cost per hectare – net loss/area	4,425	2,490	2,848	1,798	2,382

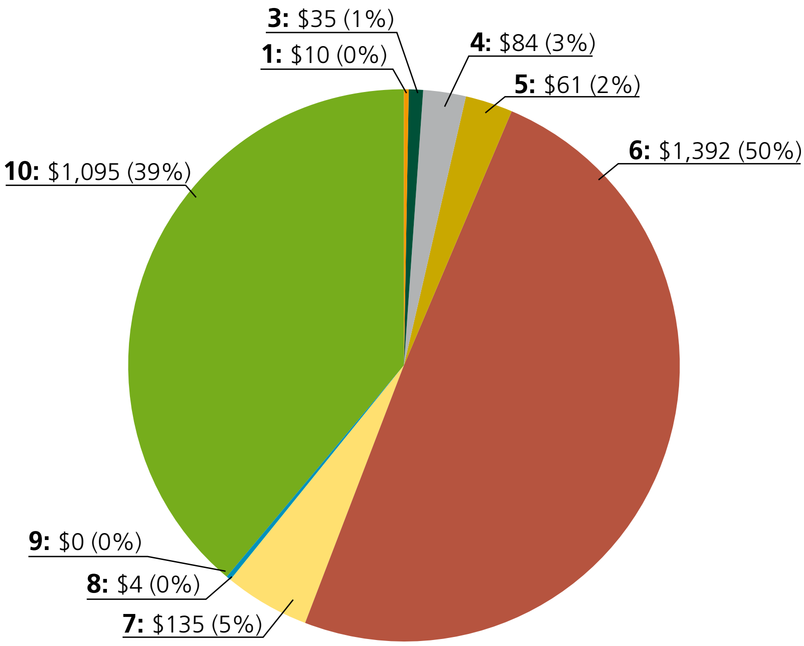
The next three pages are part of Figure 8. The legend for the graphs is:

1. Residential buildings and contents
2. Commercial and industrial buildings and contents
3. Park buildings, contents and infrastructure
4. Public infrastructure (i.e. roads and utilities)
5. Agriculture (i.e. stock, feed, crops, buildings and fencing)
6. Timber
7. Emergency response operations
8. Fatalities
9. Injuries
10. Environment

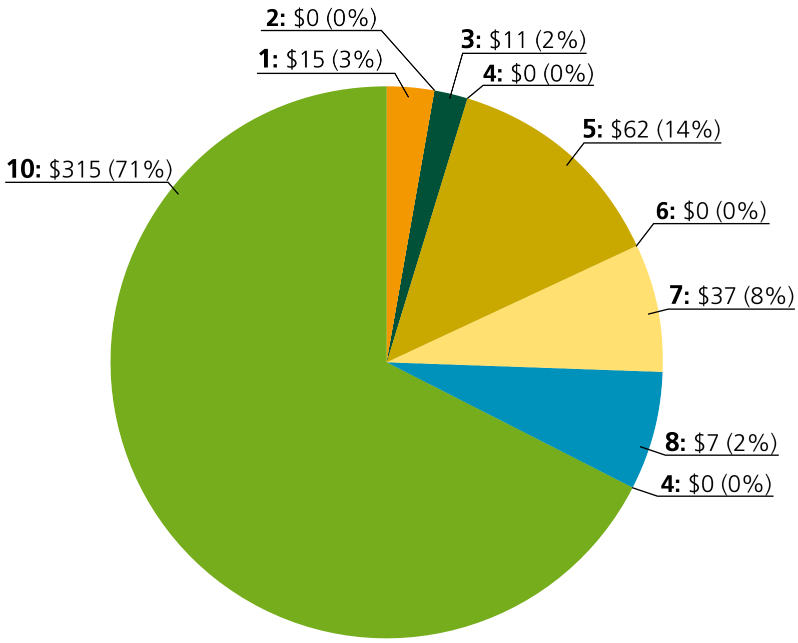
1983 Ash Wednesday Fires ($'000,000)



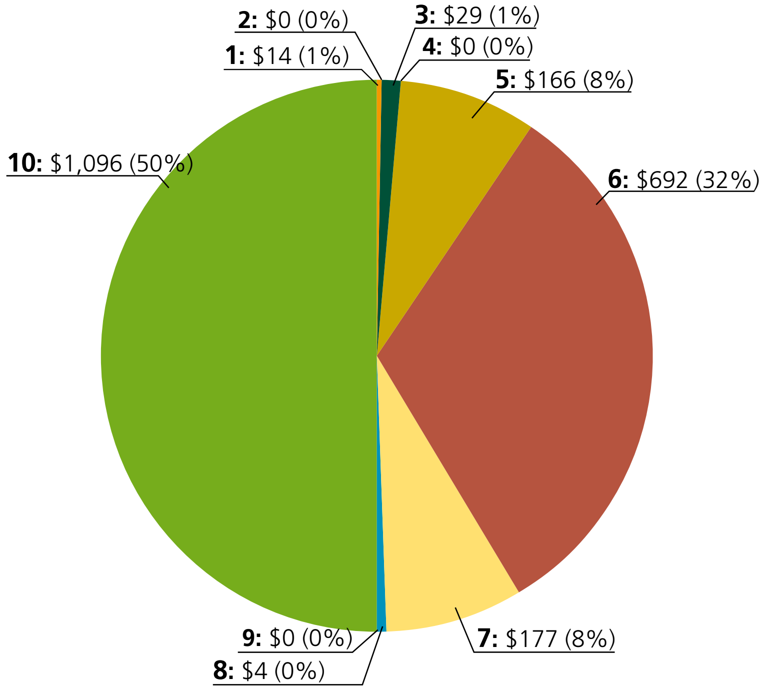
2003 Alpine Fires ($'000,000)



2005–06 Grampians Fires ($'000,000)



2006–07 Great Divide Fires ($’000,000)



2009 Black Saturday Fires ($’000,000)

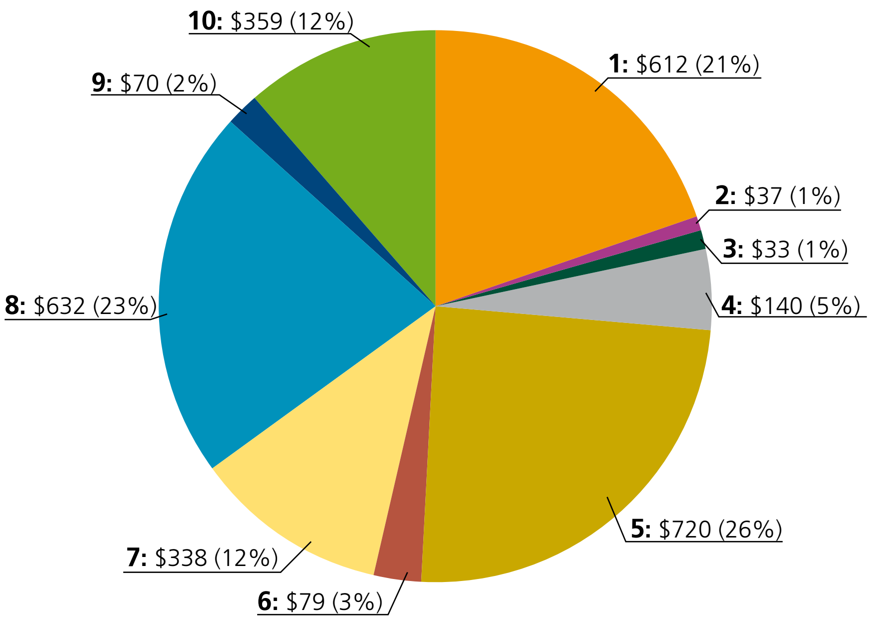
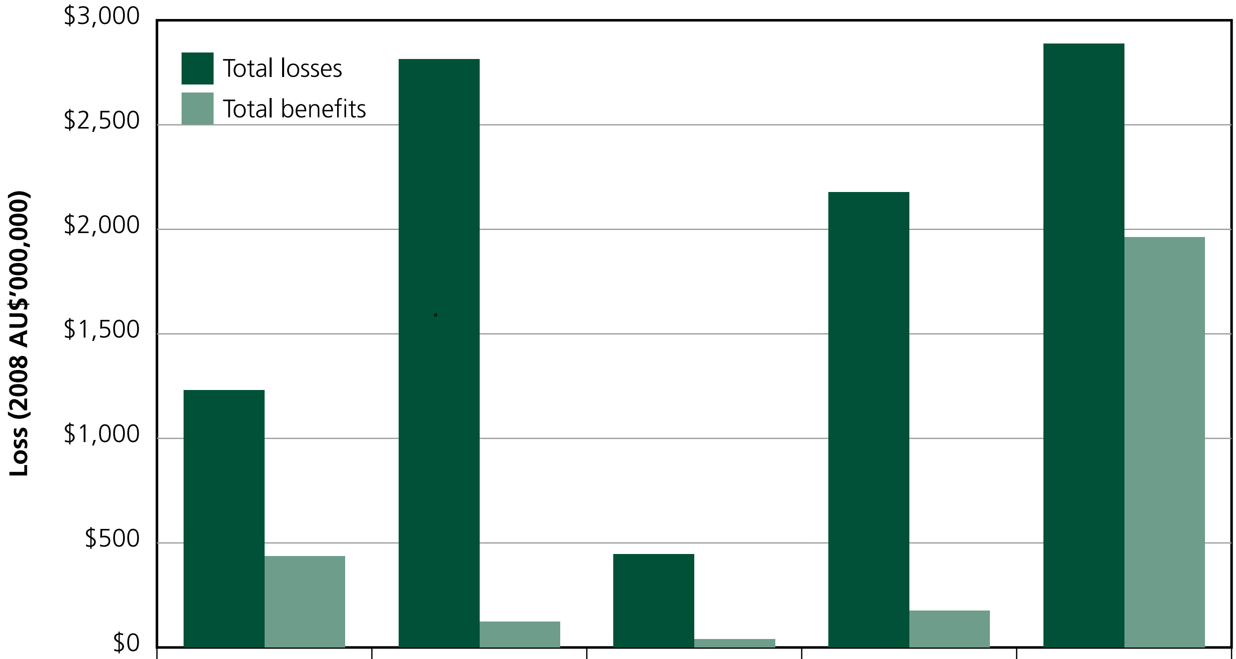


Figure 8 The types of losses as a proportion of the total loss for each fire. Values are in 2008 Australian dollars (refer to two pages above for legend)

Figure 9 shows the amount of benefits received (i.e. government aid, donations, insurance payouts) compared with the total losses. This graph demonstrates that the losses far outweigh the benefits, with benefits as a percentage of total loss accounting for between 4% (Alpine Fires) and 68% (Black Saturday Fires). The Black Saturday Fires again stand out in this graph, as the proportional (and absolute) benefits are much higher than for any of the other fires.

While many economic and social impacts can be repaired, replaced or healed with the financial benefits received, it could be argued that this does not apply to the environment (apart from conducting isolated restoration or rehabilitation works) as it requires time to regrow and restore its ecosystem services as part of the natural process. Therefore, the data have been reassessed to omit environmental losses and the results are presented in Table 10. This table does not negate the importance of the impacts to the environment, as valuing ecosystem services provides a basis on which to make decisions regarding fire management and policies.



	1983 Ash Wednesday Fires	2003 Alpine Fires	2005–06 Grampians Fires	2006–07 Great Divide Fires	2009 Black Saturday Fires
Net loss	$795	$2,691	$407	$2,002	$925
Total loss	$1230	$2814	$447	$2177	$2887
Benefit as % of total loss	35%	4%	9%	8%	68%

Figure 9 Benefits received as a proportion of the total losses

Table 10 Values with and without environmental losses

Comparison measurements	Value (2008 AU$/ha)				
	1983 Ash Wednesday Fires	2003 Alpine Fires	2005–06 Grampians Fires	2006–07 Great Divide Fires	2009 Black Saturday Fires
Cost per hectare – total loss/area	6,850	2,603	3,127	1,955	7,436
Cost per hectare – total loss/area (excluding environmental losses)	6,416	1,590	922	971	6,511
Cost per hectare – net loss/area	4,425	2,490	2,848	1,798	2,383
Cost per hectare – net loss/area (excluding environmental losses)	3,991	1,477	642	814	1,457
Benefits received as a proportion of total losses	35%	4%	9%	8%	68%
Benefits received as a proportion of total losses (excluding environmental losses)	38%	7%	30%	16%	78%

Even with the environmental losses removed, values are still similar for those fires in which they were proportionally low. The largest change is, understandably, found in the Grampians Fires, which had the largest proportion of environmental losses.

4.2 Examples of Qualitative Impacts Resulting from the Fires Studied

Previous studies have measured qualitative impacts resulting from the five fires studied. The results of three previous studies have been included in this section, although data were not collected by this author, to highlight the extent of these types of impacts and draw attention to the fact that qualitative data is just as important in the decision-making process when responding to a fire, allocating recovery funding and writing policies. Clayer, Bookless-Pratz and McFarlane (1985) distributed a survey after the Ash Wednesday Fires to assess whether health problems had changed as a result of the fires. The responses were then compared with those of 100 people not affected by the fires matched for age and gender (Table 11).

A majority of the conditions listed in Table 11 were found to have increased among the bushfire-affected population (refer to Risk ratio column). Most notably, there was a 283% increase in mental illness, 117% increase in drug problems and 96% increase in alcoholism.

In another study, Freslov (2004) surveyed a number of areas after the Alpine Fires to determine the impact of the fires on Aboriginal sites and artefacts (Table 12). The report found that severe fires aided in locating sites, firstly by defoliating vegetation to enable better line of sight and exposing the soil, and secondly by triggering erosion, which in some cases washed the overlying soil away (Freslov 2004). In other cases, the complete defoliation enabled the researchers to discover and record artefacts and sites not previously known. In terms of severe fire impacts on physical objects, Freslov (2004) found very minimal damage to artefact scatters, grinding grooves, rock shelters and quarry sites, citing sooty deposits as the main impact.

Table 11 Prevalence rate (per 100) of health problems in three groups after the Ash Wednesday Fires (risk ratios are shown for post-bushfire rates relative to pre-bushfire rates)

Condition	Comparison group	Bushfire group (before)	Bushfire group (after)	Risk ratio	95% Confidence limits
Alcoholism	4.0	1.64	3.21	1.96	1.73–2.65
Arthritis	9.0	16.51	17.10	1.04	N/A
Cancer	0.0	0.85	1.25	1.06	N/A
Cardiac disease	1.0	4.06	5.31	1.31	1.15–1.49
Diabetes	1.0	1.25	1.70	1.37	1.05–1.80
Drug problem	1.0	0.39	0.85	2.17	1.13–4.16
Upper bowel	12.0	10.09	14.94	1.48	1.32–1.66
Lower bowel	6.0	5.9	8.39	1.42	1.23–1.65
Hypertension	3.0	11.27	12.84	1.14	1.04–1.25
Mental illness	1.0	0.79	3.01	3.83	2.33–6.29
Urological disorder	3.0	2.95	3.41	1.16	1.07–1.25
Respiratory disorders	14.0	8.39	10.75	1.28	1.13–1.45
Sleep problems	24.0	21.36	38.53	1.80	1.67–1.94
Problems with nerves	17.0	16.12	30.28	1.88	1.72–2.05
Palpitations	3.0	4.06	6.95	1.71	1.84–2.11

Source: Clayer, Bookless-Pratz and McFarlane (1985, p. 13)

Table 12 Site density per hectare of Aboriginal cultural heritage values after the Alpine Fires

Survey Unit	Average visibility resulting from the fire (%)	Effective coverage (ha)	Number of sites located	Site density (sites per hectare)
Stanley State Forest	20.0	4.0	1	0.3
Mount Taylor–Tubbut	39.6	31.2	19	0.6
Tambo	29.1	13.5	10	0.7
Mount Mittamatite	58.6	14.1	11	0.8
Nariel–Pinnibar	16.5	13.0	16	1.2
Yalmy Road–Moonkan	71.4	5.1	10	2.0
Mitta Mitta–Dartmouth	42.2	13.5	28	2.1
Tom Groggin	54.2	5.7	13	2.3
Gibbo	66.4	12.0	31	2.6
Mount Selwyn	23.9	7.7	23	3.0
Mount Buffalo National Park	42.0	7.4	27	3.6
Mount Sarah–Winchester–Dargo	55.9	15.4	60	3.9
Bundarra–Glen Wills	63.8	6.4	25	3.9
Dargo 2	53.4	7.9	51	6.5
Total		**156.9**	**325**	**2.1**

Source: Freslov (2004, p. 14)

Apart from beneficial impacts of fires on ecosystems, the OESC (2008a) also listed beneficial social impacts. A household survey was carried out after the Great Divide Fires in Wellington Shire, and respondents listed the following as benefits that arose out of the bushfire:

- Highlighted and strengthened community capacity to deal with emergencies
- Created and strengthened community spirit and morale
- Improved communications and engagement within the community
- Strengthened individual self-sufficiency
- Increased community awareness of bushfire threats
- Increased preparedness and capacity to deal with future bushfires
- Increased awareness of bushfire issues
- Generated support for and greater involvement in CFA
- Increased awareness of the role and importance of volunteers
- Greater awareness of the needs of older and vulnerable people in the community
- Regenerated flora and had positive environmental effects

Five: Discussion

The discussion section summarises and validates the results obtained from this assessment, highlights what impacts were considered a high priority when assessing bushfires and proposes the next steps in the establishment of a systematic recording and reporting framework. All costs are in 2008 Australian dollars.

5.1 Comparing these Loss Values to other Assessments: are these Values too High?

The impacts assessed in this study may appear high, but when evaluated against other studies that measure bushfire impacts, they are generally comparable. The SEIA-Model (OESC 2008a), on which the framework used in this assessment is based, measured the impacts of the Great Divide Fires on the Wellington Shire as a case study. It estimated the net loss as being $65.7 million. This is a long way from the $2.002 billion estimated in the current study; however, two factors have to be taken into consideration. Firstly, the SEIA-Model (2008a) used household surveys that asked how much people were willing to pay for the non-use values of the impacted areas to calculate the environmental loss, resulting in a figure of $92,865. It should be noted, however, that this figure is totally dependent on the number of people in the population. Even a very large per-household value can result in a small total if the population is small. Secondly, seven other shires and rural cities were directly affected by this bushfire. If the value of environmental impacts used in the current report ($1.096 billion) is subtracted from the net loss value and the result is divided by the seven shires and rural cities affected, the result is $129 million. This is still much larger than the SEIA-Model value (OESC 2008a) and may be attributed to the fact that each shire and rural city would have been affected differently in terms of the area burnt and numbers of items burnt, thereby leading to some shires sustaining much greater losses than others.

Several reports have estimated the losses associated with the Ash Wednesday Fires. The BTE (2001) estimated that the total loss for both Victoria and South Australia was $1.296 billion. Given that the fire burnt approximately the same area in both states, the total loss for Victoria has been taken as half of this value, being approximately $648 million. The BTE (2001) assessment only accounted for economic and social losses (i.e. did not include environmental losses or the benefits). By only including the economic and social losses from the current loss assessment ($1.152 billion), it can be seen that the BTE (2001) figure (for Victoria only) is $504 million below the value given in the current assessment. This can be attributed to the latter valuing many more impacts, such as timber losses and losses to national and state parks.

Two parliamentary reports also estimated the total cost of the Ash Wednesday Fires, with the Premier at the time, The Hon. John Cain, quoting the loss as $506 million (Cain 1983) one month after the fires. One and a half years later, and presumably with a more accurate assessment of the losses, the House of Representatives Standing Committee on Environment and Conservation (1984) estimated that the damage done was most likely in excess of $1.298 billion. The latter value is relatively close to the total loss value (i.e. excluding benefits) produced in this report of $1.230 billion. Unfortunately, the report by The Hon. John Cain and the House of Representatives Standing Committee on Environment and Conservation did not give any information on what types of losses were included in their figures.

Two loss assessments carried out by international researchers demonstrated that the losses associated with fires in the US and New Zealand can also be very large. A 2003 southern California fire burnt through 50,586 ha of upper catchment vegetation and residences (Dunn 2005). Although this fire was approximately one-third the size of the Grampians Fires, Dunn (2005) estimated the total loss as being $1.858 billion. This took into consideration the response and recovery expenditures of public agencies, private residents and businesses and non-profit organisations over a period of two years, but did not look at the benefits. Considering that the affected catchment was a major source of drinking water, which had to now be treated, and thousands of insurance claims were made (787 total losses and 3,860 partial losses of property were claimed by private citizens and businesses), the total loss seems reasonable. In New Zealand, Wu, Kaliyati and Sanderson (2009) estimated that the average annual economic cost of bushfires from 2002 to 2007 was $82 million. This figure included costs across the economic, social and environmental categories, but did not consider the benefits. This value may not sound like much compared with those produced by the five fires studied in this report; however, the average area burnt over this period in New Zealand is approximately 5,500 ha per year (Wu, Kaliyati and Sanderson 2009) and this equates to an average of $14,927 ha^{-1} yr^{-1}. Compared with the total loss values in Table 9, this value is approximately twice as large as that from the Black Saturday Fires (the most expensive fire per hectare in the current study).

5.2 High-Priority Requirements when Accounting for Bushfires

When accounting for bushfire losses, the results of this study indicated a number of high-priority impacts that lead to substantial losses, and hence efforts should be made to manage these impacts to mitigate future costs.

Human Lives

The highest priority when responding to natural disasters is always the preservation of life. The Black Saturday Fires resulted in 174 deaths, 130 serious injuries and 670 minor injuries (Teague, McLeod and Pascoe 2009). The Ash Wednesday Fires also resulted in substantial fatalities and injuries. Although it may seem inappropriate to place a dollar value on a life in one sense, the BTE (2001) asserted that estimating the costs of intangible impacts such as this generates opportunities for more informed decision-making. It also creates a more accurate and holistic estimate of the total economic loss that is used by policy-makers when making decisions about hazard prevention and mitigation strategies (BTE 2001).

Ecosystem Services

The lack of ecosystem service values (i.e. Environmental Losses in Table 8) relating to Australian natural environments was a significant limitation in analysing the impact on the environment. Even so, the Costanza et al. (1997) framework resulted in values contributing between 6% (Ash Wednesday Fires – $78 million) and 71% (Grampians Fires – $315 million) to the total losses and highlights how valuable the environment is when compared with other loss types (Figure 8).

It could be argued that the ecosystem service values given in this assessment are at their lower potential limits. Firstly, this assessment took a conservative estimate at the amount and length of time ecosystem services would be affected, assuming that 70% of the vegetation is burnt and is affected only for the first year; however, it is assumed that it would take a lot longer for some services to function at full capacity again. Secondly, the emphasis placed on these ecosystem services may have become greater since Costanza et al. (1997) first placed a dollar value on them (e.g. climate regulation, biological resources for medicines), therefore increasing their dollar value per hectare above the value recorded in the Australian Consumer Price Index CPI.

Even without knowledge of the study of ecosystem services, they have often been given a high priority by land and fire managers. A prime example is the early recognition during the Great Divide Fires of the threat posed to the Thompson Dam catchment (the main source of Melbourne's drinking water), which was saved by the construction of a 107-km control line (Flinn, Wareing and Wadsley, 2008). Translating the importance of the environment into a dollar value is therefore an important step in an economic loss assessment, providing valuable data for the development of policies, mitigation strategies and risk management.

Timber

Timber losses were very high for the Alpine ($1.392 billion) and Great Divide ($692 million) Fires, reflecting the burning of harvestable state forests and plantations. These estimates were based on mill-gate timber and pulp wood prices[16] for hardwood ash species (Buchan 2007). The values shown above have already been discounted by the value of the timber salvaged after the bushfires. Salvaging operations begin immediately after a fire and continue for one and half to three years, depending on the resources available and speed at which the timber degrades (DSE and PV 2008). The current study found that the area salvaged differed greatly between plantations and native timber in state forests. Approximately 27% of the plantation area burnt was salvaged across the Alpine Fires and 30% was salvaged after the Great Divide Fires. Only 3% and 5% of the state forest available for harvest (87,000 ha in the Alpine and 46,396 ha in the Great Divide Fires) was salvaged within two years.

Different species of trees respond very differently to fire. Alpine and Mountain Ash, which are valued highly for their uses in flooring and furniture-making, are easily killed by fire, and deteriorate rapidly in terms of their timber quality and value (VicForests 2009). Other 'mixed' species of eucalypts, such as the Messmate Stringybark, Manna Gum and Mountain Grey Gum, possess dormant buds under the bark and on the roots that grow if the trees have been burnt (Gill 1981). Even though these trees will generally recover, the timber will likely possess some damage from the flames or heat, and will have a reduced future harvestable value due to timber degradation.

Although not calculated in this assessment, the flow-on effects resulting from direct impacts to the forestry (timber) industry to third parties can be measured

16 Mill-gate price is the price of a forest product delivered to the purchaser, such as a mill. This price includes the stumpage price paid to the owner of the standing timber before it is harvested, and the cost of cutting the trees down, moving them to a loading area and transporting them to the purchaser (AgForests Queensland 2006, p. 6).

using multipliers (McLennan 1995). Multipliers (using input–output tables) estimate the level of additional economic activity generated by the industry in question on all other industries in the economy and can be measured by (among others) production-induced effects and consumption-induced effects (Table 13). Using the multiplier values for forestry in Table 13 as an example, the initial effect is '*the initial requirement for an extra dollar's worth of output of a given industry*' (McLennan 1995, p. 18), in this case $1 million of investment from the forestry industry to expand operations. The companies supplying goods and services, such as seedlings and additional equipment, then experience an increased demand for their products of $584,000 (i.e. production-induced effect). As activity increases in the forestry industry and in the industries supplying goods and services, there is an increase in wages to employees and possibly additional employment along the chain. The spending of these wages on goods and services across all industries stimulates demand for additional goods and services of $901,000 (i.e. consumption-induced effect), further encouraging additional investment. The total flow-on impacts to all industries can therefore be considered as a factor of 1.485 higher than the direct impact to the industry in question.

Applying the value of 1.485 to the estimated direct loss to the forestry industry from the Alpine Fires (highest loss across the five fires) of $1.392 billion, the flow-on effect was estimated as $2.067 billion. By combining these two values, the total (i.e. direct and indirect) estimated losses would be $3.459 billion. The use of multipliers to forestry and agricultural losses was not included in this assessment because they were created for the Australian economy and applying these multipliers at the local level could not be justified. These values do highlight, however, that the indirect impacts would still be substantial at the local or regional level.

Agriculture

Another primary industry that sustained heavy losses was the agricultural industry. Many assets were listed within the agriculture category; however, for the Alpine, Great Divide and Black Saturday Fires, the values were predominantly made up of losses to the viticulture industry. Direct contact with the flames and the spoiling of grapes through smoke taint resulted in losses of $22, $147 and $324 million respectively. These values made up 37%, 89% and 45% of the total agricultural losses for these fires. Since smoke taint is such an expensive impact, numerous government agencies, universities and the wine industry are working together to understand the impact of smoke on grape quality and find ways to combat it (Kennison et al. 2007; Whiting and Krstic 2007).

5.3 Implications for Fire Managers and Policy-Makers

Fire and land managers have the task of managing bushfire threats by using different methods to minimise economic, social and environmental losses with limited human and financial resources (Ganewatta 2008). For this reason, fire managers are required to make choices and trade-offs between these limited resources. This concept of allocating scarce resources is the primary concern of economics. The results produced in this loss assessment will increase the range of information available to land and fire managers on which more informed decisions can be made. The applications of this analysis are broad. For example, the results of this analysis coupled with resource use information (e.g. firefighters, vehicles, aircraft) for the fires studied may assist fire managers to allocate resources more efficiently across different regions. It could also be used in conjunction with existing tools and knowledge to choose between alternative fire suppression technologies (or at the very least select a number of options that give the best overall outcome) or be used in a risk-management framework to identify important assets or regions to protect.

Table 13 Output multipliers for the forestry and agricultural sectors

Industry	Initial effect	Flow-on (indirect) effects		Total flow-on effects (i.e. multiplier)
		Production-induced effect	Consumption-induced effect	
Forestry	1.000	0.584	0.901	1.485
Agriculture	1.000	0.649	0.529	1.178

Source: McLennan 1995, p. 22

Policy-makers may also find the results of this study (as well as the general concept of using an economic framework) helpful because it presents a common basis for valuing impacts (Ganewatta and Handmer 2006). It also provides actual data on which policy decisions could be justified (although these data should not be the only evidence used to create and justify policies). Along with other tools and information on which decisions are made, the data presented in this study may assist policy-makers to compare the losses and benefits within and between each fire and construct policies that minimise the losses. These may include the improvement of assistance measures during the recovery phase or more informed policies that focus on alleviating the impacts and concerns of regional and remote communities (where many bushfires occur). From a financial point of view, policy-makers and treasury officials may want to know how the losses sustained by different levels of government affected their budgets and where budgetary stress may have occurred when responding to and recovering from the fires.

Understanding the socio-economic profile and ecological elements within the areas impacted adds another level to the analysis process when making fire and land management or policy decisions because it allows the impacts and costs to be assessed in relative terms. For example, land managers may want to know how many vulnerable ecosystem sites were burnt as a proportion of the total amount remaining. Policymakers may want to know the number of houses burnt as a proportion of the wider area. Some information was provided towards the beginning of this report to highlight how the fires may have impacted on certain demographic categories (Table 4, Table 5 and Table 6). Combining the actual impacts on the regions (for past fires) or possible impacts in the future with a thorough analysis of the region's profile will enable decisions concerning bushfire management to be more effective and the needs of society and the environment to be targeted.

5.4 Costs Outside the Assessment Boundary

For this study, the spatial and temporal boundaries were set before the data were collected, but if the boundaries were readjusted, the economic loss assessment framework would accommodate this change. It is important to understand that by changing the boundaries, however, what would be considered an economic loss and benefit would also change, therefore producing a new net cost. For example, if the Victorian Government wanted to look at the impact on the state's economy, then they would reset the assessment boundary to the state's boundary. By doing this, many impacts that were considered losses and benefits at the LGA level would no longer be losses, but neutral. For example, the destruction of businesses within the LGAs would force people to travel to other areas outside the LGA. Although this would have been considered a loss in the original assessment, it would now be considered a transfer effect occurring within the new boundary, with no losses to the state of Victoria.

Conversely, some significant impacts that were excluded from the current study would now become economic losses if the boundary was increased to include the whole of Victoria. Notably, one major impact that affected an estimated 685,000 Victorian residential, commercial and industrial customers (mostly within the Melbourne metro area) was when the Great Divide Fires tripped the main powerline connecting Victoria to New South Wales (The Nous Group, 2007). The estimated cost of this power outage was $521.8 million, with costs to customers directly affected being $245.3 million, and flow-on impacts to other customers costing $276.5 million (The Nous Group, 2007). Furthermore, many indirect impacts arising from smoke would be included, such as smoke taint to the viticulture industry and other crops (e.g. apples, berries) well outside the boundaries of the affected LGA.

Health problems arising from smoke drifting hundreds of kilometres from its source would also lead to substantial losses to the Victorian economy. In a study by Rittmaster et al. (2006), the estimated health cost (including mortality and morbidity) per person exposed to high levels of bushfire smoke ($PM_{2.5}$[17] between 35 and 55 µg/m³) over a 24-hour period in Alberta, Canada, was $23. That fire burnt 116,000 ha over seven days, and the population of 670,000 lived in two towns approximately 160 and 285 km from the fire. Smoke from the Alpine and Great Divide Fires drifted over Melbourne for many days, with

17 The standard method for assessing the impact of smoke on human health is to measure the amount of particulate matter (PM) (aerosols) in the air, which is measured according to diameter: coarse particles are between 2.5 and 10 µm (micrometres, or a millionth of a metre) (PM_{10}) and fine particles are between 1 and 2.5 µm ($PM_{2.5}$) (Tham and Bell 2008, p. 2). PM_{10} are able to be absorbed into the body, typically entering a person's respiratory system and eyes, causing a sore throat, runny nose and burning eyes, which usually disappear in healthy people once the smoke has cleared. $PM_{2.5}$ are of particular concern, as they are small enough to pass through the lungs and enter the bloodstream, sending harmful toxins to other parts of the body (Tham and Bell 2008, p. 2).

the Environment Protection Authority Victoria (EPA Victoria 2007) reporting PM_{10}[18] concentrations over 50 μg/m³ for 10 days during the Alpine Fires and 15 days during the Great Divide Fires. By applying the value of $23 per person per day to metropolitan Melbourne (population of 3.6 million) (ABS 2006) over 25 days, the estimated total health costs would be $828 million for the Alpine Fires and $1.242 billion for the Great Divide Fires. These are substantial values, only being matched by the costs associated with timber losses and losses to ecosystem services. As further evidence (although not quantified in dollar terms), Johnston et al. (2002) found a statistically significant increase in the risk of asthma in Darwin during bushfires from April to October 2000.

The boundaries placed on an economic loss assessment are crucial to what impacts are considered losses and benefits because they produce a completely different set of results, on which important decisions are then made. While the purpose of the assessment will determine the geographic (and temporal) boundaries, the OESC (2008a) argues that conducting an economic loss assessment at the regional or local level provides data from which the efficacy of recovery arrangements and programs can be measured. It also provides a greater understanding of how the community responds to the event and their level of resilience (OESC 2008a).

5.5 Proposed Next Steps for Establishing a Systematic Recording and Reporting Framework

Collecting data was at times difficult, particularly for information on the Ash Wednesday Fires, as published literature was the major source of information for this fire. Given this experience, it is clear that a systematic recording and reporting framework is necessary if the costs of bushfires are to be accounted for in the future. This would not only make the process of collecting the data more efficient, but make the impacts, losses and benefits more accessible to policy-makers, emergency management personnel and treasury, and would then be used to make more informed decisions. The proposed steps based on the experiences gained in collecting and collating bushfire data are to:

1. **Create a central database where data are stored**
   OR

   Develop search and linking tools

   Either option could be accomplished on a number of scales depending on the degree of thoroughness required. The database or linking tool could be, for instance, limited to data collected by DSE and then made available to DSE staff, accounting for such activities as fire suppression and recovery costs, and the loss of DSE assets. This would not, however, give a picture of the full range of impacts costs associated with that disaster. To take full advantage of this concept, at least basic information would be collected or made available from a number of agencies, including basic agricultural losses, community impacts, harvestable timber losses and housing and other building losses.

   With regard to the first option, storing data in a central location is not a new concept, with the CFA's (unpublished) Project Blackout collecting detailed information on fires in a spreadsheet. EMA also stores information on their online database[19], covering a wide range of natural and non-natural disasters within Australia. While these databases do collect information relating to natural disasters and fire emergencies, they are not ideal for use by decision-makers. Project Blackout, for example, is a 'static' document. That is, to receive the most up-to-date version, staff outside the CFA would have to request the spreadsheet every time they wanted to use it. It values very limited economic and social impacts: the destruction of buildings, livestock and fencing, and fatalities and injuries. The EMA Disasters Database is also limited in the range of impacts it values, typically only using the insured cost to value each disaster, and using secondary sources for its information (e.g. reports, newspaper articles, inquires). The Australian Incident Reporting System (AIRS) is a national database that currently stores information on millions of bushfire incidents. It still has its limitation, however, with Lewis (2007) highlighting that it may not hold the most accurate data (i.e. fire officers may feed the completed and processed incident report into AIRS before the full range of impacts is known). Furthermore, the system relies on the fire officer's knowledge of fire science and level of training to accurately record what has happened (Lewis 2007), indicating that

18 Refer to footnote 17.

19 Database available at: http://www.ema.gov.au/www/emaweb/emaweb.nsf/Page/Resources_DisastersDatabase_DisastersDatabase

the system could be developed to try and better cater for these limitations.

A central database, the first option, could be made available to all government employees (or restricted to the most relevant people if desired) through an online website. This database would contain a template with the impacts already listed, in which staff would enter the qualitative or quantitative data once the final impacts of the event were established. The database would ideally be a whole-of-government venture, with staff from different agencies (and possibly other organisations such as critical infrastructure, i.e. water and electricity, companies) entering their data. The OESC would be the ideal custodian of this database, as they oversee the state's emergency management arrangements. Although this represents the ideal situation, in reality there are a few issues that could prevent the database from being used to its full capacity. These issues relate to data custodianship, keeping the information up to date and complete for all bushfires and the expense (i.e. time and money) of setting it up and maintaining it.

The second option of developing search and link tools may be preferred, in which a computer program would allow users to retrieve the requested impact information from its source. This may still have some of the inherent issues identified for central databases above; however, they will most likely be to a lesser degree.

There are a number of advantages to creating either an online central database or search and linking tool:

- The data are readily accessible to those requiring bushfire information.
- The data are centrally located – either within a single database or by being retrieved from a single point. From the author's experience, this is an important advantage, as those requiring bushfire data do not have to hunt down the specific book or person who possesses the information.
- The data may, over time, provide information on trends. These may be, for example, trends on the cost of suppression vs. the value of assets lost or government recovery packages vs. the value of assets lost.
- Analysing these trends will allow policy-makers, emergency management personnel, risk managers and treasury officials to better plan for future disaster-related expenditure, including mitigation activities and programs.

2. Collect and value (where possible) indirect economic and social impacts

Owing to the difficulties in valuing indirect economic and social impacts long after the event has passed, many were not valued in this assessment. With respect to indirect economic (i.e. market-based) impacts, authors have found that these impacts generally have a greater value than the loss of the asset itself. This was highlighted by several examples in this report, such as the peak-hour chaos caused when much of Melbourne was without power during the Great Divide Fires (*2.4 2006–07 Great Divide Fires*), estimating the flow-on impacts to all industries resulting from direct impacts to the forestry and agricultural industries (Table 13), and estimating the health impacts from smoke inhalation (*5.4 Costs Outside the Assessment Boundary*). There may also be some positive indirect economic impacts resulting from a fire, such as an increased demand for supermarket products during a fire to feed firefighters in the short term, or the need for construction material and tradespeople to rebuild infrastructure in the longer term.

Collecting this information usually requires surveying affected people and businesses shortly after the fire and is therefore relatively labour-intensive. Surveys also require a very carefully planned, well-written set of questions and post-survey analysis (Barkmann et al. 2008). In terms of the current study, surveying those affected by the older fires was not a realistic option. The results of comprehensive household surveys have been published after a number of fires, focusing on people's psychological health and relationships (Clayer, Bookless-Pratz and McFarlane 1985), their movements before and during the fires, property impacts and community safety issues (Whittaker et al. 2010). A survey specifically designed to value indirect (namely household and business disruption) losses, social losses and benefits (e.g. community bonding) has been developed in the SEIA-Model (OESC 2008a) and was used after the Great Divide Fires. To provide a more systematic way of accounting for these types of losses and benefits, this survey (or something like it) could be refined and standardised for distribution after severe bushfires, enabling comparability between different events over time. This survey could also include a section on any possible economic benefits (e.g. increased accommodation demand during the fires for firefighters) received during the assessment period. Research into this area would be advantageous to fill the gap in knowledge and provide a more systematic way of accounting for indirect economic and social impacts.

Social impacts such as the loss of personal memorabilia and emotional trauma are very important, possibly more so than economic impacts at a personal level, but valuing them in dollar terms is very difficult. If, for example, a woman lost her grandfather's war medals and collection of family photographs dating back 80 years, the value she placed on these items would most likely be far greater than the fridge or TV that were also destroyed, but by how much? At the very least, these should be accounted for through qualitative data and included in the survey. Impacts to the more publicly valuable intangible assets, such as cultural heritage assets, would be sourced through the relevant organisation.

Valuing injuries using the same willingness to pay method used to estimate fatalities (Abelson 2008) would create a more representative value than the single dollar values for serious and minor injury produced by the BTE (2001). Abelson (2008) measured the value of injuries as a proportion of a statistical life year ($158,000) depending on the severity of the injury (i.e. more severe injuries received a higher proportional weighting). If possible, injury information from medical institutes (e.g. Department of Human Services, hospitals, St John Ambulance) could be obtained for the correct weighting to be applied and a more holistic picture of the costs of injuries produced.

Another loss not valued in this assessment related to the value of volunteers, as obtaining this information for each fire proved difficult. Even without this knowledge, the losses attributed to volunteer time were expected to be large. The OESC (2008a), for example, valued volunteer time at $13.7 million over 61 days in the Shire of Wellington during the Great Divide Fires. The total number of hours worked by volunteers on fire suppression activities was highlighted in the Report on Government Services 2010 (Steering Committee for the Review of Government Service Provision 2010) as an area in which performance reporting would be valuable.

3. Value environmental impacts through ecosystem service values specifically for Australian conditions

The lack of ecosystem service values relating to Australian natural environments was a great limitation in analysing the results of this assessment. This is a contentious area, with the question not so much about whether ecosystem services should be valued, but how. Several international reports exist that tackle this issue, including 'Ecosystems and Human Well-being' (Hassan, Scholes and Ash 2005), 'Assessing the Economic Value of Ecosystem Conservation' (Pagiola, von Ritter and Bishop 2004) and 'The Economics of Ecosystems & Biodiversity' (TEEB 2009). A conference titled 'Valuing Water and the Environment in Practice: Integrating Costs, Benefits and Ecosystem Services' is being held in September 2010. Within Australia, a study at the University of Adelaide valued the water purification services of the River Murray at more than $7,000 ha^{-1} yr^{-1} (Haxton 2007). The economic value of the Victorian Thompson Catchment in terms of its timber, water and carbon sequestration benefits was also modelled (Creedy and Wurzbacher 2001). The Ecosystem Service Project, a collaborative effort between CSIRO, government agencies and universities, is an Australian initiative that studies ecosystem services and emphasises the need to consider these more carefully in land management and policy decisions (Ecosystem Services Project 2002).

To ensure consistency and comparability, values are needed that can be applied to different ecosystem types across Australia. Even at this level, ecosystem composition changes across the landscape, so values at state or possibly regional levels are warranted. The scale at which the environment is valued will, however, depend on the resources available.

The value of the carbon released from the burning of vegetation into the atmosphere is of particular interest for fire managers and policy-makers alike. If measured by itself and not part of the Costanza et al. (1997) framework, as in this study, the costs would be considerable. For example, an estimated 165 million tonnes of CO_2 was produced by the Black Saturday Fires – equivalent to one third of Australia's carbon footprint (Breners-Lee 2010). If this was multiplied by the emissions price of $22 per tonne of carbon[20], then the total cost would be $3.630 billion. Given that the Alpine and Great Divide Fires burnt for many more weeks over a much greater area, the cost of the carbon released from these fires would be much higher.

Throughout this report, the importance of sound economic principles and the use of an economic loss assessment have been emphasised. It is advantageous that the proposed steps explained in this section adhere to economic principles and use a framework based on an economic loss assessment, as the assessment provides a complete and balanced account of the losses and benefits to an economy as a consequence of a disaster. It is also important that as many economic, social and environmental impacts are valued as possible, because until relatively accurate estimates are available, economic losses will remain poorly understood and the policies and strategies incorporating bushfire information will not be fully informed.

In some circumstances, however, an economic assessment may not be appropriate, as a financial assessment may be wanted instead. This type of assessment focuses on losses from the perspective of a business or businesses, or that of a local area, ignoring the benefits the economy receives, transfer effects and depreciated values of assets (Handmer 2003). An example of this may be when a town is divided by a river and a bushfire burns through the businesses on one side of the river. In this case, there will be large financial losses to the affected businesses that can be assessed and used by decision-makers. When conducting an economic assessment on the whole town, however, there may be no net loss (or gain) as a result of transfer effects. That is, people will now buy goods and services from businesses on the unburnt side of the river, keeping the money within the community and local economy, and thus resulting in no net loss of local trade. There may, however, be a significant loss of assets and indirect (or consequential) loss to the economy as a result of wages lost and therefore not spent.

Analysing losses through a financial assessment may be appropriate for specific cases, but when considering the impacts of natural disasters and fire emergencies on a local, regional, state or national scale, an economic assessment will generally reveal the impact on society and provide decision-makers with more realistic and accurate information.

20 Estimated emission cost of carbon over one year using the CPRS-5 scenario (The Treasury 2008, p. 19). The value in the original report was $20 in 2005 dollars. This was inflated to 2008 dollars using the Reserve Bank of Australia's inflation calculator.

Six: Conclusion

By valuing a wide range of economic, social and environmental impacts and benefits through an economic loss assessment, costs were shown to be very large. With respect to the five fires studied, the net losses were: Ash Wednesday Fires – $795 million, Alpine Fires – $2.691 billion, Grampians Fires – $407 million, Great Divide Fires – $2.002 billion and Black Saturday Fires – $925 million.

This economic loss assessment provides data that people in land, fire and emergency management fields can refer to when creating future policies and strategies associated with PPRR. Based on the results, several impacts were identified as being of high priority when accounting for bushfires. Regardless of the losses attributed to it, the preservation of life is always the top priority, with fatalities being very high for the Ash Wednesday and Black Saturday Fires. Other impacts that generally resulted in the highest loss values across the five fires were the costs associated with ecosystem services, and losses in timber stands and of agricultural assets.

This report was also intended to establish a basis for improving government's assessment and understanding of future bushfire impacts. Based on the experiences gained from collecting bushfire data, establishing a systematic recording and reporting framework to collect information on future bushfires would make the process a lot more efficient. Creating a central database for data or creating an online search and linking tool would be useful, ensuring that indirect economic and social impacts are collected and valued (where possible) as well as the impacts on ecosystem services .

The most important element when assessing bushfire impacts was the use of sound economic principles. By ensuring that the full range of economic, social and environmental losses and benefits were accounted for, a more complete and holistic picture was created. This subsequently gives staff involved in creating policies and PPRR strategies, managers creating risk frameworks and treasury officials detailed and objective information that they can use when making decisions. Until a large majority of the impacts and costs associated with bushfires are known, policies and strategies incorporating bushfire information will not be fully informed.

7

Seven: Appendices

Appendix 1 Methods for Estimating Ecosystem Service Values

Table 14 highlights some of the methods used to find the financial values of environmental impacts (Pagiola, von Ritter and Bishop 2004, p. 11). The first five methods are known as revealed preference methods because they use data from related markets to estimate the value. The last two are known as stated preference methods, as they use questionnaires to value changes in environmental quality, and are the only method that can be used to estimate non-use (i.e. existence) values (Morrison, In press). Morrison discusses a number of these methods within the specific context of bushfire management.

Table 14 Summary of the methods commonly used to estimate ecosystem service values

Method	Approach	Data requirements	Application	Limitations
Travel Cost Method*	Derive demand curve from data on actual travel costs	Survey to collect monetary and time costs of travel to destination, distance travelled	Recreation	Limited to recreational benefits; hard to use when trips are to multiple destinations
Hedonic Price Method	Extract effect of environmental factors on price of goods that include those factors	Prices and characteristics of goods	Air quality, scenic beauty, cultural benefits	Requires vast quantities of data; very sensitive to specification
Production Function (also known as Change in Productivity)	Trace impact of change in ecosystem services on produced goods	Change in service; impact on production; net value of produced goods	Any impact that affects produced goods	Data on change in service and consequent impact on production often lacking
Replacement Cost (and variants such as Relocation Cost)	Use cost of replacing the lost good or service	Extent of loss of goods or services, costs of replacing them	Any loss of goods or services	Tends to overestimate actual value; should be used with caution
Cost of Illness, Human Capital	Trace impact of change in ecosystem services on morbidity and mortality	Change in service; impact on health (dose–response functions); cost of illness or value of life	Any impact that affects health (e.g. air or water pollution)	Dose–response functions linking environmental conditions to health often lacking; underestimates, as omits preferences for health; value of life cannot be estimated easily
Contingent Valuation Method	Ask respondents directly their willingness to pay for a specific service	Survey that presents scenario and elicits willingness to pay for specified service	Any service (including environmental hazards)	Many potential sources of bias in responses; guidelines exist for reliable application
Choice Modelling	Ask respondents to choose their preferred option from a set of alternatives with particular attributes	Survey of respondents	Any service (including environmental hazards)	Similar to the Contingent Valuation Method; analysis of the data generated is complex

* Morrison (In press) further divides the Travel Cost Method into Zonal, Individual and Random Utility.

Appendix 2 2003 Alpine (NSW) and Canberra Fires Statistics

The tables below contain information on the 2003 Alpine (NSW) and Canberra Fires areas, ignition sources and fires dates (Table 15), major impacts (Table 16) and census data on the areas' population (Table 17), family composition (Table 18) and number of people employed per industry (Table 19). These data have not been analysed as they are not part of the main report. A '–' indicates that the information could not be sourced. Table 20 provides an overview of the net costs for the NSW and Canberra Fires.

Table 15 Fire areas, sources of ignition and significant fire dates for the NSW and Canberra Fires

Fire	Area (ha)	Source of fire (suspected or known)	Going*	Contained#	Safeø
2003 Alpine and Canberra Fires	**757,170**	**Lightning**	**07.01.03**	**Not available**	**Not available**
NSW	600,000	Lightning	07.01.03	–	–
ACT	157,170	Lightning	08.01.03	–	–

Source: Sullivan (2004) for the Alpine (NSW) Fire; Bushfire Recovery Taskforce (2003) for the Canberra Fire.

* Refers to the date on which a fire has been reported. A fire will remain 'going' while it is spreading in any direction (DSE 1996b).
\# Refers to a fire whose spread has been halted, and may be burning freely within the parameter (DSE 1996b).
ø Refers to a fire that can be left without any further patrols. It may be completely out, or pose very little threat of flaring up again (DSE 1996b).

Table 16 Summary of the major impacts caused by the NSW and Canberra Fires

Asset type destroyed or damaged	Alpine (NSW)	Canberra
Fatalities	0	4
Major injuries	–	52
Minor injuries	–	338
Homes	–	803
Agricultural buildings	–	93
Fencing (km)	–	419
Sheep	–	4,000
Cattle	–	150
Pasture (ha)	–	–
Softwood plantation timber (ha)	–	16,770

The sources of information for the next three tables are given in *2.7 Socio-Economic Profile of the Affected Areas*..

Table 17 Population of the impacted areas by age and gender for NSW and Canberra

Age bracket	Alpine (NSW) Male	Alpine (NSW) Female	Alpine (NSW) Total	Canberra Male	Canberra Female	Canberra Total
0–9	2,444	2,296	4,740	2,684	2,495	5,179
10–19	2,519	2,248	4,767	3,243	2,873	6,116
20–29	2,007	1,686	3,693	2,840	2,701	5,541
30–39	2,483	2,333	4,816	2,822	2,917	5,739
40–49	2,713	2,491	5,204	2,899	3,502	6,401
50–59	2,237	2,097	4,334	3,192	3,342	6,534
60–69	1,669	1,473	3,142	1,602	1,602	3,204
70–79	1,072	1,162	2,234	779	927	1,706
80–89	370	612	982	257	486	743
90–99	46	107	153	21	94	115
100+	3	6	9	3	3	6
Total	17,563	16,511	34,074	20,342	20,942	41,284

Table 18 Family composition in the areas affected by the NSW and Canberra Fires

Family Composition	Alpine (NSW) No. of families	Alpine (NSW) %	Canberra No. of families	Canberra %
Couple family with children	14,711	60	20,943	62
Couple family with no children	6,932	28	7,640	23
One-parent family	2,721	11	4,701	14
Other family	197	1	294	1
Total	24,561		33,578	

Table 19 Number of people employed per industry in the affected areas of NSW and Canberra

Industry	Alpine (NSW)		Canberra	
	Total	%	Total	%
Agriculture, forestry and fishing	2,515	17	85	0
Mining	24	0	6	0
Manufacturing	1,371	9	718	3
Electricity, gas, water and waste services	445	3	102	0
Construction	859	6	1,013	5
Wholesale trade	594	4	437	2
Retail trade	2,007	13	2,627	12
Accommodation and food services	1,751	12	955	4
Transport, postal and warehousing	478	3	549	3
Information media and telecommunications	156	1	262	1
Financial and insurance services	183	1	463	2
Rental, hiring and real estate services	918	6	3,200	15
Public administration and safety	540	4	5,140	24
Education and training	817	5	2,092	10
Health care and social assistance	1,044	7	2,105	10
Arts and recreational services	327	2	686	3
Other services	482	3	901	4
Inadequately described	104	1	183	1
Not stated	333	2	231	1
Total	14,948		21,755	

Table 20 Losses, benefits and net economic cost for the NSW and Canberra Fires

	Value (2008 AU$)	
Asset	**Alpine (NSW)**	**Canberra**
Total area (ha)	600,000	157,170
Economic losses	**35,700**	**233,270,315**
Residential buildings and contents	–	140,860,950
Commercial and industrial buildings and contents	–	4,908,607
Park buildings, contents and infrastructure	35,700	1,700
Public infrastructure	–	8,108,108
Agriculture	–	4,194,270
Timber	–	75,196,680
Emergency response operations	–	–
Social losses	**0**	**41,914,500**
Fatalities	0	14,608,000
Major injuries	–	22,431,188
Minor injuries	–	4,875,312
Environmental losses	**365,610,000**	**139,373,675**
Benefits	**0**	**476,273,673**
Payments by government	–	61,059,893
Donations	–	8,597,040
Insurance	–	406,616,740
Total losses	**365,645,700**	**414,558,490**
Total benefits	**0**	**476,273,673**
Net loss from bushfire	**365,645,700**	**(net gain of) 61,715,183**

Appendix 3 Disaster Loss Assessment Guidelines Steps

The Disaster Loss Assessment Guidelines (Handmer, Reed and Percovich 2002) contain 12 steps. These were addressed in the initial phase of this study before any data were collected to ensure that key steps required in an economic loss assessment were addressed. As a result, some text below may be repeated in the main body of the report. The steps and their application to this study are described below.

Step 1: Identify the purpose of the loss assessment

This project collated and summarised in a consistent format the direct and indirect economic, social and environmental impacts and loss information of five recent major Victorian (and interstate) bushfires:

- 1983 Ash Wednesday fires
- 2003 Alpine (including NSW) and Canberra Fires
- 2005–06 Grampians fire (including Mount Lubra and Deep Lead)
- 2006–07 Great Divide Complex fire (including Tatong–Watchbox Creek, Tawonga Gap and Coopers Creek)
- 2009 Black Saturday Fires (including Beechworth–Murmungee, Bunyip Ridge Track, Churchill–Jeeralang, Coleraine–Glenelg Highway, Delburn Complex, Horsham–Remlaw Road, Kilmore East–Kinglake Complex, Maiden Gully–Bracewell Street (Bendigo), Murrindindi Mill–Marysville Complex, Redesdale–Coliban Park Road, Weerite–Danedite Road and Wilsons Promontory National Park–Cathedral).

Step 2: Organise the consultation and information collection

Consultation consisted of talking to the relevant people to gather information that could not be found in the literature; the type of information required and where to source it are described in the table following.

Type of information	Source	Method	Responsible person
Hazard information	DSE, CFA	Gather data from the relevant agency person	Catherine Stephenson
Economic impact and loss information	Many, including government agencies and Local Government Areas (LGAs)	Gather data from the relevant agency or business person	Catherine Stephenson
Social impact and loss information	Mostly Dept of Human Services (DHS) and LGAs	Gather data from the relevant agency person	Catherine Stephenson
Environmental impact and loss information	Mostly DSE	Gather data from the relevant agency person	Catherine Stephenson

Step 3: Define the area and time-frame of the assessment

The spatial boundary used to assess the impact of each bushfire event on the economy was that of LGAs that were burnt to some extent. This ensured that as well as accounting for direct destruction and damage, indirect impacts in the areas surrounding the fire were also included, and by using the LGAs as the assessment boundary, data relating to each LGA could be easily tracked.

While this boundary may be convenient for some things, state government departments and agencies and other organisations all have their own regional boundary lines, which meant that impact data gathered from these sources needed to be, as best possible, aligned with LGA boundaries. The table below shows which LGAs were directly impacted by the fire. Some of the LGAs are no longer valid (particularly for the 1983 Ash Wednesday Fires); however, the names of the shires still give a good idea of where they were located.

Fire	Local Government Area	Source of data
1983 Ash Wednesday Fires	**Cudgee–Ballangeich** Shires of Hampden, Heytesbury, Mortlake and Warrnambool **East Trentham–Mount Macedon** Shires of Gisborne, Melton, Newham–Woodend and Romsey **Otways** Shires of Barrabool and Winchelsea **Belgrave Heights–Beaconsfield Upper** City of Berwick, Shires of Pakenham and Sherbrooke **Cockatoo** Shires of Pakenham and Sherbrooke **Monivae** Shire of Dundas **Branxholme** Shire of Portland **Warburton** Shire of Upper Yarra	CFA (1983)
2003 Alpine and Canberra Fires	**Victoria** Rural City of Wangaratta, Alpine Shire and Shires of East Gippsland, Indigo, Towong and Wellington, Unincorporated areas of Falls Creek and Mount Hotham (i.e. these areas fall outside municipal council boundaries)	Ministerial Taskforce on Bushfire Recovery (2003, Attachment A)
	New South Wales Bombala Council, Cooma–Monaro Shire Council, Snowy River Shire Council, Tumbarumba Shire Council, Tumut Shire Council	Author compared map of each fire boundary (Emergency Services Bureau (ESB) 2003) with maps of the LGAs within that boundary (Department of Premier and Cabinet 2010).
	Australian Capital Territory The ACT is an 'unincorporated area' and contains no local government areas. The area is divided into cities, towns, villages and localities.	Bonzle (2010)
	The areas in which houses and other buildings were destroyed were Chapman, Curtin, Duffy, Holder, Kambah, Lyons, Mount Stromlo, Rivett, Torrens and Weston	Blanchi and Leonard (2005)
2005–06 Grampians Fires	**Mount Lubra** Rural City of Ararat, Shires of Horsham, Northern Grampians and Southern Grampians **Deep Lead** Rural City of Ararat, Shire of Northern Grampians	Author compared map of each fire boundary (Fleming et al. 2007) with maps of the LGAs within that boundary (DSE 2007)

Fire	Local Government Area	Source of data
2006–07 Great Divide Fires	**City of Latrobe,** Rural Cities of Benalla and Wangaratta, Alpine Shire and Shires of Baw Baw, East Gippsland, Indigo, Mansfield, and Wellington Other shires in which bushfires occurred during the 2006–07 season were the Shires of Corangamite, Golden Plains and Moyne	Ministerial Taskforce on Bushfire Recovery (2007)
2009 Black Saturday Fires	**Beechworth–Murmungee** Rural City of Wangaratta, Alpine Shire and Shire of Indigo **Bunyip Ridge Track** Shires of Baw Baw and Cardinia **Churchill–Jeeralang** City of Latrobe, Shire of Wellington **Coleraine–Glenelg Highway** Shire of Southern Grampians **Delburn Complex** City of Latrobe, South Gippsland Shire **Horsham–Remlaw Road** Rural City of Horsham **Kilmore East–Kinglake Complex** Shires of Mansfield, Murrindindi and Yarra Ranges **Maiden Gully–Bracewell Street (Bendigo)** City of Greater Bendigo **Murrindindi Mill–Marysville Complex** City of Whittlesea, Shires of Mitchell, Murrindindi, Nillumbik and Yarra Ranges, Unincorporated area of Lake Mountain Alpine Resort **Redesdale–Coliban Park Road** Shires of Macedon Ranges, Mitchell and Mount Alexander **Weerite–Danedite Road** Corangamite Shire **Wilsons Promontory National Park–Cathedral** South Gippsland Shire	Author compared map of each fire boundary (Teague, McLeod and Pascoe 2009) with maps of the LGAs within that boundary (DSE 2007)

Information was collected for the period from the day the fires began to two years after they were declared safe. This ensured that indirect losses could be sufficiently accounted for, as these may only become known months after the actual event.

Step 4: Select the type of assessment to be made

The Disaster Loss Assessment Guidelines contain 11 criteria that can be used to guide the user when selecting the best assessment method. The averaging method is based largely on pre-existing average data on losses, e.g. average loss per kilometer of burnt fence line (Handmer, Reed and Percovich 2002). The synthetic method is based on pre-existing databases covering a range of average factors (e.g. building types and contents). Losses are based on assumptions regarding the age and condition of the item and the effect of the hazard (Handmer, Reed and Percovich 2002). The direct survey method is based on detailed surveys of a recent event to establish actual losses (Handmer, Reed and Percovich 2002).

Four criteria were considered relevant to this study, which are shown below with the most appropriate method as suggested in the guidelines:

Decision criteria	Averaging method	Synthetic method	Direct survey method
Consistency required	✔✔	✔✔	✔
Low time availability relative to area concerned	✔✔	✔	N
Large area	✔✔	✔✔	✔
Significant indirect or intangible loss	N	✔	✔✔

✔✔ = good ✔ = adequate N = not appropriate

From the above table, it appears that the averaging and synthetic methods are the most appropriate. For direct economic impacts, the SEIA-Model uses a combination of the averaging and synthetic methods. Even though the direct survey method is the most accurate way of collecting indirect economic and intangible (both direct and indirect) losses, this was inappropriate given that the five fires occurred at different times over 26 years.

Step 5: Obtain information about the hazard

The results of this step are described in *2. Profile of the Bushfires and Impacted Regions*.

Step 6: Obtain information about the people, assets and activities at risk

The Disaster Assessment Guidelines state that before the losses can be assessed, the user needs to know what people, assets and activities are at risk, as shown below.

Impacts	Source(s) of information	Collection method
People		
Fatality	DHS	Reports, information request
Physical injury	DHS, LGAs	Reports, information request
Mental injury	DHS	Reports, information request
Assets		
Residential house and contents	DHS, LGAs	Reports, information request
Caravan and contents	DHS, LGAs	Reports, information request
Commercial property and contents	DHS, LGAs	Reports, information request
Industrial property and contents	DHS, LGAs	Reports, information request
Public infrastructure (inc. roads, bridges, buildings)	VicRoads	Reports, information request

Impacts	Source(s) of information	Collection method
Park facilities (inc. huts, office buildings, shelters, fencing, walking tracks, tables)	DSE, Parks Victoria	Reports, information request
Agriculture (inc. farm buildings, livestock, fencing)	Department of Primary Industries (DPI), Victorian Farmers Federation	Reports, information request
Horticulture		Reports, information request
– viticulture	DPI, Victorian Wine Industry Association	Reports, information request
– other fruit-growers	DPI, Fruit Growers Victoria	Reports, information request
– apiaries	DPI, Victorian Apiarists Association	Reports, information request
Forestry operations		Reports, information request
– public	DSE, VicForests	Reports, information request
– private	DSE, Hancock Victorian Plantations, other private operators	Reports, information request
Cultural heritage	DSE, Parks Victoria, Environment Protection Authority Victoria, Catchment Management Authorities (CMAs), Melbourne Water	Reports, information request
Natural environment (inc. soil, air, water, biodiversity)	DSE, Parks Victoria, CMAs, Melbourne Water	Reports, information request
Activities		**Reports, information request**
Business disruption		Reports, information request
– retail	Department of Innovation, Industry and Regional Development (DIIRD)	Reports, information request
– commercial	DIIRD	Reports, information request
– industrial	DIIRD	Reports, information request
Tourism disruption	DIIRD, Tourism Victoria	Reports, information request
Emergency services response and recovery (inc. people, equipment, accommodation, food)	DSE, CFA, DHS, other organisations that supported response and recovery efforts	Reports, information request

Step 7: Identify the types of losses

This step requires the information in steps 5 and 6 to be divided into direct or indirect, and tangible or intangible impacts. An example of where impacts fall within these exact criteria is presented in Table 1. As impacts were to be divided into economic, social and environmental impacts as per the objectives of this study, this was not completed.

Step 8: Measure the extent of losses from all sources

This step was completed using the SEIA-Model, which had already broken down losses into their different impact groups, e.g. residential buildings, public buildings or structures, agricultural, stock, crops, timber. The estimated losses are presented in *4. Results.*

Costanza et al. (1997) used a dollar value per hectare per year. A bushfire usually burns through an area in a mosaic pattern (i.e. there will be areas of unburnt and burnt vegetation; the amount of vegetation burnt may range from some scorching of the understorey to complete incineration of the understorey and crowns of the trees) (Lindenmayer and McCarthy 2002). During the Alpine Fires for example, Williams et al. (2008) found that approximately 50% of the Bogong High Plains (i.e. non-treed grass and shrublands) within the fire boundary was not burnt. In another study measuring the spatial patterns of fire behaviour, Hammill and Bradstock (2009) measured the percentage of landscape burnt in two bushfires during extreme (FFDI ≈ 100) and moderate (FFDI ≈ 20) weather. During extreme weather, 71% of the landscape was burnt by either an intense understorey fire (51%) or a crown fire (20%). During moderate weather, 53% was burnt by either a patchy understorey fire (30%) or a low-intensity understorey fire (23%). The area unburnt in each fire was 1% for extreme and 2% for moderate. Based on these studies, 70% of the vegetation was assumed to be burnt.

The scope of the current loss assessment was to account for bushfire impacts over two years; however, as vegetation regrows, an estimate of what proportion of each ecosystem service is 'restored' by the second year cannot be given with any degree of confidence at present. Therefore, the final environmental impact value was chosen as 70% of the first-year loss value. Costanza et al. (1997) did not take into consideration the many beneficial impacts of fires on the ecosystem, such as stimulating seed germination via heat or smoke (Gill 1981; Auld 1996).

Step 9: Decide whether to count 'actual' or 'potential' losses

Actual losses refer to costs actually experienced in an event (e.g. the exact value of each house destroyed depending on the type of house and its condition). They take account of the unique features of the event, e.g. people's length of warning time that the disaster is approaching, their experience with previous events etc. Potential losses are the maximum costs likely to occur in an event (e.g. a single value used across all houses, regardless of its building materials and condition) and can be considered an average as they do not take into account the unique features of the event or population (Handmer, Reed and Percovich 2002).

Potential losses were used in this assessment, as they are used when applying the averaging or synthetic methods (described in step 4), which is the case for most of this report. Even though measuring potential losses is likely to overestimate the real cost, using this method enables estimates to be made in a very timely manner for the purposes of costing the impacts and providing relief and recovery payments to those affected. It is also the best option for comparing losses across multiple events, as measuring actual losses requires detailed surveys and produces highly variable results that are not readily amenable to comparisons.

Step 10: Calculate annual average damages if needed

This step is applicable when performing a cost–benefit analysis (CBA), whereby the costs and benefits of a course of action are measured to find the net benefit (Office of Best Practice Regulation 2009). In terms of natural disaster management, using the average annual damages calculation to determine the losses avoided in an average year is a very useful tool when deciding among various mitigation strategies (Handmer, Reed and Percovich 2002). Given the purposes of the current study, however, it is not relevant.

Step 11: Assess benefits to region of analysis

This step was completed through the SEIA-Model as it contains a section that accounts for benefits, such as government grants or aid and insurance payouts.

Step 12: Collate and present the results of the loss assessment

This was completed in the final stage of the SEIA-Model.

Appendix 4 Framework Selection Criteria

The purpose of the framework selection method was to measure known fire and natural hazard impact assessment models against 13 criteria, thereby determining which frameworks would best fit the requirements of the current project. Seven criteria or requirements were considered to be essential framework attributes for the purposes of this project, while six were considered to be highly desirable. These are shown below, with the reason for each criterion in parentheses. A scoring system was also developed to ensure that each framework was assessed objectively against each criterion.

Essential:

1. Can be used to enter bushfire impacts and costs
   (Fire as a natural hazard is the focus of the current project)
2. Can be used to calculate or collate economic, social and environmental impacts and costs
   (These are the three main categories underlying the current project)
3. Can be used to calculate or collate direct, indirect and intangible impacts and costs
   (Standard format for entering natural event impacts and costs)
4. Able to measure economic and not only financial costs
   (Economic analysis measures the costs to an economy (group of people) and provides a more holistic picture of a natural hazard's impacts and costs)
5. Able to cope with simple data (i.e. not too sophisticated)
   (Data used for the current project will typically consist of a straightforward assessment of impacts and costs)
6. Able to cope with missing data (i.e. not too data-driven)
   (Unlikely to find all desired data, therefore having a framework that can cope with missing data makes it more flexible and adaptable)
7. Driven by the consequence of the fire or other natural hazard (i.e. concentrates on the impacts)
   (The current project focuses on the consequences of fire as a natural hazard)

Highly desirable:

8. Purpose is similar to that of the current project
   (Similar purposes are more likely to lead to suitable methodologies and results)
9. Can provide a breakdown of the economic, social and environmental impacts and costs
   (Presents the information in an easy to understand format)
10. Can provide a breakdown of the direct, indirect and intangible impacts and costs
    (Presents the information in an easy to understand format)
11. Capable of undertaking a rapid impact assessment
    (Allows the user to estimate the extent of the impact in a relatively short amount of time so they can put response and recovery strategies into place quickly)
12. Available for free use (i.e. no licensing fee or requirement to buy software)
    (Allows information or methodologies within the existing frameworks to be easily accessed and referred to if required)
13. Software and hardware easy to use and view
    (Method should be easily used and viewed by a range of people regardless of their understanding of the underlying economic principles. Minimal training may be required to use the software)

Scoring system for each question

0	1	2	3
No	**Partially**	**Mostly**	**Fully**

7

Appendix 5 Scores and Comments for each Framework

Fourteen frameworks were assessed against the selection criteria and ranked according to how appropriate they were for the current assessment, with the highest-scoring framework being given a '1' (Table 21). A breakdown of the scores for each framework is shown after this table.

Table 21 Assessing natural disaster frameworks against a set of criteria

#	Framework	Event	Country	Reference	Score (out of 39)	Ranking
1	Wildfire Project	Bushfire	Australia	(Victorian) Office of the Emergency Services Commissioner (OESC) (OESC 2008b)	21	13
2	The Cost of Fire Now and in 2020	Bushfire	Australia	Handmer et al. (2008)	29	7
3	Socio-economic Impact of Bushfires on Rural Communities and Local Government in Gippsland and North-East Victoria	Bushfire	Australia	Gangemi et al. (2003)	20	14
4	California Fire Plan	Bushfire	USA	California Department of Forestry and Fire Protection, and State Board of Forestry and Fire Protection (USA) (1996)	30	5
5	Emergency – Rapid Impact Assessment (RIA) Framework	Bushfire, flood	Australia	(Victorian) Department of Human Services (DHS) (In development)	24	9
6	Estimating Flood Tolerability: Recent Work in Melbourne	Flood	Australia	Handmer and Choong (2008)*	24	9
7	Rapid Appraisal Method (RAM) for Floodplain Management	Flood	Australia	Read Sturgess and Associates (2000)	27	8
8	Urban Flood Protection Benefits: a Project Appraisal Guide	Flood	UK	Parker, Green and Thompson (1987)	23	11
9	Hazards US Multi-Hazard (HAZUS-MH)	Flood, earthquake, hurricane	USA	Federal Emergency Management Agency (FEMA) and National Institute of Building Sciences (NIBS) (2003)	23	11

* Unpublished report: Handmer, J. and Choong, W. 2008, University – Centre for Risk and Community Safety, Melbourne, Victoria, Australia

#	Framework	Event	Country	Reference	Score (out of 39)	Ranking
10	Socio-economic Impact Assessment Model (SEIA-Model)	Many natural disasters	Australia	(Victorian) OESC (OESC 2008a)	38	1
11	Economic Impact of Natural Disasters on Development in the Pacific. Volume 2: Economic Assessment Tools	Many natural disasters	South Pacific Islands	McKenzie, Prasad and Kaloumaira (2005)	31	4
12	Handbook for Estimating the Socio-economic and Environmental Effects of Disasters	Many natural disasters	South America and the Caribbean	Economic Commission for Latin America and the Caribbean (ECLAC) (2003)	30	5
13	Disaster Loss Assessment Guidelines	Many natural disasters	Australia	Handmer, Reed and Percovich (2002)	38	1
14	Economic Costs of Natural Disasters in Australia Framework	Many natural disasters	Australia	Bureau of Transport Economics (BTE) (2001)	34	3

1) Wildfire Project			
Rating Scores: 0 – No 1 – Partially 2 – Mostly 3 – Fully			
Event:		Bushfire	
Country:		Australia	
Reference:		(Victorian) OESC (2008b)	
	Criteria and reason for including it (in parenthesis)	**Score**	**Reasons for Score**
1	Can be used to enter bushfire impacts and costs (Bushfires are the focus of the current project)	1	The Wildfire Project uses interactive maps and databases to classify the consequence of a wildfire on a particular asset. While it does not look at the costs of a wildfire, the maps would be very useful when collating the number of assets potentially damaged or destroyed within a fire boundary
2	Can be used to calculate or collate economic, social and environmental impacts and costs (These are the three main categories underlying the current project)	2	The framework covers many social, economic and environmental impacts, but does not looks at the associated costs
3	Can be used to calculate or collate direct, indirect and intangible impacts and costs (Standard format for entering natural event losses and costs)	2	The map covers a wide range of direct, indirect and intangible impacts, but does not look at the associated costs
4	Able to measure economic and not only financial costs (Economic costs measure the costs to an economy (group of people), and provides a more holistic picture of a natural hazard's impacts and costs)	0	Framework was not designed to measure economic or financial costs
5	Able to cope with simple data (i.e. not too sophisticated) (Data used for the current project will typically consist of a straightforward assessment of impacts and costs)	0	Uses a sophisticated computer program to display vector data to measure the impact of a bushfire on assets
6	Able to cope with missing data (i.e. not too data-driven) (Unlikely to find all desired data, therefore having a framework that can cope with missing data makes it more flexible and adaptable)	3	The map and database only present data that have been entered
7	Driven by the consequence of the natural hazard (i.e. concentrates on the impacts) (The current project focuses on the consequences of the fires)	3	Framework designed to incorporate the consequences of bushfires in relation to perceived value of the assets. Even though it is driven by the consequence of losing an asset, its main use is as a wildfire planning and decision-making tool for fire managers

1) Wildfire Project			
Rating Scores: 0 – No 1 – Partially 2 – Mostly 3 – Fully			
Event:		Bushfire	
Country:		Australia	
Reference:		(Victorian) OESC (2008b)	
	Criteria and reason for including it (in parenthesis)	**Score**	**Reasons for Score**
8	The purpose is similar to that of the current project (Similar purposes are more likely to lead to suitable methodologies and results)	1	While this framework and the current project both focus on the impact of wildfires on assets, the Wildfire Project focuses on the severity of the impact in the event it occurs, whereas the current project focuses on the actual cost of the impact after it has happened
9	Can provide a breakdown of the economic, social and environmental impacts and costs (Presents the information in an easy to understand format)	2	The framework is separated into these three categories to measure impacts, but not costs
10	Can provide a breakdown of the direct, indirect and intangible impacts and costs (Presents the information in an easy to understand format)	1	The impacts cannot be broken down into these categories, as they are combined within the social, economic and environmental categories chosen for this framework. It is, however, possible to add these up manually
11	Capable of undertaking a rapid impact assessment (Allows the user to estimate the extent of the impact in a relatively short amount of time so they can put response and recovery strategies into place quickly)	3	The user can rapidly estimate the impact of a disaster by highlighting the actual or potential affected areas on the map
12	Available for free use (i.e. no licensing fee or requirement to buy software) (Allows information or methodologies within the existing frameworks to be easily accessed and referred to if required)	1	Wildfire Project currently not available to other parties, owing to custodianship issues. Will be available when the project is finalised.
13	Software and hardware easy to use and view (Method should be easily used and viewed by a range of people regardless of their understanding of the underlying economic principles. Minimal training may be required to use the software)	2	The interactive map and database would be easy to use after a short lesson on how to interpret the information, symbols, colour scale, etc. Once the user has acquired this knowledge, the program becomes a powerful tool in fire management
Total score		**21**	

2) The Cost of Fire Now and in 2020			
Rating Scores: 0 – No 1 – Partially 2 – Mostly 3 – Fully			
Event:		Bushfire	
Country:		Australia	
Reference:		Handmer et al. (2008)	
	Criteria and reason for including it (in parenthesis)	**Score**	**Reasons for Score**
1	Can be used to enter bushfire impacts and costs (Bushfires are the focus of the current project)	3	Report set up to enter bushfire impacts and costs
2	Can be used to calculate or collate economic, social and environmental impacts and costs (These are the three main categories underlying the current project)	3	Covers a range of impacts and their associated costs for all three categories
3	Can be used to calculate or collate direct, indirect and intangible impacts and costs (Standard format for entering natural event losses and costs)	3	Covers a range of impacts and their associated costs for all three categories
4	Able to measure economic and not only financial costs (Economic costs measure the costs to an economy (group of people), and provides a more holistic picture of a natural hazard's impacts and costs)	2	This framework incorporates many economic principles, but does not account for the benefits to society
5	Able to cope with simple data (i.e. not too sophisticated) (Data used for the current project will typically consist of a straightforward assessment of impacts and costs)	1	Some parts are able to cope with simple data (e.g. the number of hectares burnt), while other parts require more complex data sourced from a number of government agencies
6	Able to cope with missing data (i.e. not too data-driven) (Unlikely to find all desired data, therefore having a framework that can cope with missing data makes it more flexible and adaptable)	3	Only adds up the costs of what is entered
7	Driven by the consequence of the natural hazard (i.e. concentrates on the impacts) (The current project focuses on the consequences of the fires)	3	Focuses on the impacts of the event
8	The purpose is similar to that of the current project (Similar purposes are more likely to lead to suitable methodologies and results)	3	Both projects aim to find the cost of bushfires. This report does this on a much bigger scale by finding the cost for Australia as a whole

2) The Cost of Fire Now and in 2020			
Rating Scores: 0 – No 1 – Partially 2 – Mostly 3 – Fully			
Event:		Bushfire	
Country:		Australia	
Reference:		Handmer et al. (2008)	
	Criteria and reason for including it (in parenthesis)	**Score**	**Reasons for Score**
9	Can provide a breakdown of the economic, social and environmental impacts and costs (Presents the information in an easy to understand format)	1	The assets listed in this framework are not grouped into these categories. Once collated, the user would then have to group the impacts and costs manually
10	Can provide a breakdown of the direct, indirect and intangible impacts and costs (Presents the information in an easy to understand format)	1	The assets listed in this framework are not grouped into these categories. Once collated, the user would then have to group the impacts and costs manually
11	Capable of undertaking a rapid impact assessment (Allows the user to estimate the extent of the impact in a relatively short amount of time so they can put response and recovery strategies into place quickly)	1	While the framework is there to quickly add in the impacts, obtaining the 'background' data from the various agencies would take some time
12	Available for free use (i.e. no licensing fee or requirement to buy software) (Allows information or methodologies within the existing frameworks to be easily accessed and referred to if required)	3	Available for free use
13	Software and hardware easy to use and view (Method should be easily used and viewed by a range of people regardless of their understanding of the underlying economic principles. Minimal training may be required to use the software)	2	Report straightforward and easy to view; however, the methodology is not detailed enough to allow easy replication
Total score		**29**	

3) Socio-economic Impact of Bushfires on Rural Communities and Local Government in Gippsland and North-East Victoria			
Rating Scores: 0 – No 1 – Partially 2 – Mostly 3 – Fully			
Event:		Bushfire	
Country:		Australia	
Reference:		Gangemi et al. (2003)	
	Criteria and reason for including it (in parenthesis)	**Score**	**Reasons for Score**
1	Can be used to enter bushfire impacts and costs (Bushfires are the focus of the current project)	3	Framework uses a bushfire event as a case study to find the associated impacts and costs
2	Can be used to calculate or collate economic, social and environmental impacts and costs (These are the three main categories underlying the current project)	2	The framework provides a comprehensive list of potential economic impacts. A survey was also created to capture social impacts, and while the project scope specified that environmental impacts were not included, some were described under the social impacts section
3	Can be used to calculate or collate direct, indirect and intangible impacts and costs (Standard format for entering natural event losses and costs)	1	The report focuses more on the indirect impacts of how the bushfire affected residents' job security and businesses during and shortly after the fire, and does not collate direct or intangible impacts
4	Able to measure economic and not only financial costs (Economic costs measure the costs to an economy (group of people), and provides a more holistic picture of a natural hazard's impacts and costs)	2	While it does measure the impact of a bushfire on a group of people, it does not account for the benefits the community receives (i.e. government relief grants, insurance payouts)
5	Able to cope with simple data (i.e. not too sophisticated) (Data used for the current project will typically consist of a straightforward assessment of impacts and costs)	0	The calculations require much ABS data, such as a defined area's population and proportion in the labour force to then determine the financial cost of the bushfire. These requirements makes the process relatively complex
6	Able to cope with missing data (i.e. not too data-driven) (Unlikely to find all desired data, therefore having a framework that can cope with missing data makes it more flexible and adaptable)	1	The calculation process used in this report requires that complete data are available at most stages
7	Driven by the consequence of the natural hazard (i.e. concentrates on the impacts) (The current project focuses on the consequences of the fires)	3	Focuses on the impacts of the event

3) Socio-economic Impact of Bushfires on Rural Communities and Local Government in Gippsland and North-East Victoria			
Rating Scores: 0 – No 1 – Partially 2 – Mostly 3 – Fully			
Event:		Bushfire	
Country:		Australia	
Reference:		Gangemi et al. (2003)	
8	The purpose is similar to that of the current project (Similar purposes are more likely to lead to suitable methodologies and results)	2	This report also aims to account for the social and economic impacts of a specific bushfire event, but not environmental impacts
9	Can provide a breakdown of the economic, social and environmental impacts and costs (Presents the information in an easy to understand format)	1	It provides a comprehensive breakdown of the economic impacts in dollar terms. It would be hard to break down the social and environmental impacts (where described under the social impact section), as they are blended together through pages of text
10	Can provide a breakdown of the direct, indirect and intangible impacts and costs (Presents the information in an easy to understand format)	1	The framework breaks down the indirect impacts and costs well. However, as direct and intangible impacts are not tabulated (i.e. only described in text), a breakdown of these impacts cannot be provided
11	Capable of undertaking a rapid impact assessment (Allows the user to estimate the extent of the impact in a relatively short amount of time so they can put response and recovery strategies into place quickly)	0	The process would take a relatively long time, owing to its initial data requirements and the need to survey affected people in order to find the total economic cost of the disaster
12	Available for free use (i.e. no licensing fee or requirement to buy software) (Allows information or methodologies within the existing frameworks to be easily accessed and referred to if required)	3	Since this report uses ABS data, it would be available to anyone
13	Software and hardware easy to use and view (Method should be easily used and viewed by a range of people regardless of their understanding of the underlying economic principles. Minimal training may be required to use the software)	1	The steps involved to find the final economic cost are relatively long, as a lot of baseline data are required from the ABS to begin with; however, the results are presented in clear and easy-to-follow tables
Total score		**20**	

4) California Fire Plan			
Rating Scores: 0 – No 1 – Partially 2 – Mostly 3 – Fully			
Event:		Bushfire	
Country:		USA	
Reference:		California Department of Forestry and Fire Protection and State Board of Forestry and Fire Protection (1996)	
	Criteria and reason for including it (in parenthesis)	**Score**	**Reasons for Score**
1	Can be used to enter bushfire impacts and costs (Bushfires are the focus of the current project)	3	The framework considers a number of bushfire impacts and their costs
2	Can be used to calculate or collate economic, social and environmental impacts and costs (These are the three main categories underlying the current project)	3	The assets listed in the framework cover impacts and costs from all three economic, social and environmental categories and allocates unit multipliers to many of these
3	Can be used to calculate or collate direct, indirect and intangible impacts and costs (Standard format for entering natural event losses and costs)	3	The assets listed in the framework cover impacts and costs from all three categories and allocates unit multipliers to many of these
4	Able to measure economic and not only financial costs (Economic costs measure the costs to an economy (group of people), and provides a more holistic picture of a natural hazard's impacts and costs)	2	This framework's main purpose is to reduce the costs of fires and it therefore focuses on the negative impacts to society, in terms of financial and intangible losses. i.e. it does not consider the benefits of a fire
5	Able to cope with simple data (i.e. not too sophisticated) (Data used for the current project will typically consist of a straightforward assessment of impacts and costs)	3	Only requires the number of assets lost or damaged in order to find the relevant cost
6	Able to cope with missing data (i.e. not too data-driven) (Unlikely to find all desired data, therefore having a framework that can cope with missing data makes it more flexible and adaptable)	3	Only adds up the costs of data entered, regardless of missing data
7	Driven by the consequence of the natural hazard (i.e. concentrates on the impacts) (The current project focuses on the consequences of the fires)	3	Even though this framework incorporates the desire for government (at all levels) to mitigate and reduce the impact of bushfires, it still looks at the consequence of the hazard (i.e. how much the loss of an asset is) to create its estimates

4) California Fire Plan			
Rating Scores: 0 – No 1 – Partially 2 – Mostly 3 – Fully			
Event:		Bushfire	
Country:		USA	
Reference:		California Department of Forestry and Fire Protection and State Board of Forestry and Fire Protection (1996)	
8	The purpose is similar to that of the current project (Similar purposes are more likely to lead to suitable methodologies and results)	1	Even though the current project and the California Fire Plan collect information on bushfire costs and losses, the California Fire Plan aims to reduce these costs through mitigation and initial attack strategies, rather than account for the impacts once they have occurred
9	Can provide a breakdown of the economic, social and environmental impacts and costs (Presents the information in an easy to understand format)	1	The assets listed as at risk in this framework are not grouped into these categories. Once collated, the user would have to group the impacts and costs manually
10	Can provide a breakdown of the direct, indirect and intangible impacts and costs (Presents the information in an easy to understand format)	1	The assets listed as at risk in this framework are not grouped into these categories. Once collated, the user would have to group the impacts and costs manually
11	Capable of undertaking a rapid impact assessment (Allows the user to estimate the extent of the impact in a relatively short amount of time so they can put response and recovery strategies into place quickly)	3	The user would only require the number or area of destroyed assets to provide an estimate of the cost
12	Available for free use (i.e. no licensing fee or requirement to buy software) (Allows information or methodologies within the existing frameworks to be easily accessed and referred to if required)	3	As long as the Plan is referenced as the source of data, it can be used (however, the information specifically applies to California and data might not be compatible with Australian conditions)
13	Software and hardware easy to use and view (Method should be easily used and viewed by a range of people regardless of their understanding of the underlying economic principles. Minimal training may be required to use the software)	1	Because the unit multipliers are in US dollars and use imperial measurements, converting the values given for each asset will be an additional task. Also, although there is a table describing what method to use to find the cost of the asset, the reader still has to sift through the text to find the unit multiplier
Total score		**30**	

5) Emergency – Rapid Impact Assessment (RIA) Framework			
Rating Scores: 0 – No 1 – Partially 2 – Mostly 3 – Fully			
Event:		Bushfire, Flood	
Country:		Australia	
Reference:		(Victorian) DHS (In development)	
	Criteria and reason for including it (in parenthesis)	**Score**	**Reasons for Score**
1	Can be used to enter bushfire impacts and costs (Bushfires are the focus of the current project)	1	Can be used to enter data on assets, which can subsequently be used to examine the impact of fire. It does not, however, assess the costs associated with bushfire impacts
2	Can be used to calculate or collate economic, social and environmental impacts and costs (These are the three main categories underlying the current project)	2	The framework does gather data on these three impacts, but does not have mechanisms in place to find their costs
3	Can be used to calculate or collate direct, indirect and intangible impacts and costs (Standard format for entering natural event losses and costs)	2	The framework enables the user to collate direct and indirect impacts, but does not incorporate intangible impacts or costs
4	Able to measure economic and not only financial costs (Economic costs measure the costs to an economy (group of people), and provides a more holistic picture of a natural hazard's impacts and costs)	1	It measures most components of an economic analysis, but does not measure the benefits or the actual cost of an event
5	Able to cope with simple data (i.e. not too sophisticated) (Data used for the current project will typically consist of a straightforward assessment of impacts and costs)	3	The checklists used to gather the information only require basic quantitative and qualitative data
6	Able to cope with missing data (i.e. not too data-driven) (Unlikely to find all desired data, therefore having a framework that can cope with missing data makes it more flexible and adaptable)	3	Only adds up the available impacts, regardless of absent data
7	Driven by the consequence of the natural hazard (i.e. concentrates on the impacts) (The current project focuses on the consequences of the fires)	3	All impacts listed are as a consequence of the event
8	The purpose is similar to that of the current project (Similar purposes are more likely to lead to suitable methodologies and results)	1	This framework is concerned with the rapid collection and collation of data and not with the financial costs attached

5) Emergency – Rapid Impact Assessment (RIA) Framework			
Rating Scores: 0 – No 1 – Partially 2 – Mostly 3 – Fully			
Event:		Bushfire, Flood	
Country:		Australia	
Reference:		(Victorian) DHS (In development)	
9	Can provide a breakdown of the economic, social and environmental impacts and costs (Presents the information in an easy to understand format)	1	The information collected is separated into individual impact types, and could be added together manually to give the impacts for each of these categories. This framework does not, however, find the costs of these impacts
10	Can provide a breakdown of the direct, indirect and intangible impacts and costs (Presents the information in an easy to understand format)	1	The information collected is separated into individual impact types, and could be added together manually to find the impacts for each of these categories. This framework does not, however, find the costs of these impacts
11	Capable of undertaking a rapid impact assessment (Allows the user to estimate the extent of the impact in a relatively short amount of time so they can put response and recovery strategies into place quickly)	3	That is the purpose of this framework
12	Available for free use (i.e. no licensing fee or requirement to buy software) (Allows information or methodologies within the existing frameworks to be easily accessed and referred to if required)	0	Still being developed
13	Software and hardware easy to use and view (Method should be easily used and viewed by a range of people regardless of their understanding of the underlying economic principles. Minimal training may be required to use the software)	3	Forms used throughout the process of collecting and collating data are very straightforward
Total score		**24**	

6) Estimating Flood Tolerability: Recent Work in Melbourne			
Rating Scores: 0 – No 1 – Partially 2 – Mostly 3 – Fully			
Event:		Flood	
Country:		Australia	
Reference:		Handmer and Choong (2008)[11]	
	Criteria and reason for including it (in parenthesis)	**Score**	**Reasons for Score**
1	Can be used to enter bushfire impacts and costs (Bushfires are the focus of the current project)	2	Terms used in the risk equation can apply to bushfires as well. Assessment weightings cannot be used for bushfires, as they relate to flood-specific measurements (e.g. flood level, flood hazard factor)
2	Can be used to calculate or collate economic, social and environmental impacts and costs (These are the three main categories underlying the current project)	2	The calculation includes social and economic impacts and costs. It does not consider environmental impacts, as these were not part of the scope
3	Can be used to calculate or collate direct, indirect and intangible impacts and costs (Standard format for entering natural event losses and costs)	3	Has components within the calculation that measure all three types
4	Able to measure economic and not only financial costs (Economic costs measure the costs to an economy (group of people), and provides a more holistic picture of a natural hazard's impacts and costs)	1	Measures some components of economic costs (e.g. intangibles), but not others (e.g. benefits)
5	Able to cope with simple data (i.e. not too sophisticated) (Data used for the current project will typically consist of a straightforward assessment of impacts and costs)	0	Since a large proportion of the final calculation is based on intangible impacts, sourcing the data is not simple. Furthermore, weightings are assigned to each impact type, adding another layer to the complexity
6	Able to cope with missing data (i.e. not too data-driven) (Unlikely to find all desired data, therefore having a framework that can cope with missing data makes it more flexible and adaptable)	3	Only adds up the costs of what is there, regardless of missing data
7	Driven by the consequence of the natural hazard (i.e. concentrates on the impacts) (The current project focuses on the consequences of the fires)	3	Most of the components of the formula consider the consequence of the impact on possible losses (e.g. exposure, vulnerability) and people's reaction (e.g. outrage)

6) Estimating Flood Tolerability: Recent Work in Melbourne			
Rating Scores: 0 – No 1 – Partially 2 – Mostly 3 – Fully			
Event:		Flood	
Country:		Australia	
Reference:		Handmer and Choong (2008)[11]	
	Criteria and reason for including it (in parenthesis)	**Score**	**Reasons for Score**
8	The purpose is similar to that of the current project (Similar purposes are more likely to lead to suitable methodologies and results)	1	The Estimating Flood Tolerability report and the current assessment calculate both tangible and intangible losses; however, this report focuses on risk perception, tolerability and outrage, which are not considered in the current project
9	Can provide a breakdown of the economic, social and environmental impacts and costs (Presents the information in an easy to understand format)	2	As the calculation is composed of separate social and economic measurements, it would be easy to provide a breakdown. It does not, however, assess environmental impacts
10	Can provide a breakdown of the direct, indirect and intangible impacts and costs (Presents the information in an easy to understand format)	3	As the calculation is composed of separate direct, indirect and intangible measurements, it would be easy to provide a breakdown
11	Capable of undertaking a rapid impact assessment (Allows the user to estimate the extent of the impact in a relatively short amount of time so they can put response and recovery strategies into place quickly)	0	Assessing ‘outrage’ and other intangible impacts would require time and expertise
12	Available for free use (i.e. no licensing fee or requirement to buy software) (Allows information or methodologies within the existing frameworks to be easily accessed and referred to if required)	3	Available for free use
13	Software and hardware easy to use and view (Method should be easily used and viewed by a range of people regardless of their understanding of the underlying economic principles. Minimal training may be required to use the software)	1	For those not familiar with flood-related terminology or concepts, this may prove a little difficult to follow
Total score		**24**	

7) Rapid Appraisal Method (RAM) for Floodplain Management			
Rating Scores: 0 – No 1 – Partially 2 – Mostly 3 – Fully			
Event:		Flood	
Country:		Australia	
Reference:		Read Sturgess and Associates (2000)	
	Criteria and reason for including it (in parenthesis)	**Score**	**Reasons for Score**
1	Can be used to enter bushfire impacts and costs (Bushfires are the focus of the current project)	1	The steps involved and terminology are strongly targeted towards flooding events, but the loss values (in terms of dollars) given for each impact type could be used for bushfires
2	Can be used to calculate or collate economic, social and environmental impacts and costs (These are the three main categories underlying the current project)	3	Is able to calculate all three impact types. For environmental impacts, the framework creates a scaling system (–3 to 3) to assess the importance of these impacts
3	Can be used to calculate or collate direct, indirect and intangible impacts and costs (Standard format for entering natural event losses and costs)	3	Even though the framework is focused on flood events, it lists a number of impacts from these categories that apply to bushfires and the unit multipliers that can be used to cost these impacts
4	Able to measure economic and not only financial costs (Economic costs measure the costs to an economy (group of people), and provides a more holistic picture of a natural hazard's impacts and costs)	3	Framework based on economic analysis
5	Able to cope with simple data (i.e. not too sophisticated) (Data used for the current project will typically consist of a straightforward assessment of impacts and costs)	1	Requires some flood-specific data, such as the relative frequency of flooding in each month, that are not relevant to bushfire impacts. The specific loss values (in terms of dollars) are, however, able to cope with simple data
6	Able to cope with missing data (i.e. not too data-driven) (Unlikely to find all desired data, therefore having a framework that can cope with missing data makes it more flexible and adaptable)	2	Although it requires data on average annual flooding events and water conditions to calculate the average annual flood damages value, it only adds up the costs of the impact types specified
7	Driven by the consequence of the natural hazard (i.e. concentrates on the impacts) (The current project focuses on the consequences of the fires)	3	Even though this framework looks at the costs and benefits of mitigation strategies, it is still driven by the consequence of a hazard by attempting to reduce losses

7) Rapid Appraisal Method (RAM) for Floodplain Management			
Rating Scores: 0 – No 1 – Partially 2 – Mostly 3 – Fully			
Event:		Flood	
Country:		Australia	
Reference:		Read Sturgess and Associates (2000)	
	Criteria and reason for including it (in parenthesis)	**Score**	**Reasons for Score**
8	The purpose is similar to that of the current project (Similar purposes are more likely to lead to suitable methodologies and results)	1	RAM's purpose is not similar to that of the current project, as it primarily assesses the potential costs and benefits of flood protection. However, it is able to consider the impacts and costs of a potential flood as well
9	Can provide a breakdown of the economic, social and environmental impacts and costs (Presents the information in an easy to understand format)	2	The table presented as the final step in the RAM framework does separate the economic impact types. For social and environmental impacts, the individual assessment forms used in this framework would have to be referred to separately
10	Can provide a breakdown of the direct, indirect and intangible impacts and costs (Presents the information in an easy to understand format)	2	The direct costs are broken down by impact type in the final table, while the indirect costs are shown as an amalgamated cost on one line. The assessments for the intangible impacts (social and environmental) would have to be referred to separately
11	Capable of undertaking a rapid impact assessment (Allows the user to estimate the extent of the impact in a relatively short amount of time so they can put response and recovery strategies into place quickly)	2	The initial flood-related information required may hinder an impact assessment slightly, but the provision of unit multipliers makes other parts relatively quick
12	Available for free use (i.e. no licensing fee or requirement to buy software) (Allows information or methodologies within the existing frameworks to be easily accessed and referred to if required)	3	Available for free use under copyright
13	Software and hardware easy to use and view (Method should be easily used and viewed by a range of people regardless of their understanding of the underlying economic principles. Minimal training may be required to use the software)	1	The framework is based on flood-specific methodologies and uses terminology and acronyms relevant to flooding events, which makes it difficult for those without flood-related knowledge to fully understand
Total score		**27**	

8) Urban Flood Protection Benefits: a Project Appraisal Guide			
Rating Scores: 0 – No 1 – Partially 2 – Mostly 3 – Fully			
Event:		Flood	
Country:		UK	
Reference:		Parker, Green and Thompson (1987)	
	Criteria and reason for including it (in parenthesis)	**Score**	**Reasons for Score**
1	Can be used to enter bushfire impacts and costs (Bushfires are the focus of the current project)	1	There are some unit multipliers that can be used for bushfires, although most of the multipliers and methodology are based on flood information (e.g. depth of water level)
2	Can be used to calculate or collate economic, social and environmental impacts and costs (These are the three main categories underlying the current project)	1	Each chapter covers the assessment of a different economic impact type, but does not cover social or environmental impacts
3	Can be used to calculate or collate direct, indirect and intangible impacts and costs (Standard format for entering natural event losses and costs)	2	The guide assesses tangible direct and indirect impacts and costs only
4	Able to measure economic and not only financial costs (Economic costs measure the costs to an economy (group of people), and provides a more holistic picture of a natural hazard's impacts and costs)	2	The guide measures the potential impacts and losses to a range of community groups (e.g. retail, manufacturing), and not the benefits once a flood has occurred
5	Able to cope with simple data (i.e. not too sophisticated) (Data used for the current project will typically consist of a straightforward assessment of impacts and costs)	3	The user only typically requires the duration or depth of a flood to find the associated costs
6	Able to cope with missing data (i.e. not too data-driven) (Unlikely to find all desired data, therefore having a framework that can cope with missing data makes it more flexible and adaptable)	3	Since the guide is broken down into separate impact type chapters, the user is able to select the chapter that suits their data
7	Driven by the consequence of the natural hazard (i.e. concentrates on the impacts) (The current project focuses on the consequences of the fires)	3	All the calculations are based on flood loss potentials and the benefits of protection strategies, therefore being driven by the consequence of the event

8) Urban Flood Protection Benefits: a Project Appraisal Guide			
Rating Scores: 0 – No 1 – Partially 2 – Mostly 3 – Fully			
Event:		Flood	
Country:		UK	
Reference:		Parker, Green and Thompson (1987)	
	Criteria and reason for including it (in parenthesis)	**Score**	**Reasons for Score**
8	The purpose is similar to that of the current project (Similar purposes are more likely to lead to suitable methodologies and results)	1	The guide's purpose is not similar to that of the current project, as it assesses the potential benefits of flood protection and not the impact of a real flood. It does, however, look at the impacts and costs of a potential flood
9	Can provide a breakdown of the economic, social and environmental impacts and costs (Presents the information in an easy to understand format)	1	Each chapter provides a breakdown of the economic costs, but does not cover social or environmental impacts and costs
10	Can provide a breakdown of the direct, indirect and intangible impacts and costs (Presents the information in an easy to understand format)	2	Can provide a breakdown of direct and indirect impacts and costs, but not intangible impacts and costs
11	Capable of undertaking a rapid impact assessment (Allows the user to estimate the extent of the impact in a relatively short amount of time so they can put response and recovery strategies into place quickly)	0	A rapid impact assessment implies that all impacts are accounted for; however, this guide does not cover a large number of impacts. In addition, this guide goes into detail about each impact covered and requires expert knowledge to understand the material if a rapid impact assessment is to be undertaken
12	Available for free use (i.e. no licensing fee or requirement to buy software) (Allows information or methodologies within the existing frameworks to be easily accessed and referred to if required)	3	Available for free use under copyright
13	Software and hardware easy to use and view (Method should be easily used and viewed by a range of people regardless of their understanding of the underlying economic principles. Minimal training may be required to use the software)	1	As the guide is a 149-page book (excluding appendices), it requires the user to read through large sections of text to understand the concepts and undertake the assessment. Although it is very thorough, the user may not initially find the guide easy to use and view
Total score		**23**	

9) Hazards US Multi-Hazard (HAZUS-MH)			
Rating Scores: 0 – No 1 – Partially 2 – Mostly 3 – Fully			
Event:		Flood, earthquake, hurricane	
Country:		USA	
Reference:		Federal Emergency Management Agency (FEMA) and National Institute of Building Sciences (NIBS) (2003)	
1	Can be used to enter bushfire impacts and costs (Bushfires are the focus of the current project)	0	The data sets and mathematical formulae used to estimate the impact of a natural hazard are specifically targeted towards floods, earthquakes and hurricanes
2	Can be used to calculate or collate economic, social and environmental impacts and costs (These are the three main categories underlying the current project)	3	Resultant data give predictions for all three impacts and their associated costs
3	Can be used to calculate or collate direct, indirect and intangible impacts and costs (Standard format for entering natural event losses and costs)	3	Resultant data give predictions for all three impacts and their associated costs
4	Able to measure economic and not only financial costs (Economic costs measure the costs to an economy (group of people), and provides a more holistic picture of a natural hazard's impacts and costs)	3	Based on economic and not financial analysis
5	Able to cope with simple data (i.e. not too sophisticated) (Data used for the current project will typically consist of a straightforward assessment of impacts and costs)	1	Level 1 (the most basic) analysis already has inbuilt data about the given area; however, Level 2 and 3 analyses require a lot of location-specific data to work
6	Able to cope with missing data (i.e. not too data-driven) (Unlikely to find all desired data, therefore having a framework that can cope with missing data makes it more flexible and adaptable)	1	In order to give the most beneficial results, the software would require all necessary data
7	Driven by the consequence of the natural hazard (i.e. concentrates on the impacts) (The current project focuses on the consequences of the fires)	3	All impacts listed are as a consequence of the event
8	The purpose is similar to that of the current project (Similar purposes are more likely to lead to suitable methodologies and results)	3	This framework's aim is similar to that of the current project, i.e. it estimates the economic, social and environmental impacts of three natural disasters

9) Hazards US Multi-Hazard (HAZUS-MH)			
Rating Scores: 0 – No 1 – Partially 2 – Mostly 3 – Fully			
Event:		Flood, earthquake, hurricane	
Country:		USA	
Reference:		Federal Emergency Management Agency (FEMA) and National Institute of Building Sciences (NIBS) (2003)	
9	Can provide a breakdown of the economic, social and environmental impacts and costs (Presents the information in an easy to understand format)	1	It is assumed that the results would be tabulated and that the impacts would have to be grouped manually into these categories
10	Can provide a breakdown of the direct, indirect and intangible impacts and costs (Presents the information in an easy to understand format)	1	It is assumed that the results would be tabulated and that the impacts would have to be grouped manually into these categories
11	Capable of undertaking a rapid impact assessment (Allows the user to estimate the extent of the impact in a relatively short amount of time so they can put response and recovery strategies into place quickly)	2	With one of the three levels of analysis within the HAZUS-MH framework, it might be possible to undertake a rapid impact assessment
12	Available for free use (i.e. no licensing fee or requirement to buy software) (Allows information or methodologies within the existing frameworks to be easily accessed and referred to if required)	1	While the disc is free to order, the costs of buying the additional supporting programs is costly. FEMA estimated that the costs for a Level 1 analysis would be in the range US$2,000–5,000 (in 1996 prices)
13	Software and hardware easy to use and view (Method should be easily used and viewed by a range of people regardless of their understanding of the underlying economic principles. Minimal training may be required to use the software)	1	FEMA requests that all users attend a training day to learn about the software. For Level 2 and 3 analysers, FEMA states that the user must source people with engineering and geotechnical expertise to complete the analysis
Total score		**23**	

10) Socio-economic Impact Assessment Model (SEIA-Model)			
Rating Scores: 0 – No 1 – Partially 2 – Mostly 3 – Fully			
Event:		Many natural disasters	
Country:		Australia	
Reference:		(Victorian) OESC (2008a)	
	Criteria and reason for including it (in parenthesis)	**Score**	**Reasons for Score**
1	Can be used to enter bushfire impacts and costs (Bushfires are the focus of the current project)	3	Framework is generic and can be used to enter bushfire impacts and costs. The case study examined the 2006–07 bushfires
2	Can be used to calculate or collate economic, social and environmental impacts and costs (These are the three main categories underlying the current project)	3	Many impacts within these categories are covered in the framework. Provides dollar value for environmental impacts by asking those surveyed what price they would place on the environment
3	Can be used to calculate or collate direct, indirect and intangible impacts and costs (Standard format for entering natural event losses and costs)	3	Framework set up to collate and calculate these three categories separately
4	Able to measure economic and not only financial costs (Economic costs measure the costs to an economy (group of people), and provides a more holistic picture of a natural hazard's impacts and costs)	3	Framework based on economic analysis, including both the losses and benefits to society
5	Able to cope with simple data (i.e. not too sophisticated) (Data used for the current project will typically consist of a straightforward assessment of impacts and costs)	3	Only requires the number of assets lost or damaged in order to find the relevant cost
6	Able to cope with missing data (i.e. not too data-driven) (Unlikely to find all desired data, therefore having a framework that can cope with missing data makes it more flexible and adaptable)	3	Only adds up the costs of data entered, regardless of missing data
7	Driven by the consequence of the natural hazard (i.e. concentrates on the impacts) (The current project focuses on the consequences of the fires)	3	All impacts listed are as a consequence of the event

10) Socio-economic Impact Assessment Model (SEIA-Model)			
Rating Scores: 0 – No 1 – Partially 2 – Mostly 3 – Fully			
Event:		Many natural disasters	
Country:		Australia	
Reference:		(Victorian) OESC (2008a)	
	Criteria and reason for including it (in parenthesis)	**Score**	**Reasons for Score**
8	The purpose is similar to that of the current project (Similar purposes are more likely to lead to suitable methodologies and results)	3	The purpose of the SEIA-Model aligns very closely with the current project, and it also presents a case study to demonstrate the framework in action
9	Can provide a breakdown of the economic, social and environmental impacts and costs (Presents the information in an easy to understand format)	2	Since the economic costs are shown as tangible (direct or indirect) costs and the social and environmental costs are broken down within the intangible section in the final table, it would be relatively easy to separate all three impacts
10	Can provide a breakdown of the direct, indirect and intangible impacts and costs (Presents the information in an easy to understand format)	3	As the framework is set up to cover these categories separately, the total costs are shown for each category as well
11	Capable of undertaking a rapid impact assessment (Allows the user to estimate the extent of the impact in a relatively short amount of time so they can put response and recovery strategies into place quickly)	3	The template is in place to allow quick assessment of a disaster
12	Available for free use (i.e. no licensing fee or requirement to buy software) (Allows information or methodologies within the existing frameworks to be easily accessed and referred to if required)	3	Available for free use
13	Software and hardware easy to use and view (Method should be easily used and viewed by a range of people regardless of their understanding of the underlying economic principles. Minimal training may be required to use the software)	3	Framework process very easy to follow and clear tables allow the impact and cost data to be easily viewed
Total score		**38**	

11) Economic Impact of Natural Disasters on Development in the Pacific. Volume 2: Economic Assessment Tools			
Rating Scores: 0 – No 1 – Partially 2 – Mostly 3 – Fully			
Event:		Many natural disasters	
Country:		South Pacific Islands	
Reference:		McKenzie, Prasad and Kaloumaira (2005)	
	Criteria and reason for including it (in parenthesis)	**Score**	**Reasons for Score**
1	Can be used to enter bushfire impacts and costs (Bushfires are the focus of the current project)	2	Framework is generic and can be used for bushfire impacts but not costs
2	Can be used to calculate or collate economic, social and environmental impacts and costs (These are the three main categories underlying the current project)	2	Can be used to collate all three impact types, but does not provide any monetary values (i.e. unit multipliers) for calculating these impacts
3	Can be used to calculate or collate direct, indirect and intangible impacts and costs (Standard format for entering natural event losses and costs)	2	Contains a lot of information on how to collate all three impact types, but not on how to calculate them
4	Able to measure economic and not only financial costs (Economic costs measure the costs to an economy (group of people), and provides a more holistic picture of a natural hazard's impacts and costs)	3	Based on economic and not financial analysis
5	Able to cope with simple data (i.e. not too sophisticated) (Data used for the current project will typically consist of a straightforward assessment of impacts and costs)	3	The model can cope with simple data, which are inserted into simple templates
6	Able to cope with missing data (i.e. not too data-driven) (Unlikely to find all desired data, therefore having a framework that can cope with missing data makes it more flexible and adaptable)	3	The model can cope with missing data, as it only adds up what is there
7	Driven by the consequence of the natural hazard (i.e. concentrates on the impacts) (The current project focuses on the consequences of the fires)	3	All impacts listed are as a consequence of the event

11) Economic Impact of Natural Disasters on Development in the Pacific. Volume 2: Economic Assessment Tools			
Rating Scores: 0 – No 1 – Partially 2 – Mostly 3 – Fully			
Event:		Many natural disasters	
Country:		South Pacific Islands	
Reference:		McKenzie, Prasad and Kaloumaira (2005)	
8	The purpose is similar to that of the current project (Similar purposes are more likely to lead to suitable methodologies and results)	3	The first tool in this report aligns very closely with the current project
9	Can provide a breakdown of the economic, social and environmental impacts and costs (Presents the information in an easy to understand format)	2	Can provide a breakdown of all three impacts in the final table provided, but does not use a column for costs
10	Can provide a breakdown of the direct, indirect and intangible impacts and costs (Presents the information in an easy to understand format)	1	User can manually break down these impacts, as they are mixed within the social, economic and environmental impact sections
11	Capable of undertaking a rapid impact assessment (Allows the user to estimate the extent of the impact in a relatively short amount of time so they can put response and recovery strategies into place quickly)	1	While this framework incorporates many impact types and ways to assess impacts, it does not seem designed to rapidly assess impacts
12	Available for free use (i.e. no licensing fee or requirement to buy software) (Allows information or methodologies within the existing frameworks to be easily accessed and referred to if required)	3	Available for free use
13	Software and hardware easy to use and view (Method should be easily used and viewed by a range of people regardless of their understanding of the underlying economic principles. Minimal training may be required to use the software)	3	Information flows well through the document. Impact types (i.e. social, economic and environmental) are thoroughly discussed with many explanations and examples to provide clarity
Total score		**31**	

12) Handbook for Estimating theSocio-economic and Environmental Effects of Disasters			
Rating Scores: 0 – No 1 – Partially 2 – Mostly 3 – Fully			
Event:			Many natural disasters
Country:			South America and the Caribbean
Reference:			Economic Commission for Latin America and the Caribbean (ECLAC) (2003)
	Criteria and reason for including it (in parenthesis)	**Score**	**Reasons for Score**
1	Can be used to enter bushfire impacts and costs (Bushfires are the focus of the current project)	3	The report contains a thorough list of impacts that could be applied to bushfires and methodologies on how to cost them
2	Can be used to calculate or collate economic, social and environmental impacts and costs (These are the three main categories underlying the current project)	3	Can be used to collate and cost all three impact types
3	Can be used to calculate or collate direct, indirect and intangible impacts and costs (Standard format for entering natural event losses and costs)	3	Can be used to collate and cost all three impact types
4	Able to measure economic and not only financial costs (Economic costs measure the costs to an economy (group of people), and provides a more holistic picture of a natural hazard's impacts and costs)	2	Measures many economic values but does not consider the benefits to an economy
5	Able to cope with simple data (i.e. not too sophisticated) (Data used for the current project will typically consist of a straightforward assessment of impacts and costs)	2	There are equations throughout the handbook that require statistical data
6	Able to cope with missing data (i.e. not too data-driven) (Unlikely to find all desired data, therefore having a framework that can cope with missing data makes it more flexible and adaptable)	3	The model can cope with missing data, as it only adds up what is there
7	Driven by the consequence of the natural hazard (i.e. concentrates on the impacts) (The current project focuses on the consequences of the fires)	3	All impacts listed are as a consequence of the event
8	The purpose is similar to that of the current project (Similar purposes are more likely to lead to suitable methodologies and results)	3	Like the current project, this report aims to measure in monetary terms the social, economic and environmental impacts of disasters to an affected region

12) Handbook for Estimating theSocio-economic and Environmental Effects of Disasters			
Rating Scores: 0 – No 1 – Partially 2 – Mostly 3 – Fully			
Event:		Many natural disasters	
Country:		South America and the Caribbean	
Reference:		Economic Commission for Latin America and the Caribbean (ECLAC) (2003)	
	Criteria and reason for including it (in parenthesis)	**Score**	**Reasons for Score**
9	Can provide a breakdown of the economic, social and environmental impacts and costs (Presents the information in an easy to understand format)	2	Since all impact types have their own methodology, it would be simple to find the impacts and costs of each impact type within the economic, social and environmental categories. The difficulty comes when wanting to find the breakdown of the impacts and costs of each category as a whole, as a lot of time would need to be spent collating the costs of each individual impact type
10	Can provide a breakdown of the direct, indirect and intangible impacts and costs (Presents the information in an easy to understand format)	1	Although possible, it would require a lot of calculations, as the report breaks the impacts into their economic, social and environmental categories and then each impact into direct and indirect impacts
11	Capable of undertaking a rapid impact assessment (Allows the user to estimate the extent of the impact in a relatively short amount of time so they can put response and recovery strategies into place quickly)	0	Owing to the extensive amount of information contained in the 357-page handbook, it could not be used in a rapid impact assessment
12	Available for free use (i.e. no licensing fee or requirement to buy software) (Allows information or methodologies within the existing frameworks to be easily accessed and referred to if required)	3	Available for free use under copyright
13	Software and hardware easy to use and view (Method should be easily used and viewed by a range of people regardless of their understanding of the underlying economic principles. Minimal training may be required to use the software)	2	The handbook is generally easy to use and view. The inadequate scaling of diagrams and tables makes them too small to view properly, and the number of pages makes it a long read
Total score		**30**	

13) Disaster Loss Assessment Guidelines			
Rating Scores: 0 – No 1 – Partially 2 – Mostly 3 – Fully			
Event:		Many natural disasters	
Country:		Australia	
Reference:		Handmer, Reed and Percovich (2002)	
	Criteria and reason for including it (in parenthesis)	**Score**	**Reasons for Score**
1	Can be used to enter bushfire impacts and costs (Bushfires are the focus of the current project)	3	Although this framework primarily focuses on flood events, the process for costing a disaster can be applied to bushfires
2	Can be used to calculate or collate economic, social and environmental impacts and costs (These are the three main categories underlying the current project)	3	This framework is able to calculate all three impact types
3	Can be used to calculate or collate direct, indirect and intangible impacts and costs (Standard format for entering natural event losses and costs)	3	Process specifies that impacts be entered under these headings. Many examples are listed for each category
4	Able to measure economic and not only financial costs (Economic costs measure the costs to an economy (group of people), and provides a more holistic picture of a natural hazard's impacts and costs)	3	Framework is based on economic analysis, as it looks at both the losses and benefits to society. The steps involved in this framework ensure that many aspects of a thorough economic analysis are covered
5	Able to cope with simple data (i.e. not too sophisticated) (Data used for the current project will typically consist of a straightforward assessment of impacts and costs)	3	Only requires the number of assets lost or damaged in order to find the relevant cost for each impact type
6	Able to cope with missing data (i.e. not too data-driven) (Unlikely to find all desired data, therefore having a framework that can cope with missing data makes it more flexible and adaptable)	3	Only adds up the costs of existing data, regardless of absent data
7	Driven by the consequence of the natural hazard (i.e. concentrates on the impacts) (The current project focuses on the consequences of the fires)	3	Driven by the consequence of the hazard, as it considers a range of losses in its framework
8	The purpose is similar to that of the current project (Similar purposes are more likely to lead to suitable methodologies and results)	3	The purpose of this report aligns very closely with the current project, and it also presents a case study to demonstrate the framework in action

13) Disaster Loss Assessment Guidelines			
Rating Scores: 0 – No 1 – Partially 2 – Mostly 3 – Fully			
Event:		Many natural disasters	
Country:		Australia	
Reference:		Handmer, Reed and Percovich (2002)	
	Criteria and reason for including it (in parenthesis)	**Score**	**Reasons for Score**
9	Can provide a breakdown of the economic, social and environmental impacts and costs (Presents the information in an easy to understand format)	2	Since the economic costs are shown as tangible (direct or indirect) costs and the social and environmental costs are broken down within the intangible section in the final table, it would be relatively easy to separate all three impacts
10	Can provide a breakdown of the direct, indirect and intangible impacts and costs (Presents the information in an easy to understand format)	3	Already tabulated to provide a breakdown of these separate costs before giving a grand total
11	Capable of undertaking a rapid impact assessment (Allows the user to estimate the extent of the impact in a relatively short amount of time so they can put response and recovery strategies into place quickly)	3	The steps within this framework are easy to follow and many take little time to progress through
12	Available for free use (i.e. no licensing fee or requirement to buy software) (Allows information or methodologies within the existing frameworks to be easily accessed and referred to if required)	3	Available for free use under copyright
13	Software and hardware easy to use and view (Method should be easily used and viewed by a range of people regardless of their understanding of the underlying economic principles. Minimal training may be required to use the software)	3	Framework is very clear and steps involved are set out in a way that makes them easy to follow and the end result easy to view
Total score		**38**	

14) Economic Costs of Natural Disasters in Australia Framework			
Rating Scores: 0 – No 1 – Partially 2 – Mostly 3 – Fully			
Event:		Many natural disasters	
Country:		Australia	
Reference:		Bureau of Transport Economics (BTE) (2001)	
	Criteria and reason for including it (in parenthesis)	**Score**	**Reasons for Score**
1	Can be used to enter bushfire impacts and costs (Bushfires are the focus of the current project)	3	Impact categories given in the BTE report are generic and can easily be used for bushfire impacts and costs
2	Can be used to calculate or collate economic, social and environmental impacts and costs (These are the three main categories underlying the current project)	2	Mostly economic impacts and costs, with some social and no environmental impacts
3	Can be used to calculate or collate direct, indirect and intangible impacts and costs (Standard format for entering natural event losses and costs)	3	BTE framework set up to account for all of these
4	Able to measure economic and not only financial costs (Economic costs measure the costs to an economy (group of people), and provides a more holistic picture of a natural hazard's impacts and costs)	2	BTE report based on economic and not financial analysis; however, it does not include the benefits in its estimations
5	Able to cope with simple data (i.e. not too sophisticated) (Data used for the current project will typically consist of a straightforward assessment of impacts and costs)	3	The calculations used to find the cost of an impact are very simple and require little data
6	Able to cope with missing data (i.e. not too data-driven) (Unlikely to find all desired data, therefore having a framework that can cope with missing data makes it more flexible and adaptable)	3	The report only adds up the costs listed, and does not rely on every impact type being accounted for
7	Driven by the consequence of the natural hazard (i.e. concentrates on the impacts) (The current project focuses on the consequences of the fires)	3	All impacts listed are as a consequence of the event
8	The purpose is similar to that of the current project (Similar purposes are more likely to lead to suitable methodologies and results)	2	Like the current project, the BTE document sets out to more accurately cost natural disasters, but unlike the current project, does not assess environmental impacts

14) Economic Costs of Natural Disasters in Australia Framework			
Rating Scores: 0 – No 1 – Partially 2 – Mostly 3 – Fully			
Event:		Many natural disasters	
Country:		Australia	
Reference:		Bureau of Transport Economics (BTE) (2001)	
	Criteria and reason for including it (in parenthesis)	**Score**	**Reasons for Score**
9	Can provide a breakdown of the economic, social and environmental impacts and costs (Presents the information in an easy to understand format)	1	Economic, social and environmental impacts and costs are combined in the direct, indirect and intangible sub-sections. The user would therefore have to manually separate and add up these impacts and costs
10	Can provide a breakdown of the direct, indirect and intangible impacts and costs (Presents the information in an easy to understand format)	3	BTE framework set up to account for all of these separately before giving a grand total
11	Capable of undertaking a rapid impact assessment (Allows the user to estimate the extent of the impact in a relatively short amount of time so they can put response and recovery strategies into place quickly)	3	The framework provides a table that lists a large number of impacts and also provides unit multipliers for each impact
12	Available for free use (i.e. no licensing fee or requirement to buy software) (Allows information or methodologies within the existing frameworks to be easily accessed and referred to if required)	3	Available for free use under copyright
13	Software and hardware easy to use and view (Method should be easily used and viewed by a range of people regardless of their understanding of the underlying economic principles. Minimal training may be required to use the software)	3	The tables used can be easily replicated in Excel or similar software. Tables straightforward and easy to view
Total score		**34**	

Appendix 6 SEIA-Model Steps

The SEIA-Model contains eight steps, which are reproduced below. These were addressed in the initial phase of this study. As a result, some of the text or the information collected below may be repeated in the main body of the report. The steps and their application to this study are described below.

Step 1: Description of the emergency to establish its operational response requirements and geographical and temporal details

A description of the fires and the operational responses are described in *2. Profile of the Bushfires and Impacted Regions*.

Step 2: Baseline profile of assessment area to describe its:

i) Economic and social activity
ii) Assets that may be affected by the emergency – identifying assets within impacted area using geographic information system (GIS) data
iii) Community well-being

Brief descriptions of the economic and social activities in the assessment area are described in *2. Profile of the Bushfires and Impacted Regions*. Specific assets that might have been affected by each fire and data on community wellbeing were not sought.

Step 3: Identification and assessment of direct tangible and intangible losses, damage and costs from the emergency including:

Tangible costs:

i) Residential, business and industry premises, stock and contents
ii) Infrastructure
iii) Agricultural, timber, stock, crops

Intangible costs:

i) Death and injury
ii) Health and psychological impacts
iii) Culture and heritage loss and damage
iv) Loss of memorabilia and environmental loss and damage

These impacts were collected and valued (where possible). The results are presented in Table 8 using the categories economic, social and environmental.

Step 4: Identification and assessment of indirect costs including:

i) Business disruption losses and benefits
ii) Disruption to transport networks
iii) Disruption to essential service provision
iv) Disruption to public services
v) Disruption to households
vi) Costs of emergency response and relief to the regional area

Identifying indirect costs can be difficult, as detailed business and household surveys are the best way to obtain information from which calculations can be made. Much of this information could not be collected by surveys owing to the large time span over which the fires occurred. As a result, the cost of emergency response and the flow-on effects to third parties (not included in the SEIA-Model) for each fire were the only indirect impacts estimated.

Step 5: Identify and assess the benefits of:

i) Insurance payments
ii) Payments by governments
iii) Recovery and restoration programs
iv) Economic activity generated from within the assessed district

These were sourced from the Insurance Council of Australia[21] and various government reports. The amount received from donations was also included in the current study, as donations were seen as a benefit to those affected.

Step 6: Quantification (and qualification) of costs and benefits

This was conducted throughout the data-gathering phase in Steps 3, 4 and 5.

Step 7: Comparison of costs and benefits with and without the wildfire to establish net socio-economic impact

The net economic loss was found by adding up all the (quantitative) losses and benefits separately and then subtracting the benefits from the losses.

Step 8: Analysis of costs and benefits considering community sustainability and future emergency mitigation and preparedness strategies

The analysis is presented the *Results* and *Discussion* sections.

21 Available at: http://www.insurancecouncil.com.au/IndustryStatisticsData/CatastropheDisasterStatistics/tabid/1572/Default.aspx

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Appendix 7 Ecosystem Services, Functions and Value per Hectare

Table 22 presents the full 17 ecosystem services used by Costanza et al. (1997) when valuing the world's ecosystem services and natural capital. Services highlighted in yellow (Numbers 13 and 14) were not used, being accounted for in other sections of the assessment. Services highlighted in blue (Numbers 16 and 17) are used to account for impacts within other sections.

Table 22 Ecosystem services and functions

#	Ecosystem service*	Ecosystem functions	Examples
1	Gas regulation	Regulation of atmospheric chemical composition	CO_2–O_2 balance, O_3 for UVB protection, and SO_x levels
2	Climate regulation	Regulation of global temperature, precipitation, and other biologically mediated climatic processes at global or local levels	Greenhouse gas regulation, DMS production affecting cloud formation
3	Disturbance regulation	Capacitance, damping and integrity of ecosystem response to environmental fluctuations	Storm protection, flood control, drought recovery and other aspects of habitat response to environmental variability mainly controlled by vegetation structure
4	Water regulation	Regulation of hydrological flows	Provisioning of water for agriculture (such as irrigation) or industrial (such as milling) processes or transportation
5	Water supply	Storage and retention of water	Provisioning of water by watersheds, reservoirs and aquifers
6	Erosion control and sediment retention	Retention of soil within an ecosystem	Prevention of loss of soil by wind, runoff, or other removal processes, storage of silt in lakes and wetlands
7	Soil formation	Soil formation processes	Weathering of rock and the accumulation of organic material
8	Nutrient cycling	Storage, internal cycling, processing and acquisition of nutrients	Nitrogen fixation, N, P and other elemental or nutrient cycles
9	Waste treatment	Recovery of mobile nutrients and removal or breakdown of excess xenic nutrients and compounds	Waste treatment, pollution control, detoxification
10	Pollution	Movement of floral gametes	Provisioning of pollinators for the reproduction of plant populations
11	Biological control	Trophic–dynamic regulations of populations	Keystone predator control of prey species, reduction of herbivory by top predators
12	Refugia	Habitat for resident and transient populations	Nurseries, habitat for migratory species, regional habitats for locally harvested species, or overwintering grounds
13	Food production	That portion of gross primary production extractable as food	Production of fish, game, crops, nuts, fruits by hunting, gathering, subsistence farming or fishing

#	Ecosystem service*	Ecosystem functions	Examples
14	Raw materials	That portion of gross primary production extractable as raw materials	The production of lumber, fuel or fodder
15	Genetic resources	Sources of unique biological materials and products	Medicine, products for material science, genes for resistance to plant pathogens and crop pests, ornamental species (pets and horticultural varieties of plants)
16	Recreation	Providing opportunities for recreational activities	Eco-tourism, sport fishing, and other outdoor recreational activities
17	Cultural	Providing opportunities for non-commercial uses	Aesthetic, artistic, educational, spiritual, and/or scientific values of ecosystems

* Ecosystem 'goods' are included in ecosystem services.
Source: Costanza et al. 1997, p. 254

Table 23 demonstrates the values placed on the ecosystem services used in the present assessment. They were originally in 1994 US dollars, and have been converted to 2008 Australian dollars. The four biomes shown below are those applicable to the five fires being studied, with open cells indicating a lack of available information and grey cells indicating that the service does not occur or is known to be negligible.

Two values were reduced to reflect the changes made in Handmer et al. (2008) regarding the estimated impact of fire on these services. They were climate regulation in Forests, in which the estimated impact was 75% and waste treatment in Grassland, which had an estimated impact of 20%. The estimated impact of fire on the other services was assumed to be 100%.

Table 23 Summary of average global value of annual ecosystem services

Ecosystem service	2008 AU$ ha^{-1} yr^{-1}			
	Forest	Swamp or floodplain	Grassland	Crop land
Gas regulation		536	15	
Climate regulation	214			
Disturbance regulation	4	14,651		
Water regulation	4	61	6	
Water supply	6	15,380		
Erosion control	195		59	
Soil formation	21		1	
Nutrient cycling	731			
Waste treatment	176	3,358	34	
Pollination			50	28
Biological control	4		47	49
Habitat and refugia		888		
Genetic resources	33			
Recreation	133	994	4	
Cultural	4	3,563		
Total	**1,525**	**39,431**	**216**	**77**

Source: Costanza et al. 1997, p. 256

Appendix 8 Sources of Information from Selected Literature

Apart from the detailed data received from government agencies for all but the 1983 Ash Wednesday Fires, the following books, reports and inquires contained valuable information. The literature listed below contains not only direct impacts, but also information relating to indirect and intangible impacts.

1983 Ash Wednesday Fires

- *Ash Wednesday Bush Fires*, Cain (Ministerial Statement to the Parliament of Victoria) 1983
- *The major fires originating 16th February, 1983*, CFA 1983
- *Annual Report 1982–83*, Forests Commission Victoria 1983

2003 Alpine and Canberra Fires

- *The Report of the Bushfire Recovery Taskforce – Australian Capital Territory October 2003*, Bushfire Recovery Taskforce 2003
- *The Campaign Fires: North-East/East Gippsland Fires 2003*, CFA 2003
- *Report of the Inquiry into the 2002–2003 Victorian Bushfires*, Esplin, Gill and Enright 2003
- *Inquiry into the Operational Response to the January 2003 Bushfires in the ACT*, McLeod 2003
- *Final Report from the Ministerial Taskforce on Bushfire Recovery*, Ministerial Taskforce on Bushfire Recovery 2003
- *The Victorian Alpine Fires: January–March 2003*, Wareing and Flinn 2003

2005–06 Deep Lead and Mount Lubra Fires

- *Beyond the Smoke: Fires, Destruction and Images of Hope – Grampians Region 2006*, Fleming et al. 2007

2006–07 Great Divide Fires

- *Great Divide Fire Recovery Plan*, DSE and PV 2008
- *The Victorian Great Divide Fires: December 2006–February 2007,* Flinn, Wareing and Wadsley 2008
- *2007 Report from the Ministerial Taskforce on Bushfire Recovery*, Ministerial Taskforce on Bushfire Recovery 2007

2009 Black Saturday Fires

- *Firestorm: Black Saturday's Tragedy, 7th February 2009*, Committee of Parents and Friends of Glenvale School 2009
- *2009 Victorian Bushfires Royal Commission Interim Report*, Teague, McLeod and Pascoe 2009
- *Rebuilding Together: a Statewide Plan for Bushfire Reconstruction and Recovery*, Victorian Bushfire Reconstruction and Recovery Authority 2009

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