CHAPTER **FIVE** - BUSHFIRES

5.1 Bushfires in the landscape

During the Black Saturday bushfires one hundred and seventy three people died. Over 2,000 homes were destroyed and 430,000 hectares burnt.

Our recent history

During the Black Saturday bushfires one hundred and seventy three people died. Over 2,000 homes were destroyed and 430,000 hectares burnt. In addition, in the week preceding the fires, three hundred and seventy four people had their deaths hastened by the extreme heat events which reduced human resilience and turned a broad swathe of the environment into a tinderbox.

These personal tragedies and impacts are extreme, even given our history of exposure to bushfire events.

The Victorian Bushfires Royal Commission, 2009 (VBCR) led to a set of extensive recommendations and triggered major changes in how bushfire responses are planned and response managed. There were also changes introduced to strengthen the consideration of bushfire at different stages of the land use planning process and to better integrate the planning and building systems.

It is important to consider how these events and the phenomena of climate change are linked - to learn from those tragic events. CSIRO *State of the Climate* 2012 builds on the bushfire exposure knowledge in its *State of the Climate* 2010. We are now armed with two authoritative outlines of the climate science as it applies to us in this region. We have also seen in Chapter One of this paper, that notwithstanding the diversion of La Niña events we can only, realistically, expect the trend of increased temperatures to continue, persistent dry spells to test us, and bushfire vulnerability to continue and elevate (Figure 39).

The planet is warming, the climate is changing and Australia is vulnerable. Events that were once worst-case scenarios will become more likely. Governments will face the challenge of identifying areas and factors of extreme risk – both now and in the future - and adapt policy and practical responses to address these risks.

In the wake of the 2009 fires we, as a community, need to better reconcile human reactions and lifestyle choices with developing methods of dealing with forest ecological and climatic patterns. Long term retreat or transition options can be very sensitive matters for communities who might see these approaches as threatening their traditions and choices. Although future projected risks can be hard to visualise, the consequences, for example, of relocation a town, are not.

The Victorian Government has taken steps to improve emergency service delivery, improve our ability to respond to large-scale events and to implement the recommendations from the VBRC.

As people choose to live in fire prone areas, there needs to be a greater emphasis on personal responsibility in preparedness for fires. This imperative was acknowledged by the VBRC which reported that alongside the responsibilities of all tiers of government, "communities, individuals and households need to take greater responsibility for their own safety and to act on advice and other cues given to them before and on the day of a bushfire."[201]

Work has been undertaken in Victoria to address issues raised by the VBRC. The Victorian Government has taken steps to improve emergency service delivery, improve our ability to respond to large-scale events and to implement the recommendations from the VBRC. This includes the release in 2011 of, *Victoria Prepared: An Action Plan,* as a companion document to the *Green Paper on Emergency Management*.

Feedback on the *Green Paper,* along with the final report of the *Comri Review of the 2010-11 Flood Warnings and Response* (Victorian Floods Review), informed the development of a comprehensive policy proposal to reform Victoria's emergency management arrangements. The Victorian Government has indicated its commitment to improving the state's capacity to deal with and respond to natural disasters in the future.[202]

In December 2012 the Victorian Government released the Emergency Management White Paper, which sets out reforms for the emergency management in the state.[viii] The reforms are intended to move the sector towards an all-hazards, all agencies approach and improve emergency management, with a strong emphasis on risk mitigation. The changes include the following:

- A new overarching emergency management body, Emergency Management Victoria, which will make sure agencies and departments plan and work together as well as share resources before, during and after an emergency. For the first time, one agency will oversee response and management for natural disasters and emergencies from preparation right through to community recovery
- The creation of an Emergency Management Commissioner, who will assume the operational responsibilities of the current Fire Services Commissioner and oversee control arrangements for fire, flood and other emergencies
- The establishment of a State Crisis and Resilience Council as the government's peak body responsible for developing and coordinating emergency management policy and strategy and overseeing its implementation
- Reducing more than forty government committees involved in emergency management down to four
- A volunteer consultative committee called the Volunteer Consultative Forum to give volunteers direct input into the reform process
- The statutory role of Inspector General for Emergency Management will be established to review and monitor performance of Victoria's emergency management arrangements.

viii http://www.premier.vic.gov.au/media-centre/media-releases/5633-coalition-government-unveils-vision-for-emergency-management.html <http://www.premier.vic.gov.au/media-centre/media-releases/5633-coalition-government-unveils-vision-for-emergency-management.html

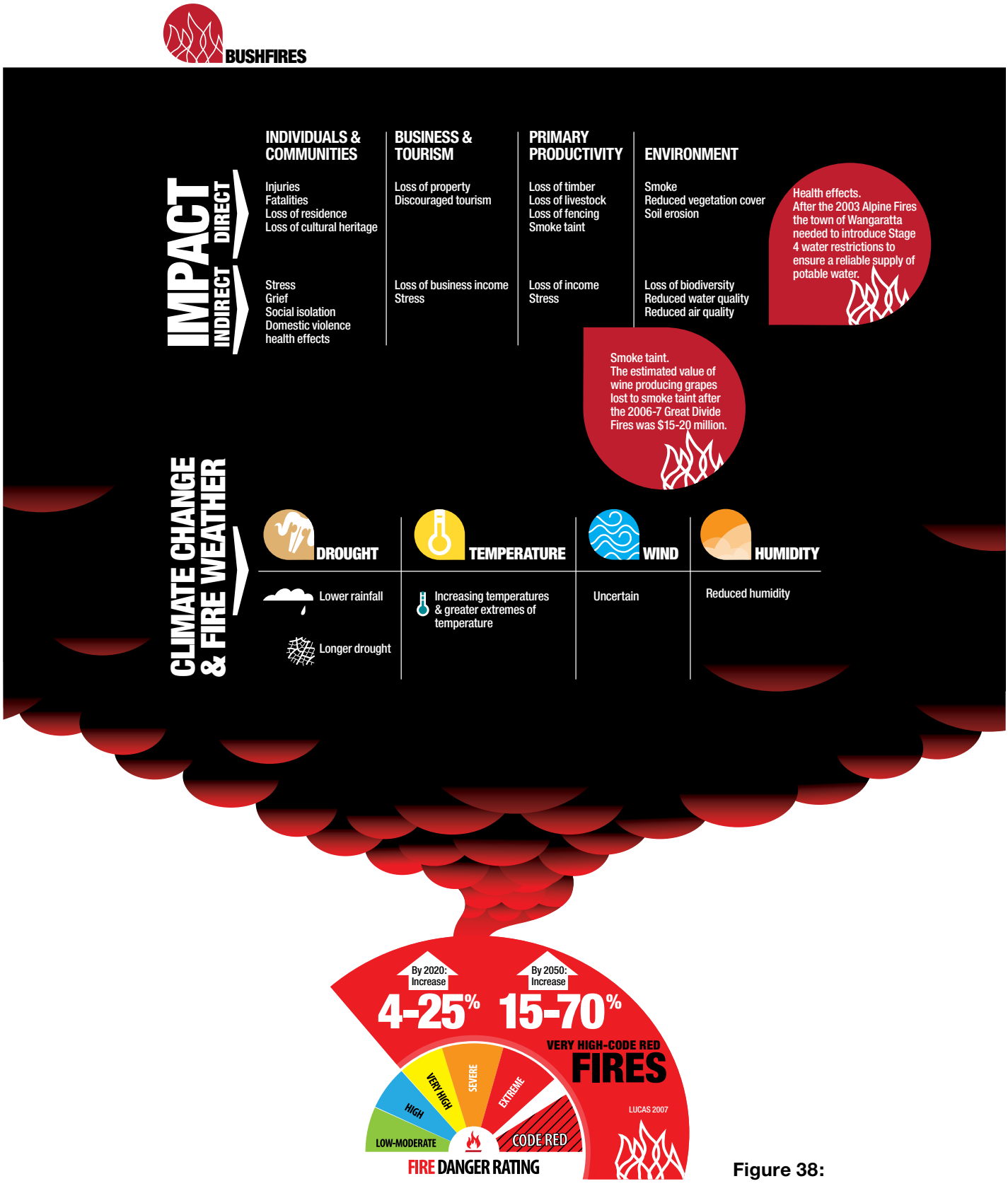


Figure 38:
Climate change increases bushfire occurrence and severity.
Source IPCC, Bushfire CRC, CFA and CSIRO. CfES developed infographic.

Rising temperatures, decreased water availability and increased atmospheric CO_2 may be working in opposite directions to influence fuel growth depending on local climate and dominant plant species.

Fire ecology

Managing fire in our ecosystems is not easy.

Bushfire is a natural phenomenon that plays an essential role in the ecology of the continent, causing profuse germination and flowering by many plant types.[203]

Eucalypts have evolved rich in flammable waxes and volatile oils. Some Australian species will only regenerate after fire destroys the host forest area.[204]

Although fire is integral to the Australian landscape, its cyclical frequency in the forests and shrublands of south-eastern Australia is about 14-40 years[205] but can occur at intervals of less than 10 years.[206]

Plant species that provide fuel for fires vary widely across the state and ecosystems are highly diverse. As such, burning (either natural or managed) that is more frequent than historical cycles may effect ecosystem functioning and biodiversity in complex ways.[207]

Similarly, the role of climate change driving changes in fire ecology is impossible to predict with certainty.

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

Rising temperatures, decreased water availability and increased atmospheric CO_2 may be working in opposite directions to influence fuel growth depending on local climate and dominant plant species. This means that changes in fuel availability will be specific to ecosystems and local climate and difficult to predict at a large scale.[208]

Fire and communities

Our planning efforts also grapple with the level of complexity which plays out in this environment.

The *Fire Danger Rating Scale* calculated to reflect a combination of factors - high temperatures, strong winds and dry fuel - is familiar and signals “Fire Weather”.

Ratings are based on the Forest Fire Danger Index (FFDI) or Grassland Fire Danger Index (GFDI) which summarise weather conditions and fuel dryness. An artefact of the 1960s, the index was never intended to exceed a rating of 100. The Black Saturday conditions produced values of up to 200.[209] On Black Saturday these weather conditions and high fuel load meant that fire spread rapidly and unpredictably after ignition, often exceeding the capacity for containment.[210]

The response to our now elevated understanding of the risk of fire was to introduce a ‘new’ category of risk, *Code Red,* for potentially catastrophic fire-risk days (Figure 39).

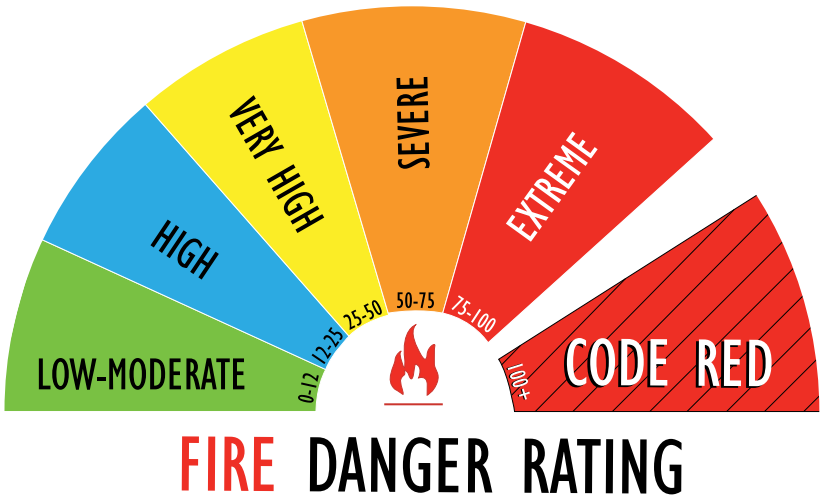


Figure 39:
Fire Danger Rating.
Source CFA**.**

On the new risk wheel, conditions rated as “extreme” and “code red” (ratings in excess of 100 FFDI or 150 GFDI) are hot, dry and windy. If a fire starts and takes hold on such a day, it is envisaged that it will be uncontrollable, unpredictable and fast moving.[211]

5.2 The complexity of impact

Losses felt in the aftermath of bushfires are often expressed in financial terms and, sometimes, in social impacts.

This unnecessarily narrows the potential impacts. The consequences of fires are wide-ranging, stretching well beyond the purely financial or human centred.

Environmental Impacts

Environmental impacts include immediate and short term reductions in air quality. Water quality, both potable and commercial, is also adversely impacted. Soil erosion can result from the denuding of the landscape, and whilst rainfall events might be welcome they will only exacerbate this problem by polluting catchments. Biodiversity losses are clear and often reported.[212] It has also been suggested that the loss of wildlife corridors can adversely impact biodiversity, in particular vulnerable or threatened species.

Human Health Impacts – water quality in large and small townships

Bushfires have a high capacity to disrupt drinking water supplies across Victoria. The negative impacts on drinking water supplies usually manifest themselves in two ways. Firstly, the fire destroys treatment or distribution assets, which disrupts a water corporation’s ability to treat raw water to a drinking water standard, and/or distribute treated drinking water to customers. Secondly, the fire negatively impacts on the catchment areas from which the raw water is harvested. Fires in catchment areas usually lead to a deterioration in the quality of the raw water, which may result in the water being unable to be treated to a drinking water standard.

Rural and regional drinking water supplies in Victoria are managed by regional water corporations. They have the responsibility of ensuring that their customers have access to safe drinking water. In the event of a bushfire affecting drinking water quality, the affected water corporation will provide advice to its customers. This advice may consist of advice to either boil the drinking water prior to consumption, or not to use the water at all, or putting customers on restrictions to conserve the available supply of treated water, as happened at Kilmore after the Black Saturday bushfires. If the water is not safe to consume, even after boiling, the water corporation will organise an alternative supply of drinking water.

The impacts of large scale bushfires on drinking water supplies have been experienced for many years after the fires have been extinguished, as in some areas of the state, raw water quality has changed markedly, and semi-permanently, after fires. This has required water corporations to invest in new infrastructure, to help manage ongoing risks to drinking water quality.

Townships may find it necessary to introduce water restrictions following fires, due to soil erosion.[213] Erosion changes the chemical properties in soil, and releases increased levels of nutrients, metals and toxins into surrounding waterways causing reductions in water quality.[214] These effects may not be felt until long after the fire itself and can exacerbate other environmental stresses.

In 2006, bushfires at Mt Lubra in the Grampians destroyed large tracts of the catchment, but the critical impact on water resources was avoided until the major floods of January 2011 washed large amounts of ash and debris into Lake Bellfield - the principal source of town water for Horsham in the Wimmera. Water quality in the region is still adversely impacted in the Wimmera Mallee region.[215]

Concerns about catchment degradation are real and widespread. The Thomson River catchment to Melbourne's east supplies 36% of Melbourne's reservoir water and serious impacts were narrowly avoided on Black Saturday.

Broader social impacts

Social impacts will be broad and profound. Immediate health impacts occur from direct exposure to fire and smoke.

Bushfire conditions also heighten stress. Mental health issues are regarded as a significant by-product of many of the physical manifestations of climate change events. Extreme events like floods have mental health consequences, as does the long attrition involved in protracted dry weather events like drought.

Over 2,000 homes were lost during Black Saturday with devastating consequences, not just to life and property.

In such circumstances people are driven to seek temporary accommodation beyond their communities. Social networks and the social cohesion which we know promotes better responses to climate change impacts are destroyed. People have to contend with social isolation and with feelings of loss and grief.[216]

Family violence reportedly increases after natural disasters[217] and research is currently underway to determine the correlation between fires and relationship violence in Australia.[218]

Quantifying losses – financial

Financial loss and costs of severe bushfires, again a partial narrative, will be significant after fires.

Scholarship out of the East Melbourne based Bushfire Cooperative Research Centre (CRC) and RMIT University has assessed in detail the economic impacts of five major bushfires, by assigning financial values to environmental and social impacts and combining these with directly measureable financial losses (Figure 40).[219]

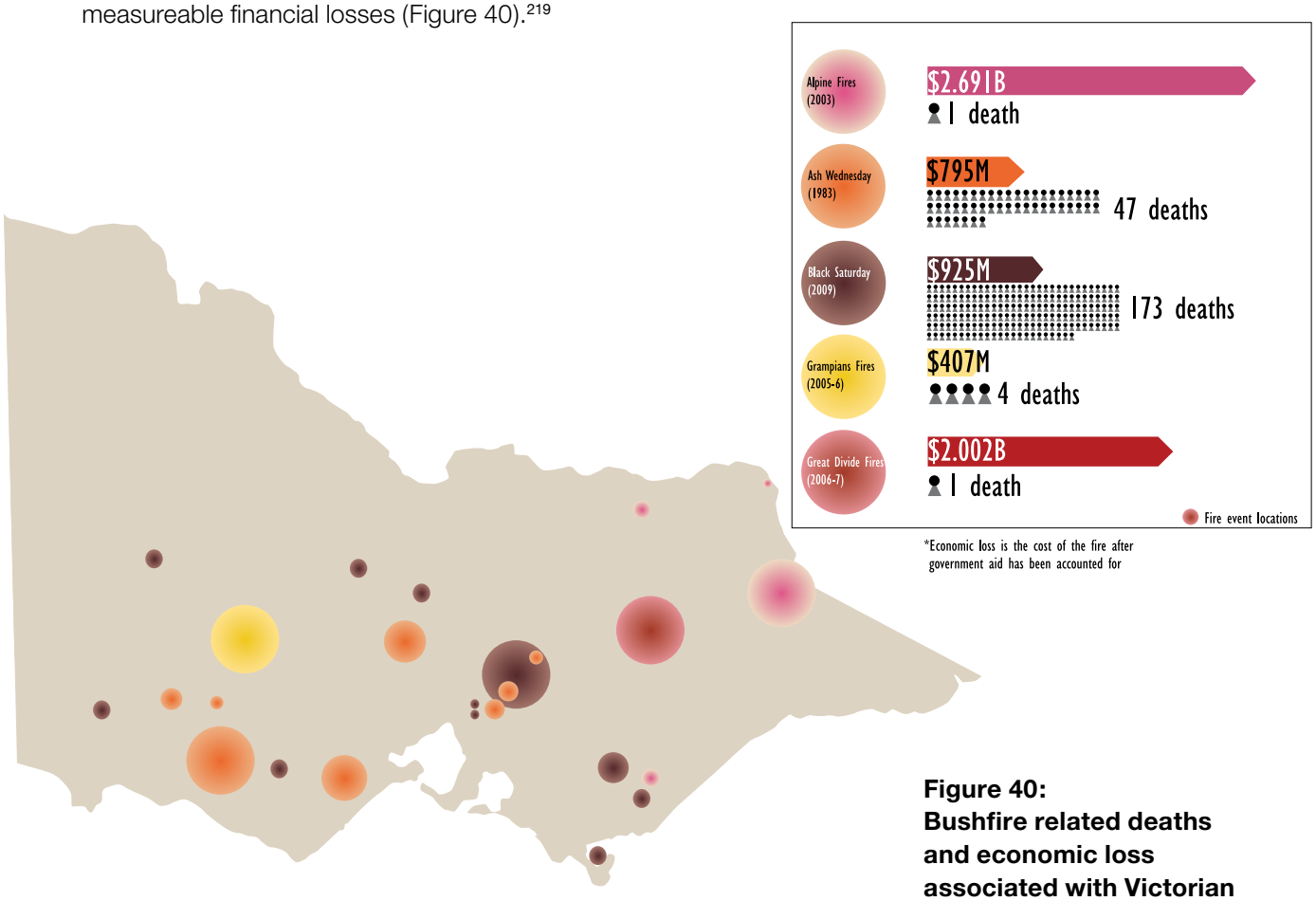


Figure 40:
Bushfire related deaths and economic loss associated with Victorian fires.[220]
Source Bushfires CRC, CfES developed infographic.

Primary production is the major loss and comes in the form of agricultural assets (including buildings and fencing), loss of crops, harvestable timber and livestock.

Other substantial financial losses include the impacts on small business and tourism. A $200M downturn in tourist activity occurred in the northeast of Victoria and in Gippsland in the aftermath of the 2006-07 bushfires.[221]

In addition to the losses expressed in monetary terms, we also need to be cognisant of the 'value' we as a community place on social losses such as disruptions to households and communities and the reduced health of individuals. Some of the greatest losses during these events were associated with the environment, such as impacts to biodiversity and the quality of our air and water.

Seasonal indices are useful in analysing past fires and determining fire links with climatic conditions.

5.3 Bushfires in a changing climate

As well as assessing day-to-day risk or severity of fire weather in the State, the Forest Fire Danger Index (FFDI) provides an indicator of seasonal severity. It does this by summing up the Forest Fire Danger Index for every day in the fire season.

Seasonal indices are useful in analysing past fires and determining fire links with climatic conditions.

To inform this process DSE has compiled a dataset that begins in 1901. The data records the severity of each fire season and plots it against long-term climatic data, such as temperature and rainfall anomalies.

We know that during the 20th century, Victoria experienced a number of decade-long wet and dry periods.

Dry periods and fire risk – fires are happening more often

Dry periods result in large expanses of dry fuel and frequent fire weather.

The Millennium Drought lasted 13 years and is our most recent exposure to such conditions.

During these unprecedented dry conditions, Victorians experienced a string of severe fires, culminating in Black Saturday in 2009.

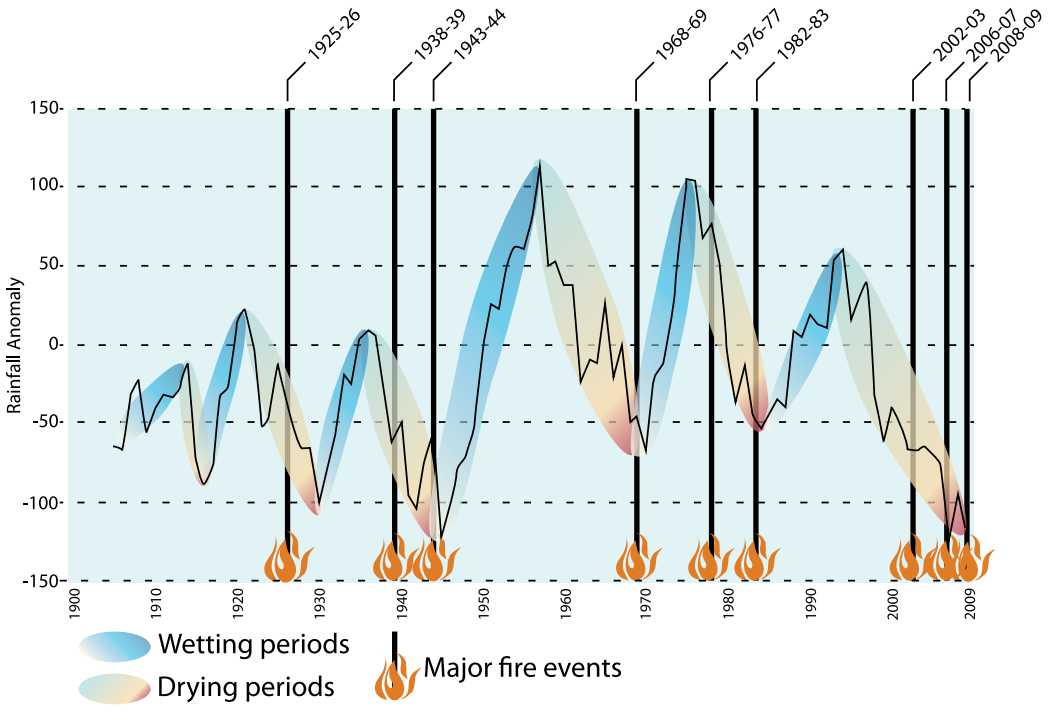


Figure 41: **The historic rainfall anomaly showing wet and dry periods between 1901 and 2009 with major fire events.** Source Department of Sustainability and Environment.

Severe fire seasons occur when rainfall decreases after heightened rainfall events have provided conditions in which fuel accumulates. So, the rainfall first provides the conditions in which a fire will later occur (Figure 41).

The data suggests fires are getting worse

The indices can also be used to analyse how the frequency of fires of different severity has changed over time and how the level of frequency might change in the future.

To determine this, each of the fire seasons on record was classified according to its impacts using the graduated scale: non-significant, important, serious, major and catastrophic.

Historically, the severity of fires has followed a predictable pattern.

Non-significant fire seasons were frequent - on average every second year since 1900.

Major and catastrophic fires have been rare, occurring in about 14 out of 100 years.

If we assume that the last 15 years of climate are more representative of future climate than the entire 20th century record, we see that the severity of fires In Victoria has changed in the period 1995-2009, when these events are compared to our complete record (Figure 42).[222]

When the indices data are analysed in more recent periods, it becomes clear that non-significant seasons are becoming rarer. Almost every season can be categorised as having produced fire events which can be described at least as “important”.

More concerning, the analysis of the data prompts the conclusion that “serious” and “major” fire seasons are becoming much more common.

This analysis of the data suggests that even though the number of fires may not have changed, their impacts are presently (and, upon extrapolation, in the future) expected to worsen.

It is anticipated that an increase in ‘serious’ - ‘major’ seasons may be more likely. Further - and of concern to planners, environmentalists, land managers, health professionals, governments and the general public - seasons with no significant impact may become a thing of the past.

More concerning, the analysis of the data prompts the conclusion that “serious” and “major” fire seasons are becoming much more common.

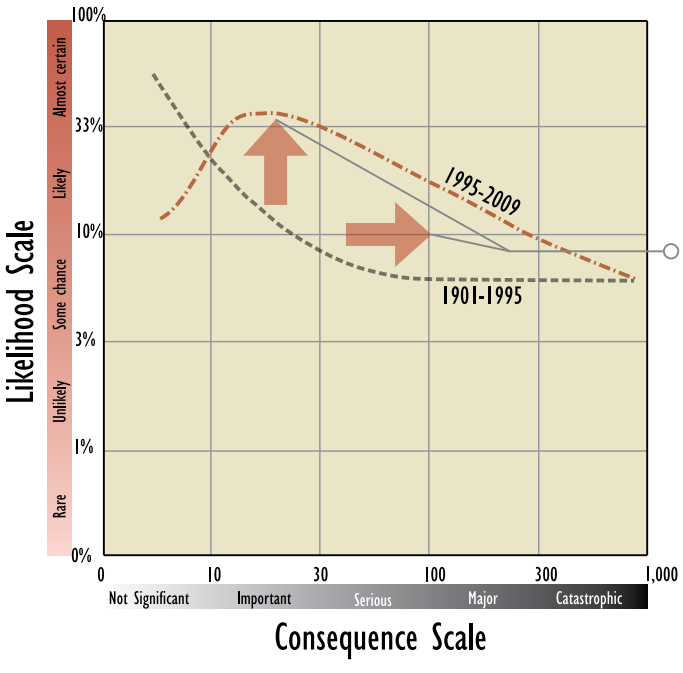


Figure 42: Analysis of the occurrence and severity of bushfires in Victoria during the periods 1901-2009 and 1995-2009. When compared to the 20th century, recent years have seen an increase in occurrence of loss-causing fires. Source Department of Sustainability and Environment.

Climate change and the danger of fire

It is self-evident that the severity of fire seasons is closely linked with low rainfall and soil dryness. Climate change, in our country, is suggested as a key driver of these conditions.

CSIRO projects from its own and other data that drier conditions will become more common in Australia in the coming years.[223] Associated with these conditions, it would appear that fires are more likely to be ignited by lightning strike connected to increasing storm activity.[224] The implication of these climatic projections, based as they are upon scientific analysis, is that the discernible trend of increasingly severe fire seasons is likely to continue (Figure 43).

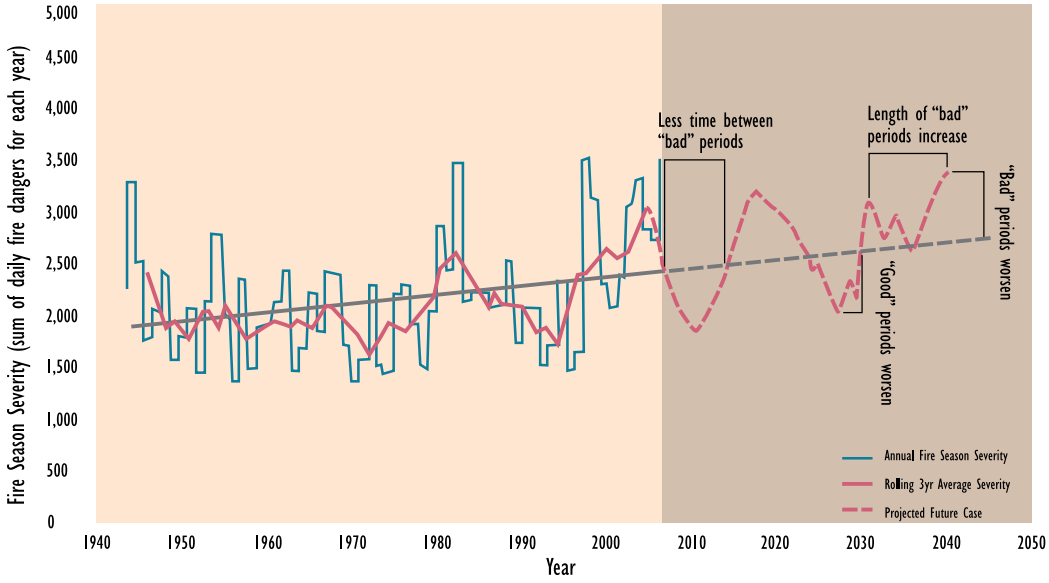


Figure 43: The trend in fire severity in Victoria shows an increase. Source Department of Sustainability and Environment.

Expressing this shift in fire danger by reference to the index rating tool, the number of days with Forest Fire Danger Index ratings of greater than 25 may increase across a range of 4-25% by 2020. By 2050 the range of increased risk may be 15-70% (Figure 44).[225]

The relationship between climate and bushfires fire is complex. This means that relatively small changes in temperature and rainfall have the potential to lead to large effects on the occurrence, intensity and impacts of fire. Such uncertainties call for robust planning approaches which recognise the implications of inaction.

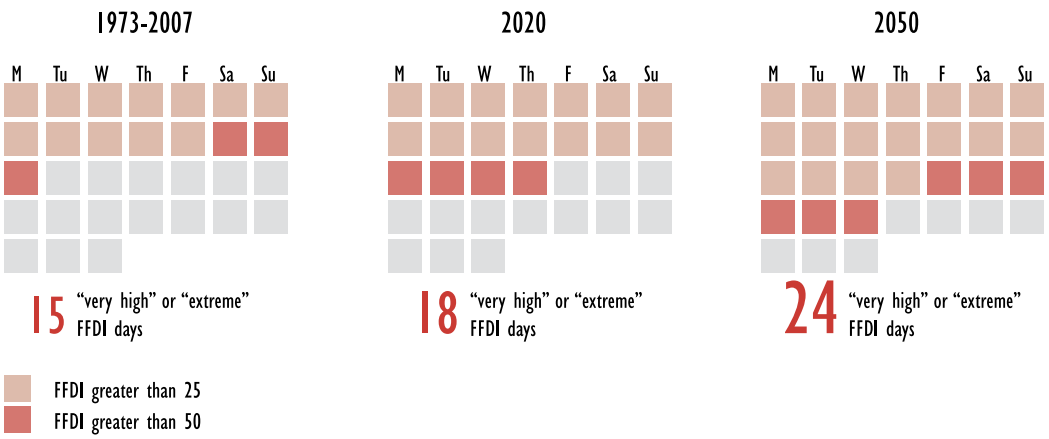


Figure 44: Projected increase in fire weather conditions in 2030 and 2050.[226] Source Bushfire CRC, CfES developed infographic.

5.4 Bushfire risks in Victoria

Can we reduce fire impacts?

The VBRC recommended that the planning and building systems more explicitly respond to bushfire considerations. Central to this is ensuring that the necessary regulatory responses are triggered by an accurate assessment of the bushfire hazard according to criteria based on the best available science. Such mapping is the important foundation for ensuring that the existence of a bushfire hazard is explicitly recognised and that the appropriate risk assessments, through either a planning or building system response, is undertaken.

The approach above is now being taken forward, with updated mapping being prepared and extensive regulatory reform in both the planning and building systems being implemented in 2011. Such reforms reinforce the way in which planning and building can reduce the impacts of bushfire on human life, property and community infrastructure.[227]

Controlled burning

'Controlled burning' is often recommended as the most appropriate method of reducing the number of extreme fires.[228]

Successive state governments have committed to burning 5% of public land annually, as was recommended by the VBRC. Regardless of the political persuasion of the administration driving the target this plan has drawn criticism as arbitrary and inappropriate to the needs of many local communities and ecological systems. The final report of Bushfires Royal Commission Implementation Monitor recommended that this target – based solely on hectares burnt – be reviewed. The report commented that "a true test of the effectiveness of the planned burning program is the extent to which the severity of bushfire is reduced in high risk areas and bushfires are more manageable in these areas" and advocated that risk reduction, rather that area, be used to define controlled burning targets.[229]

Given the likelihood of increasing occurrence of fires in the future, identifying risks from extreme fires, both to communities and ecosystems, and reducing exposure where possible, is crucial.

Reduction of exposure

Reductions in exposure lessen impacts and this need is being met by land buy-backs and the prevention of building on at-risk sites.[230]

Evidence indicates that 92% of house loss occurs within 150 metres of the bushfire hazard. Beyond this area house loss can also occur from long distance embers[231] affected by extreme weather and fire behaviour. In Victoria there are new rules about clearing and maintaining defendable space around buildings.[232]

Evidence indicates that 92% of house loss occurs within 150 metres of the bushfire hazard.

Unsurprisingly, severity of fires has been observed to be strongly correlated with greatest losses [233] including biodiversity losses (e.g. the Grampians, and Great Dividing Range fires).[234] Bushfire management, including controlled burning, can reduce fire severity, reducing the exposure of communities and ecosystems to code-red fires and their attendant impacts. However, this needs to be sensitive to local ecological requirements and their natural burning regimes, which will often be much longer (decades rather than years) than the timed target burns currently being imposed.

Responses seeking to minimise fire ignition and intensity through active land management, for the protection of biodiversity will be discussed in greater detail in the *Victorian State of Environment Report (2013).*

Identifying risks

Identifying fire risks is essential for planning for the future.

Victoria is quickly moving to a more consistent and streamlined identification of the bushfire hazard for the purpose of regulatory planning and building responses. In line with recommendations from the VBRC, updated criteria based on the best available science and applied consistently by skilled technicians forms the basis for updated mapping in the planning system (Bushfire Management Overlay) and the building system (Bushfire Prone Area).

Unlike many other hazard-based mapping products, mapping in the planning and building systems are readily available on publically accessed websites and provide State-wide information. This is owing to the effect they have on property rights and people's entitlements to develop their land. This also means that planning and building systems are often taken as proxies for other systems and processes, particularly those that seek to identify risk rather than hazard.

Mapping the bushfire hazard according to consistent criteria that responds to the purpose of the map (in this case, triggered regulatory response in the planning and building systems) provides a firm basis for regulatory systems to consider risk as part of the development approval process (either a building permit or a planning permit).[235]

The approach in Victoria provides for three tiers of bushfire hazard identification:-

- Low – No building or planning response.
- Medium – Building system response only.
- High – Planning system and building system response together.

This tiered approach ensures that the regulatory tools available are tailored to the hazard.

Consistent with the recommendations of the VBRC, updated mapping has been accompanied by regulatory reform to the Victoria Planning Provisions, planning schemes and the building regulations. These make much more explicit the policy response to the different levels of bushfire hazard identified in the mapping, the risk assessments which must be undertaken, and the impacts this has on securing more fire-resilient development.

The State Planning Policy for bushfire (Clause 13.05 of planning schemes across Victoria) explicitly requires that the bushfire hazard be identified on the basis of the best available science. As this science improves, including in relation to the impacts of climate change, the regulatory systems will need to be responsive.

The VBRC delivered the basis for improving the capacity to protect life and property and respond to future fire events. The next challenge is building on these far reaching reforms to incorporate amplified risks due to climate change factors.

Responding to the VBRC, the Victorian Government has released maps of newly classified Bushfire-Prone Areas (BPAs). As these are defined by the presence of flammable vegetation, they cover approximately 80% of the state. The BPA scheme is a tool for applying fire regulations and is not intended to inform the public about present day or future projected, climate propelled fire risks.

The public can access a web interface which maps the proximity of homes to bushfire prone areas and refuge areas. This mapping of bushfire-prone areas is a valuable tool in making planning decisions.

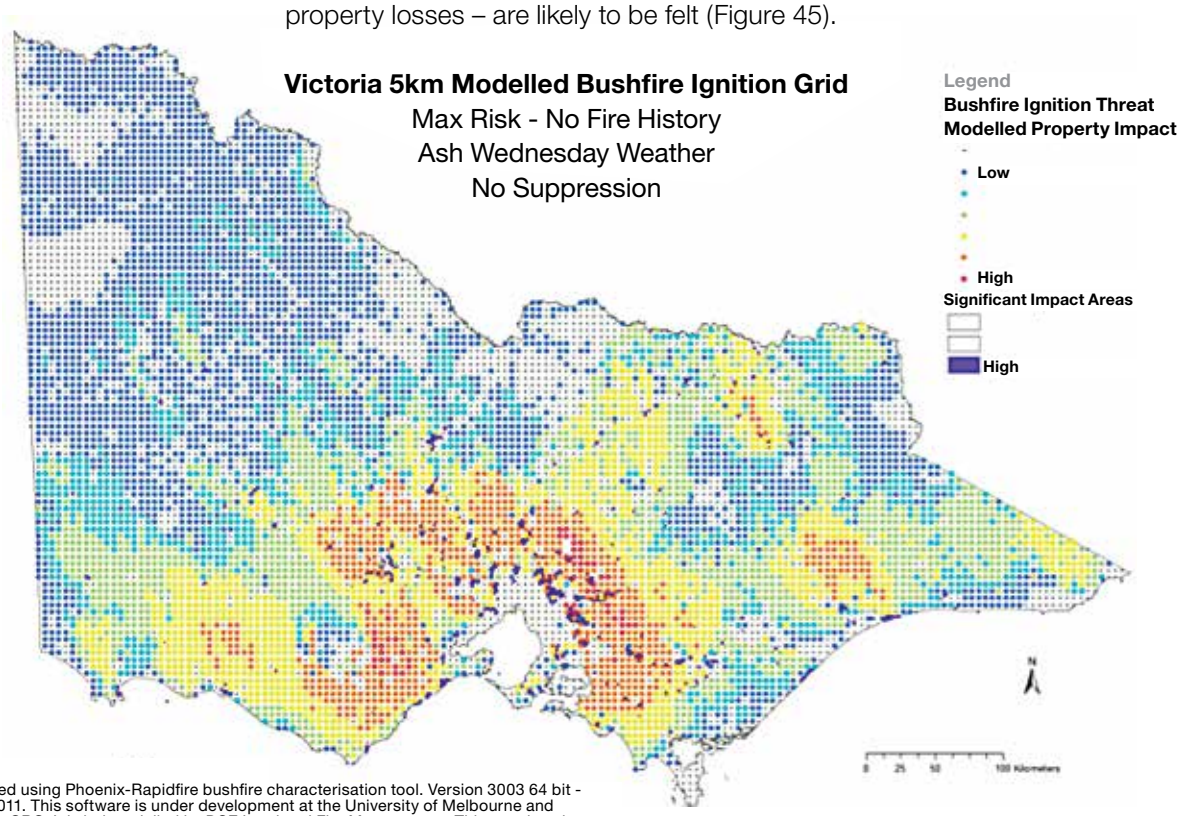
Landowners or developers seeking to construct new homes in designated bushfire-prone areas now need to meet new regulations in order to build.[236]

The public can access a web interface which maps the proximity of homes to bushfire prone areas and refuge areas. This mapping of bushfire-prone areas is a valuable tool in making planning decisions.

Comprehensive risk mapping in Victoria

DSE has used the bushfire characterisation model Phoenix-Rapidfire to model the location of areas at greatest risk from code-red level bushfires, assuming that there is no fire management regime in place.

This reveals where the most significant impacts – defined here as property losses – are likely to be felt (Figure 45).



Produced using Phoenix-Rapidfire bushfire characterisation tool. Version 3003 64 bit - 7 Apr 2011. This software is under development at the University of Melbourne and Bushfire CRC. It is being trialled by DSE Land and Fire Management. This map is only suitable for broad level planning use and should not be used for local level planning.

Figure 45: Map of broad, relative bushfire threat or risk landscapes across Victoria. Source Department of Sustainability and Environment.

This work is invaluable for public awareness and education to ensure understanding of the risk to life and property from bushfire. It would compliment more detailed specific purpose mapping including those used in regulatory systems.

The benefits to Victoria of DSE research into fire regimes have been demonstrated in a pilot project focusing on the Otway region.[237] This pilot has evaluated how fire management options affect outcomes for community protection, biodiversity and water. Although further research is still needed to validate model outcomes, this is providing crucial insights into setting priorities when weighing up competing demands and managing for several objectives. Such insights will be vital when engaging with communities to set priorities for risk reduction.

Initiatives of this nature are also vital in moving beyond the purely responsive management of fire impacts towards rigorous testing of management strategies under a range of conditions and building capacity to engage in adaptive management. Although climate change scenarios are not explicitly included, it is possible to incorporate these events into decision making processes to progressively incorporate greater resilience into our fire planning and response capacity as our knowledge of changes in climatic features develops.

National Data Grid

Although it is relatively simple to quantify potential fire loses in terms of burnt properties, less tangible impacts are harder to include and local community values are absent from the current mapping of Victorian bushfire-prone areas.

An approach that will allow greater integration of these values into risk assessments is the planned inclusion of fire-risk planning into the proposed National Data Grid (NDG). The NDG, hosted in Carlton by the Cooperative Research Centre for Spatial information (CRC SI) seeks to provide an Australia-wide platform to integrate data from numerous providers across the country and create a portal through which users can combine and interrogate data.

Further, and in our own region, as part of its fire management planning, the Emergency Services Commission, Victoria, has created a Consequence of Loss database that maps economic, infrastructure and environmental assets that are prone to fire damage.

Using this database, areas containing high-value natural and built assets can be identified using consistent criteria.

These data were originally intended to be made available for use by local planners to identify assets that are of high value in local emergency planning (for example, timber bridges that act as a sole transport link for a community). However, before this system could be implemented the Black Saturday fires occurred and the project was not completed as planned.

The Emergency Services Commission now intends to integrate this database into the proposed National Grid to create consistent data inputs to mapping areas of high value (and therefore high risk) from natural disasters.

Although it is relatively simple to quantify potential fire loses in terms of burnt properties, less tangible impacts are harder to include and local community values are absent from the current mapping of Victorian bushfire-prone areas.

Instructive international and other national examples of fire risk communication

Approaches that include educating those at risk to better understand their risk exposure, communicating the messages with more clarity and more forcefully and measuring community values are being pursued in several jurisdictions around the world.

USA

In the southern USA, the Southern Wildfire Risk Assessment (SWRA) project is being used to communicate bushfire risks for 13 states.

This initiative identifies those areas most prone to fires and provides several risk output metrics. These metrics are focused on identifying those areas where mitigation measures will be of greatest value and should be prioritized.

Moreover, the outputs from SWRA are used as a tool to facilitate communication with residents to educate and address community needs and priorities. Many southern states use the SWRA results for local government agency partnerships for both mitigation planning, prevention and outreach.

This portal offers a much higher resolution of fire risk than a straightforward presentation of the presence of flammable vegetation.

In Texas, the initial SWRA has been updated and deployed using a web mapping application called the Texas Wildfire Risk Assessment Portal, or TxWRAP (tex-rap). TxWRAP provides several custom geo-web and geo-mobile applications that provide easy access to the risk information for mitigation and prevention planning. The applications have been built for non-GIS users (including the public) and providing analysis capabilities for analysing risk data for specific project areas. The suite of applications are focused on state and local government fire agencies usage, and are a primary mechanism for the Texas Forest Service to create awareness, educate the public, and empower ranchers and agencies with proactive fire planning.

This tool enables the assessments generated by the State of Texas to be presented to members of the public and local agencies via a web portal that allows users to view risk levels at high resolution.

The primary drivers for this work were demands for a formal regulatory process using risk assessment as the primary mechanism for mitigation and to provide a relatively simple mechanism for local planners and fire managers to access and assess this information.

Figure 47 is an example output from this portal. The Public Viewer application provides a tool that helps local homeowners determine their risk, providing general mitigation guidelines, and connecting them to a local planner where they can get more detailed information. This is referred to as the *What's Your Risk?* tool.

This portal offers a much higher resolution of fire risk than a straightforward presentation of the presence of flammable vegetation.

This level of detail aids more rigorous planning by both communities and resource managers.

TxWRAP was released in April 2012. In the first three months the site has had high usage and traffic and has helped the Texas Forest Service forge partnerships with many other Texas agencies, fire departments and private landowners in establishing mitigation and prevention programs that were not possible before. Enhancements to the site are underway to provide more applications focused on specific planning priorities and business requirements.

Figure 46: Screenshot of the TxWRAP portal.[238]

This model contains an explicit consideration of values that will be affected by fires to assess risks.

So, high-risk areas are defined not only by the likelihood of severe fires but also reference a grading of loss exposure.

Potential fire impacts are assessed in terms of damage to agriculture and infrastructure and penetration of fire into urban areas.

Similar projects have been carried out in many fire-prone jurisdictions in the USA where agencies have worked with consulting firms to identify high-risk zones that incorporate community values which extend beyond straightforward property and financial losses. GIS analysis and web portals are routinely used to improve public access to the information.[239]

Parks Tasmania

Closer to home, Parks TAS have developed a similar risk assessment model that integrates fire likelihood with metrics of consequence.[240]

This expands on SWRA because, alongside agricultural and infrastructure losses, it includes the impact of fire on ecosystem components (flora, fauna and water) and cultural heritage, enabling the community to define consequences of fire that are aligned with their own values and develop risk mitigation measures accordingly.

Planning and education

Victoria is home to world class expertise in identifying and assessing bushfire risks in a changing climate. As this capacity to identify high-risk, and climate change exposed areas increases, options for retreat and adaptive planning will need to be clearly explored and explained to the public.

Controlled burning, when guided by appropriate risk management is an important tool to reduce fuel loads and the intensity of naturally occurring bushfires but should not be used in isolation. An integrated approach to reducing risks from fire also includes government intervention to reduce exposure in the highest risk areas (for example, planning regulations or the current relocation policy) and public education.

In at risk areas there needs to be greater engagement with communities across the whole spectrum of issues – from readily understood and immediate fire risk to climate change exposure and eventualities.

At present, Victoria uses the *Prepare, Act, Survive* approach in which householders must decide to either invest in the resources to defend their property during a fire or leave well before a fire starts. As part of this, the CFA advise that homes will not be defendable during a Code Red fire.

As peri-urban areas expand, and some people choose a rural lifestyle setting, the exposure to bushfire risk can be increased. New residents can be unfamiliar with the environmental context and hazards associated with non-urban locations. These populations can become increasingly vulnerable to fires.[241]

As well as reducing exposure wherever possible, through regulation and planning and building controls, we need to deliver coordinated education and training for those choosing to live in high-risk peri-urban and bush areas.

A policy of this nature is only appropriate when communities are capable of identifying fire conditions, and anticipating likely conditions for a Code Red fire - when they are empowered to act autonomously and respond appropriately to minimise loss of life during fires. With education and training, an approach of devolved responsibility will be appropriate for the majority of fire events.

CSIRO reports that weather associated with high fire danger has shown a rapid increase in the late 1990s to early 2000s at many locations in south-eastern Australia.[242] Climate projections for a hotter and drier state, mean we should continue our efforts for fire preparedness, including support for community responses and state-wide processes to assist and protect people.

CHAPTER **SIX** - HEATWAVES

More Australians die from heatwaves than from any other form of natural disaster[243] and heat events have killed more people than any other natural hazard experienced in Australia over the past 200 years. And, heatwaves do not pass with the setting of the sun, rather we are seeing increasing instances of hotter nights.

Hot drying periods are expected to become more frequent and more intense due to climate change.

6.1 The heatwave experience

The January 2009 Victorian heatwaves (temperatures were 12-15 degrees above normal)[ix] hastened the deaths of 374 people. South Australia experienced contemporaneous heat events. Perth has experienced[x] eight heat events in the period November 2011 to March 2012. The CSIRO *State of the Climate 2012 report* says that heatwaves will be a problem of increasing frequency and intensity across the continent (Figure 48). There is a clear public policy need to formulate an adaptation plan for heat related impacts.

Beyond our own heatwave data, heatwaves internationally have contributed to large scale deaths, such as the 2003 European heatwave in which around 52,000 Europeans died, including more than 14,800 deaths in France alone.[244]

However, it is not only humans who are impacted, it is also the natural estate.

In the agricultural sector production, livestock and crop losses have long been a product of heatwaves[245] and management interventions and long-term planning is necessary.

The key public policy issue for heatwaves is to ensure our community, particularly our vulnerable members and our health systems and our urban centres, agriculture sectors and infrastructure are more resilient and/or more adaptive to heatwave conditions.

Future heatwave events

Hot drying periods are expected to become more frequent and more intense due to climate change. Increased monthly mean temperatures and also increased extremes of high temperature are expected to occur producing more frequent and more intense heatwaves.[246]

For IPCC/CSIRO scenarios where there are continuing high-emission levels of greenhouse gases, the incidence of days over 35°C is predicted to increase by around three times for Melbourne by the end of the 21st century.[247]

ix Victoria's highest temperature on record is 48.8°C on 7 February 2009.
x Prolonged periods of high temperature durations.

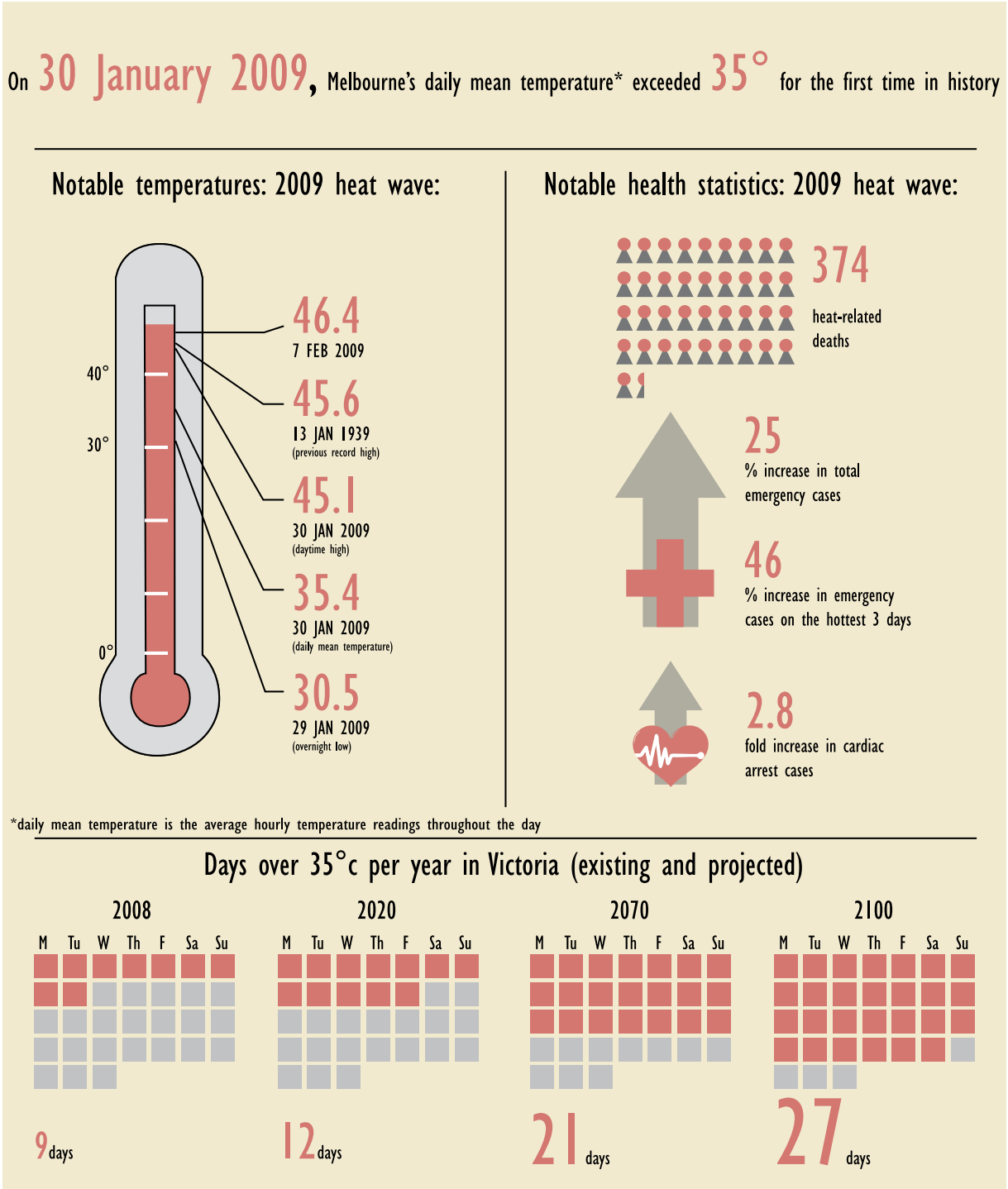


Figure 47:
Source Department of Health, CSIRO. CfES develped infographic.

This change in the climate will impact different places in different ways – as the study of heatwaves suggests is the case.

In city settings we will see the number of hot days compounded by the urban heat island effect.

6.2 Impact of heatwaves

Our cities in heatwaves

Heatwaves, including the phenomenon of increasing hot nights, in respect of which the elderly are particularly vulnerable, are intensified by the urban heat island phenomenon.

The urban heat island is created through the absorption of heat by materials such as concrete and asphalt, which in high density areas, such as metropolitan Melbourne, result in temperature increase.[248] Heat generated by energy usage also contributes to the urban heat island effect.

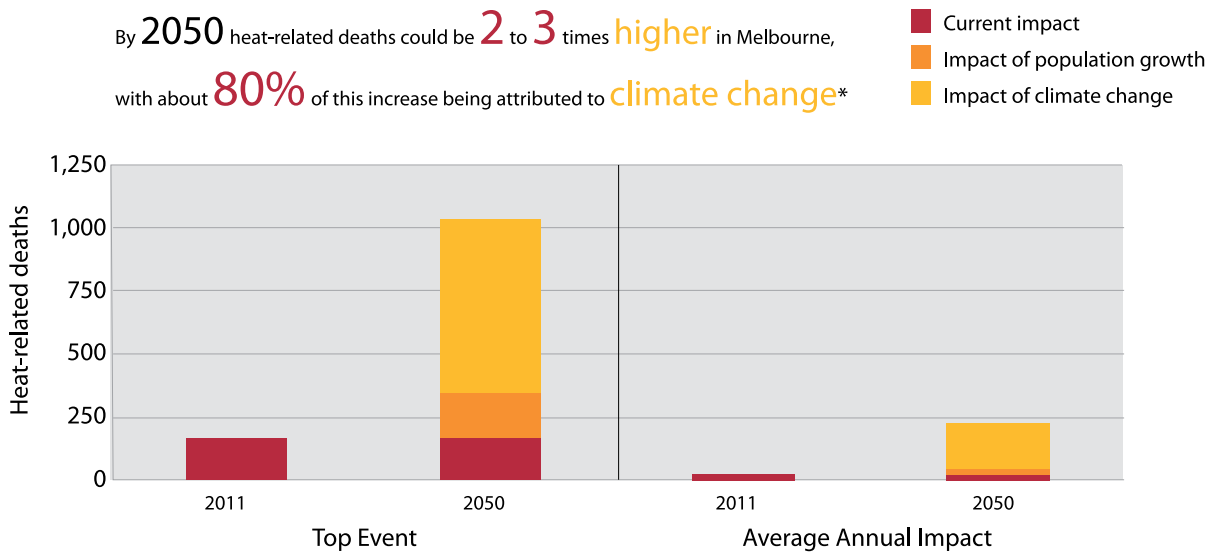
This phenomenon was first described in the early 1800's by Luke Howard a pharmacist/chemist who wrote in *The Climate of London*:

> *But the temperature of the city is not to be considered as that of the climate. It partakes too much of an artificial warmth, induced by its structure, by a crowded population and consumption of great quantities of fuel.*[249]

People in Heatwaves

Recent modelling of a 'business as usual' climate change scenario for Melbourne suggests that by the middle of the twenty-first century, there could be a death toll two to three times higher in the most extreme heat events than we have experienced to this point (Figure 48).[250]

This modelling projects that climate change will be the main contributing factor to heat-related deaths by 2050.[251]



*represents a 'middle of the road' climate change scenario, as modelled in "Protecting human health and safety during severe and extreme heat events," PWC, 2011.

Figure 48:
Price Waterhouse Coopers, Protecting Human Health and Safety during severe and extreme heat events 2011.[252]

The impact of heat on human health is not well understood. To survive the human core-body temperature needs to remain around 37°C. If the body produces or absorbs more heat than it can remove through sweating the core-body temperature will increase (Figure 49).

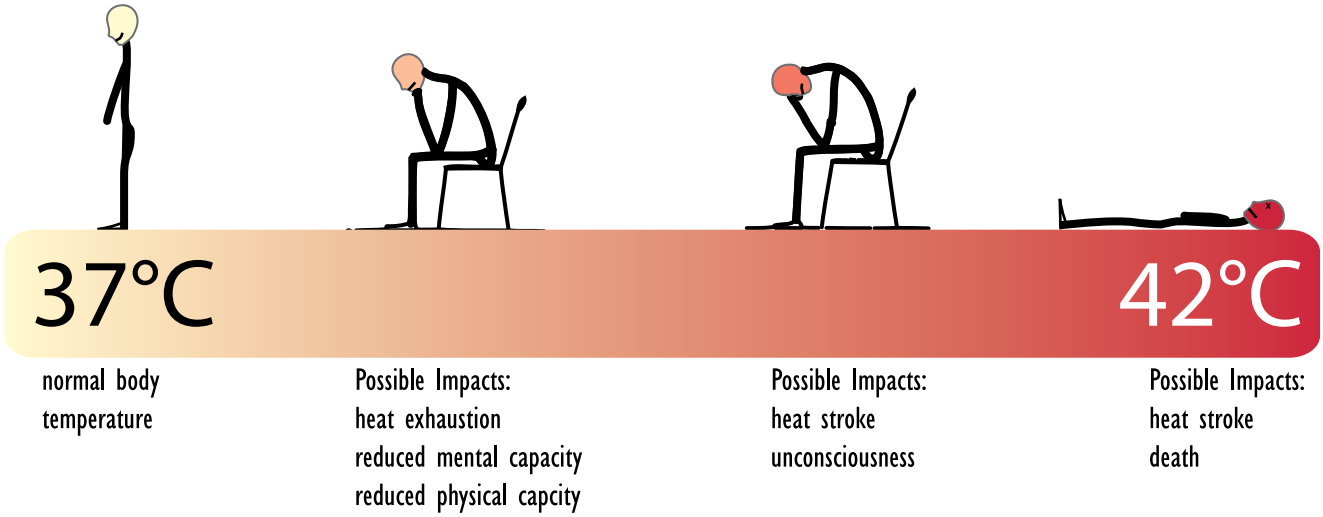


Figure 49:
Source Climate Commission, 2011.[253]

The most common causes of death seen during heatwaves are related to cardiac conditions, asthma and other respiratory illness, kidney disease, diabetes, nervous system diseases and cancer. For those people already in vulnerable circumstances – for instance those with health problems (such as people on medication or with pre-existing illness and/ or injury), older people and low socioeconomic groups – the heat only exacerbates their vulnerability.

The capacity to respond to the physical and psychological effects of heatwaves is compounded by the fact that health services are heavily impacted during heatwaves and much of the impact of heatwaves is felt at night as heat does not abate. Services including ambulance call outs, emergency department presentations, and nurse on call services receive additional requests during heatwaves to deal with heat-stress patients.

Heat related psychological affects on people

Less commonly known, is that heatwaves have been associated with psychological health impacts. Mental illness is becoming more common in Australia. In any given year, one in five Australians suffers from a mental disorder of some kind, potentially making millions of people more vulnerable to mental ill-health in an increasingly hostile climate.[254]

The emotional and psychological toll of extreme weather events and natural disasters can linger for months and sometimes years, affecting extended families, people's capacity to work and community wellbeing. Higher rates of drug and alcohol misuse, violence, family dissolution, and suicide have been marked as 'more likely' to follow more extreme weather events. Evidence is beginning to emerge that drought and heat waves lead to higher rates of self-harm and suicide - as much as 8% higher.[255] An increase in violence and anti-social behaviour is also a potential implication of heatwaves, particularly when alcohol is involved.[256] Recent studies also indicate a correlation between very hot and humid conditions and hospital admissions for facial fractures. Victoria Police have commented that they need to consider the operational implications of hotter conditions.[257]

People most vulnerable to heatwaves

Heatwaves can affect anybody, including the young and healthy. However, there are certain groups that are more vulnerable to its effects due to factors such as their age group, health, environment, social and economic circumstances, location or occupation.

During the 2009 Victorian heatwave most of the increase in mortality occurred in people aged 75 or older.[258] An analysis of heat-related emergency department data identified and assessed heat vulnerability in Victoria, showed people aged 65 years or more were significantly more likely to present to an emergency department in Melbourne with a heat-related condition than people from other age groups. Adding to this, people who have a medical condition and people taking medicines that affect the way the body reacts to heat are vulnerable to extreme heat events.

Lower socio-economic groups are particularly vulnerable to heat as they have a higher prevalence of heat related health risk factors and tend to live in some of the most heat exposed parts of the city. They also have fewer financial resources to invest in climate adaptation actions, such as the installation of air conditioning, and are more likely to live in rental properties with limited capacity to undertake building improvements. Heatwaves are also known to affect mood and psychological well being, impair concentration and make people feel lethargic. This only adds to the heat related health risk for lower socio-economic groups, further compounding the already well established link between social disadvantage, deprivation and poor health outcomes.

During the 2009 Victorian heatwave most of the increase in mortality occurred in people aged 75 or older.[258]

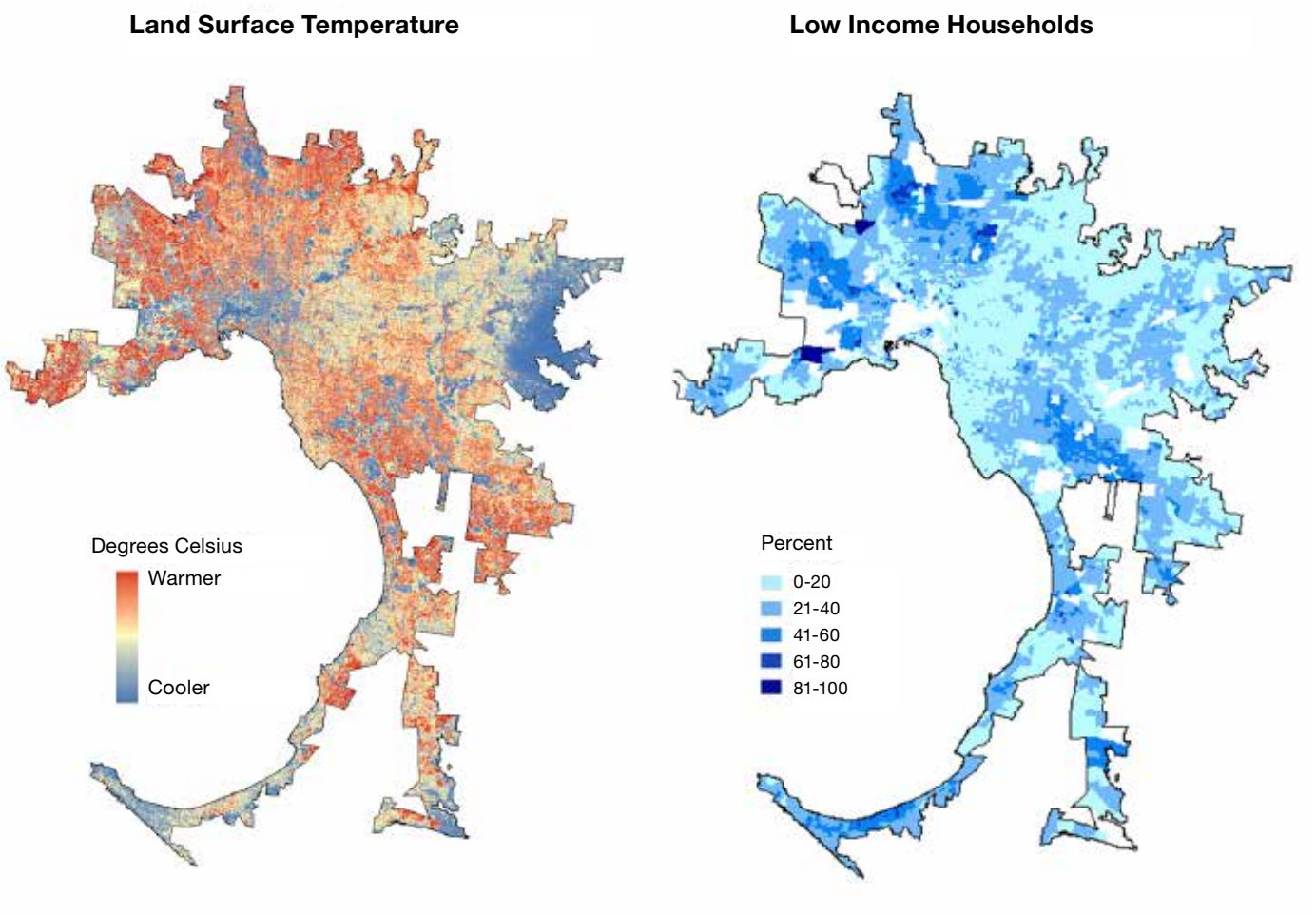


Figure 50:
Map showing land surface temperatures (LST) of metropolitan Melbourne was derived from Landsat TM data collected on 10 December 2006. Image obtained from Geoscience Australia and processed/analysed by CSIRO. Map showing percentage of low income households is based on ABS Census 2006 data and census collector districts, with low income defined as equivalised household income between $1-399/week.
Source Beaty, Matt; Barnett, Guy; Meyers, Jacqui; Spinks, Anneliese (2012). Heat vulnerability of low income households in four Australian cities. 2012 NCCARF National Adaptation Conference: Climate Adaptation in Action: Sharing Knowledge, Melbourne, 26 - 28 June 2012 . NCCARF. 1p.

Impact of heatwaves on our natural assets

Severe heatwaves can have serious impacts on the health of native species, particularly when heatwaves coincide with long periods of drought. The Victorian heatwaves in January and February 2009 resulted in the emaciation and deaths of several species including Grey-headed Flying-foxes and possums, particularly Ringtail Possums.[260] Other animals known to suffer from heatwaves include koalas and bird species. Juveniles are often at most risk from extreme heat periods.

Native flora is also threatened by heatwaves. Seedlings, in particular, are at risk from the combination of heatwaves and drought.[261] In addition, the increased occurrence of extreme events is likely to lead to shifts in the composition of vegetation and the loss of habitat.

Biodiversity loss

Whilst many Australian species are adapted to cope with occasional heatwave events, the projected increase in the severity and frequency of heatwaves is likely to have significant consequences for Victoria's native flora and fauna, with greater heat-related mortality rates expected in the future. Heatwave events resulting in high mortalities are of particular concern for threatened species already subject to a range of pressures. For example, the 2010 Western Australia heatwaves resulted in significant deaths of the Carnaby's Cockatoo.[262] The population of this endangered cockatoo has declined dramatically in recent years and such losses further increase the risk of extinction.[263]

Impacts of Victoria's 2009 heatwaves on Grey-headed Flying-fox[264]

Flying-foxes are sensitive to extreme temperatures because they tend to roost on exposed branches of canopy trees. During January and February 2009, two heatwaves resulted in the deaths of 4,868 flying-foxes from the Yarra Bend colony. This included 3,539 flying-fox deaths on 7 February when temperatures reached 46.4°C.

The mass mortality of Grey-headed Flying-fox during extreme heat events has been recorded elsewhere in eastern Australia. At least 19 other heat-related mortality events have been reported since 1994, resulting in over 24,000 Grey-headed Flying-fox deaths. This includes the death of 4,800 Grey-headed Flying-foxes after an extreme heat event in Sydney, in early January 2006. Before 1994, there were only three reported mass die-offs in eastern Australia, suggesting that these events have become more common and could be attributed to an increased occurrence of heatwaves.

Heatwave effects - agriculture

Victorian agricultural industries face a greater challenge of adapting to heatwaves than in many other parts of Australia.[265]

Figure 51:
CfES developed infographic.[266]

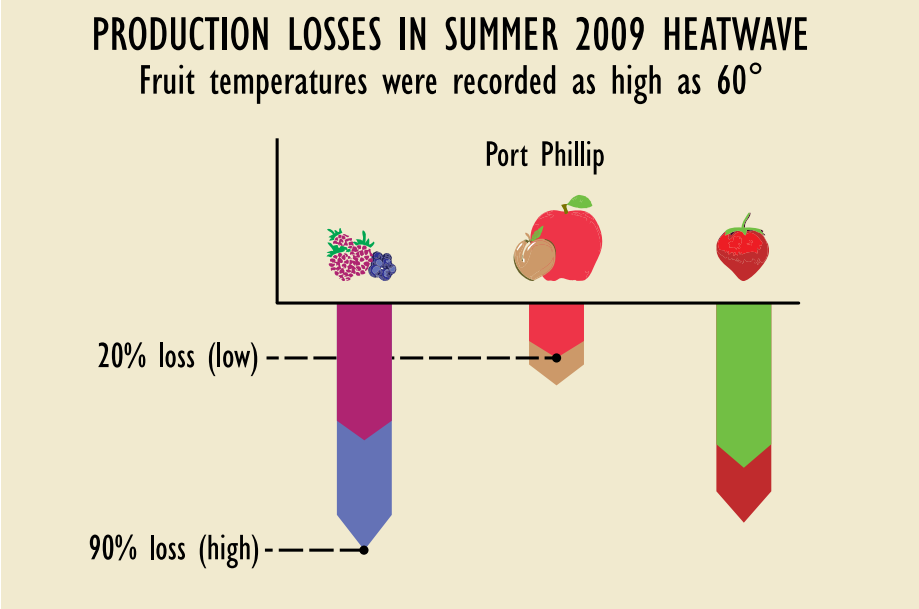
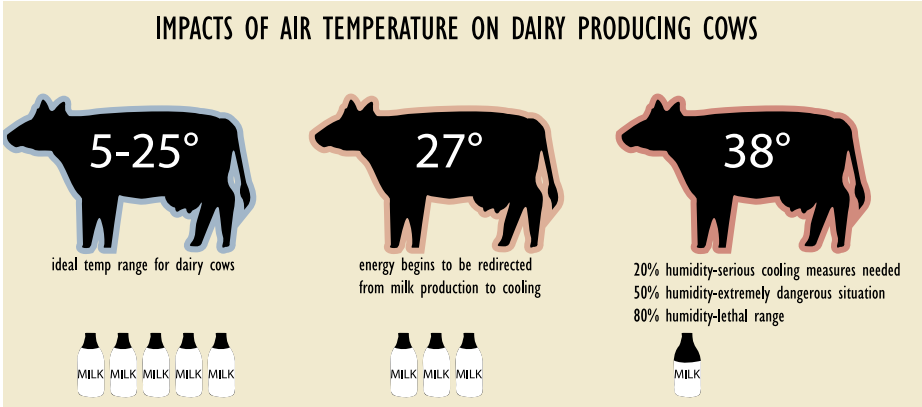


Figure 52:
CfES developed infographic.[267]



Victorian agriculture comprises cropping, beef and dairy, wool production, and a complex array of horticulture. Agriculture is worth billions of dollars to the Victorian economy and is vital for regional communities.

Heatwave intervention – livestock

Heat impacts on livestock performance, health and welfare is becoming a serious issue especially for Australian dairy farmers.[268] The effects of heat stress include a drop in milk production, reduced herd fertility and lower milk protein and fat tests. It can also trigger weight losses and create health problems (Figure 51).

Simple steps like shade and water provision in farm management practice are important for animal welfare and livestock production. Livestock production increases when they have access to shade.[269] Other agriculture management intervention methods for heatwaves include; changes to milking times, access to cool drinking water at all times, changes to paddock rotation, developing a summer nutrition program and altering mating management.[270]

Heatwave intervention – horticulture and viticulture

Crop production in Victoria includes the grain industry (wheat, barley, canola, field peas and other grains), the horticulture and viticulture industries (vegetables, fruit – particularly pome fruit, citrus, stone fruit and berries, nuts and grapes).

Extreme heat can cause crops such as wheat to age faster and reduce yields.[271]

Increases in heatwaves present challenges for growing crops in Victoria. Heatwave impacts from the Victorian 2009 heatwaves included fruit that was downgraded because of reduced storage-life and a smaller size and substantial product loss in the pear and apple industries (Figure 50).[272] On 7 February 2009 temperatures reached 46.1°C at Shepparton in the Goulburn Valley, Victoria. Growers reported losses due to apple sunburn of 30 – 70%, and some crops were not even harvested in the Goulburn Valley. Flesh of the worst affected fruit turned soft, while other fruit had sunburn patches on those surfaces most exposed to sunlight. Damage was greatest on sun-exposed fruit, where fruit temperatures of up to 60°C were recorded.

Estimates of losses in viticulture during the 2009 South-East Australian heatwave, were not always related just to the heat exceeding certain thresholds. Management practices employed in the lead up and through the event also played a part.[273] Encouraging management approaches such as good canopy growth and shading of potentially exposed fruit, is important in reducing heat damage.[274]

Cooling centres may provide residents with air-conditioning, shade and/ or water, located at various places like community centres, libraries or unoccupied schools during summer.

6.3 Innovation and development

People-centred

Heatwaves can affect anyone. Heat related illness can range in severity, from mild conditions such as rash or cramps to more serious and life threatening ones such as heat stroke. Heatwaves can also exacerbate pre existing medical conditions such as heart disease. Ensuring the community is informed, supported and protected from the health impact of extreme heat will minimise the health impacts of theses events.

Without appropriate knowledge, planning, preparation and resources, people, especially those most vulnerable, put their physical and psychological health, and potentially their lives at risk.

Heatwave intervention methods include heat health alerts and education, cooling centres, building retrofits, cool roofs and urban forests.

Heat health alerts

The Victorian Heat Health Alert System (HHAS) notifies internal and external stakeholders of forecast heatwave conditions which are likely to impact on human health.[275] Heat health alerts are activated when forecast temperatures from the Bureau of Meteorology are indicated to exceed a heat health temperature threshold or over prolonged consecutive periods of excess heat as this can still impact on health and community services. Heat health thresholds in northern Victoria are higher than heat health thresholds in the southern part of Victoria.

An alert can be issued statewide or district specific. The alerts contain information on when the temperature is forecast to exceed the threshold and the district the alert is based on. It is then expected that internal and external stakeholders respond in accordance with local heatwave plans and operational protocols to ensure safe service provision and business continuity.

The alert is sent by Victoria's Chief Health Officer via email and is also made available on the Chief Health Officer's website. The broader community can apply to receive a Really Simple Syndication (RSS) feed from the Chief Health Officer's website or heat health information via the Better Health Channel free iPhone application.[276]

Municipal councils in Victoria have developed local Heatwave Plans. The department provides resources such as the *Heatwave Planning Guide* and the *Heatwave plan review tool* to assist local councils. Most plans sit with the council Municipal Public Health Plan.

Cooling centres

Cooling centres provide an environment for residents to retreat from the heat. Cooling centres may provide residents with air-conditioning, shade and/ or water, located at various places like community centres, libraries or unoccupied schools during summer. Across Victoria a number of cooling centres have been allocated or trialled.

Beechworth Health Service has established a series of 'Cool Relief' centres across Beechworth, Yackandandah and Tangambalanga and it is anticipated that the concept will extend across the Indigo Shire.

Retrofits providing natural ventilation

In Moreland, the Kinda Cooling project is an initiative from the Moreland Energy Foundation Limited to make kindergarten buildings more comfortable, particularly in summer, using blinds on north-facing windows, fans, cross ventilation and night purging. This design reduces the reliance of air-conditioning, and is a critical step to avoid heat stress impacts associated with electricity blackouts in heatwaves (refer to the Infrastructure chapter). The retrofit is more energy-efficient and cost-saving for the community-run kindergarten than the alternative of installing an air-conditioner with high capital and on-going energy costs while also providing the benefits of a cool environment for the children during heatwaves.

Urban-centred: Cool roofs

A cool roof is one that reflects heat and emits absorbed radiation at a higher rate than standard materials.[277] Cool roof or white roof projects as they are also known – because of the white solar-reflective paint used – are becoming more popular and adopted internationally because of the many benefits they provide in reducing the heat absorption of buildings. The benefits of cool roofs include reducing the community's urban heat island effect, lower maintenance and use of air-conditioning thus reducing electricity bills and amongst other benefits cool roofs keep buildings cooler and at a more constant temperature – reducing human heat health stresses.

The Moreland kindergartens retrofit included the painting of its large tin roof with a heat reflective paint to reduce heat absorption in the building. The cool roof has contributed to the overall benefits of the retrofit. The ArtPlay building at Birrarung Marr has taken steps to reduce building heat through painting its roof white. The ArtPlay building cool roof has meant children are not sent home because it's too hot in the building and has contributed to programs being able to be run longer, benefiting the people who occupy the building.[278]

Urban forests

Urban forests are a key contributor to quality urban environments providing shade through canopy cover, improving air quality, reducing the urban heat island effect, improving biodiversity and aesthetics of the urban environment.

To future proof Melbourne's western suburbs from the urban heat island effect during the day, an urban forest project called Greening the West has been developed by City West Water. With Melbourne's western suburbs being generally hotter and drier than the rest of the city and its community being poorer in health, this project aims to minimise the urban heat island effect, improve air quality, improve the environment and health status of Melbourne's west through increasing vegetation and tree canopy cover through its suburbs.

Cool roof or white roof projects as they are also known – because of the white solar-reflective paint used – are becoming more popular and adopted internationally because of the many benefits they provide in reducing the heat absorption of buildings.

Under construction in Milan, Italy is Bosco Verticale, the world's first vertical forest, an apartment tower, with each apartment having a balcony planted with trees.

The City of Melbourne has developed the *Urban Forest Strategy* to reduce the impact of the urban heat island effect. The *Urban Forest Strategy* aims to use trees and vegetation to reduce city temperatures, day and night. The council's draft *Urban Forest Strategy* and draft *Open Space Strategy* will ensure healthier, greener and more resilient landscapes and open spaces over the next 100 years. Following more than a decade of drought, severe water restrictions and periods of extreme heat, combined with an ageing tree stock, the city's trees were under immense stress and many were in a state of accelerated decline.[279] This has been addressed.

Under construction in Milan, Italy is Bosco Verticale, the world's first vertical forest, an apartment tower, with each apartment having a balcony planted with trees (Figure 53). In the summer, the trees will shade the windows and filter the city's dust and in the winter, sunlight will shine through the bare branches. The architect, Stefano Boeri says that building such a tower adds only 5% to construction costs. The architect notes that if the units were to be constructed unstacked as stand-alone units across a single surface, the project would require 50,000 square meters of land, and 10,000 square meters of woodland.[280]

Figure 53: Bosco Verticale, Milan.[281]

In the *Living Melbourne, Living Victoria Roadmap* developed by the Living Victoria Ministerial Advisory Council, the council proposed a vision as a starting point for improving water resources management which would contribute to a more liveable, sustainable and productive Melbourne.

The council noted that water management plays an important role in underpinning the vitality and prosperity of the city through, amongst other things, supporting green landscapes that significantly enhance urban amenity and help to combat the impacts of the urban heat island effect. Further linkages between urban water management and urban liveability were also addressed by the council.[282]

CONCLUSION

I began this paper with a list of recent highly authoritative commentaries about climate change, its impacts, and our role in its production. This **Climate Change Foundation Paper** adds to the expanding range of reports on climate change issues.

Concerns about climate change are firming. They are not evaporating. We are tracking at the higher end of earlier projections.

In Australia we are vulnerable. In Victoria our seaboard, our biodiversity, our infrastructure are all at risk. Native species and agricultural production are both exposed. The risk of extreme events is elevated.

Impacts cascade and compound. We have described such scenarios in this **paper**. To read them is to be deeply concerned.

Calls have been made for “aggressive” intervention. The situation we confront clearly warrants such a response across all tiers of government, industry sectors and the broader community.

In accordance with the legislation which guides my office, recommendations will be made in the **State of the Environment Report**.

Concerns about climate change are firming. They are not evaporating.

ENDNOTES

1 State of the Climate 2012 CSIRO and the Bureau of Meteorology, Australian Government

2 Report on Climate Change and Greenhouse Gas Emissions in Victoria, Victorian Government Department of Sustainability and Environment Melbourne, March 2012

3 http://www.theage.com.au/opinion/society-and-culture/here-comes-the-sun-chilling-verdict-on-a-climate-going-to-extremes-20120806-23q5o.html accessed 8 Aug 2012

4 *We have nothing to lose* Prof. Dr. Dr. Peter Höppe MUNICH RE Topics Geo Natural catastrophes 2010, Analyses, assessments, positions, 2011

5 *Many Publics: Participation, Inventiveness and Change*, Commissioner of Environmental Sustainability, State of Victoria, April 2012

6 Science Policy People, State of the Environment Reporting 2013, Victoria, (2010) Commissioner for Environmental Sustainability, State of Victoria

7 *Commissioner for Environmental Sustainability Act* 2003

8 State of the Climate March 2010 and State of the Climate 2012 CSIRO and the Bureau of Meteorology, Australian Government

9 SEACI http://www.seaci.org/publications/synthesis.html

10 Australia State of the Environment 2011, Australian Government, Department of Sustainability, environment, Water, Population and Communities

11 Low Carbon Growth Plan for Australia, March 2010 and others ClimateWorks Australia

12 Global Climate Leadership Review 2012, The Climate Institute

13 OECD (2011) Towards Green Growth

14 http://e360.yale.edu/feature/ecological_corridors_connecting_fragmented_pockets_of_wildlife_habitat/2450/

15 Program for Climate Model Diagnosis and Intercomparison, http://www-pcmdi.llnl.gov/about/index.php retrieved 20 August 2012

16 IPCC, 2007: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller, eds.). Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. http://unfccc.int/essential_background/convention/background/items/1349.php retrieved 9 August 2012

17 http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-faqs.pdf retrieved 9 August 2012

18 IPCC (2007) The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. FAQ 1.2 Figure 1. http://www.ipcc.ch/publications_and_data/ar4/wg1/en/faq-1-3-figure-1.html retrieved 14 August 2012

19 James Hansen, J., Sato, M. and Ruedy, R., 2012, 'Perception of climate change', *Proceedings of the National Academy of Sciences of the United States of America* www.pnas.org/cgi/doi/10.1073/pnas.1205276109

20 CSIRO, 2007, *Climate Change in Australia – Technical report 2007* Chapter 5

21 Anderson, K. and Bows A., 2011, Beyond dangerous climate change: emission scenarios for a new world. *Philosophical Transactions of the Royal Society A*, vol 369, pp 20-44

22 DSE, 2012, *Report on climate change and greenhouse gas emissions in Victoria. As required under Section 17 of the Climate Change Act 2010*, p 22

23 OECD, 2012, *OECD Environmental Outlook to 2050: The Consequences of Inaction, OECD Publishing*. doi: 10.1787/9789264122246-en

24 WMO, 2011, *Greenhouse Gas Bulletin No. 7* http://www.wmo.int/pages/prog/arep/gaw/ghg/GHGbulletin.html retrieved 19 October 2012

25 OECD, 2011. The OECD Environmental Outlook to 2050, Key findings on climate change. http://www.oecd.org/document/11/0,3746,en_2649_37465_49036555_1_1_1_37465,00.html retrieved 19 October 2012

26 IPCC, 1995, *Climate Change 1995, The Science of Climate Change: Summary for Policymakers and Technical Summary of the Working Group I Report*, p 22.

27 http://www.climatechange.gov.au/climate-change/emissions.aspx

28 IPCC, 2000. *Emissions Scenarios*. Nakicenovic, N and Swart, R., eds., Cambridge University Press, UK

29 Raupach M.R., Marland, G., Ciais, P., Le Quéré, C., Canadell, J.G., Klepper, G., and Field, C.B., 2007, 'Global and regional drivers of accelerating CO_2 emissions' *Proceedings of the National Academy of Sciences of the United States of America*, vol104, pp10288-10293; Raupach, M.R. and Canadell, J.G., 2010, 'Carbon and the Anthropocene' *Current Opinion in Environmental Sustainability*, col4:doi:10.1016/j.cosust.2010.04.003; GCP, 2011, 'Global carbon budget' *Global Carbon Project*, http://www.globalcarbonproject.org/carbonbudget/index.htm. retrieved 15 August2012

30 Data provided by CSIRO using method described in: Watterson, I. G., 2008, Calculation of probability density functions for temperature and precipitation change under global warming. *Journal of Geophysical Research*, vol 113, D12106, doi:10.1029/2007JD009254.

31 IPCC, 2007: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M. Averyt, K.B., Tignor, M. and Miller, H.L., eds.). Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. Figure 10.28.

32 IPCC, 2007, Impacts, Adaptation and Vulnerability, Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. (Parry, M.L., Canziani, O.F., Palutikof, J.P., van der Linden, P.J., and Hanson, C.E., eds) Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. Figure 11.4; modified by CSIRO (2010) *Adaptation science: Opportunities and responses to climate change impacts*.

33 Wu, L., Cai, W., Zhang, L., Nakamura, H., Timmermann, A., Joyce, T., McPhaden, M.J., Alexander, M., Qiu, B., Visbeck, M., Chang, P. and Giese, B., 2012, 'Enhanced warming over the global subtropical western boundary currents' *Nature Climate Change*, vol 2, pp161-166

34 CSIRO and BoM, 2012, *State of the Climate*

35 Data provided by CSIRO using method described in: Watterson, I. G., 2008, Calculation of probability density functions for temperature and precipitation change under global warming. *Journal of Geophysical Research*, vol 113, D12106, doi:10.1029/2007JD009254.

36 CSIRO, 2007, *Climate Change in Australia – Technical Report*, Chapter 5.

37 Bureau of Meteorology; Comrie, N., 2011, *Review of the 2010-11 Flood Warnings and Response*, Victorian Government; Stephenson, C., 2010, *The impacts, losses and benefits sustained from five severe bushfires in south-eastern Australia. Fire and Adaptive Management Report No. 88.* Bushfire Cooperative Research Centre; Victorian Government Department of Human Services, 2009, *January 2009 Heatwave in Victoria: An Assessment of Health Impacts*

38 South Eastern Australian Climate Initiative http://www.seaci.org/publications/documents/SEACI-2Reports/SEACI2_Factsheet2of4_WEB_110714.pdf retrieved 16 October 2012

39 South Eastern Australian Climate Initiative http://www.seaci.org/publications/documents/SEACI-2Reports/SEACI2_Factsheet2of4_WEB_110714.pdf retrieved 16 October 2012

40 Nicholls, N., 2011, 'What caused the eastern Australia heavy rains and floods of 2010/11?; *Bulletin of the Australian Meteorological and Oceanographic Society, v*ol.24. p 34

41 Climate Commission, 2012, *The Science behind southeast Australia's wet, cool summer*

42 Pall, P., Aina, T., Stone, D.A., Stott, P.A., Nozawa, T., Hilberts, A.G.J., Lohmann, D. and Allen, M.R., 2011, 'Anthropogenic greenhouse gas contribution to flood risk in England and Wales in autumn 2000'*, Nature,* vol 470, 382-386

43 IPCC, 2012: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (Field, C.B., Barros, V., Stocker, T.F., Qin, D., Dokken, D.J., Ebi, K.L., Mastrandrea, M.D., Mach, K.J., Plattner, G.-K., Allen, S.K., Tignor, M. and Midgley, P.M.eds.). Cambridge University Press, Cambridge, UK,and New York, NY, USA

44 Munich Re,2012, *Topic GEO Natural catastrophes 2011Analyses, assessments, positions*

45 Koppen, W, 2011, The thermal zones of the Earth according to the duration of hot, moderate and cold periods and to the impact of heat on the organic world. *Meteorologische Zeitschrift*, vol 20, pp. 351-360(10)

46 Stern, H., De Hoedt, G. & Ernst, J., 2000, Objective classification of Australian climates *Australian Meteorology Magazine*, vol 49, pp 87-96

47 NOAA Celebrates 200 years of science, service and stewardship http://celebrating200years.noaa.gov/ retrieved 19 October 2012

48 Data provided from the Coupled Model Intercomparison project (CMIP3), processed by CSIRO

49 Dunlop, M., and Brown, P.R., 2008, '*mplications of climate change for Australia's National Reserve System: A preliminary assessment* Report to the Department of Climate Change, February 2008. Department of Climate Change, Canberra, Australia.

50 Berreton, R., Bennet, S. and Manseergh, I, 1995, Enhanced greenhouse climate change and its Potential effect on selected fauna of south-eastern Australia: a trend analysis. *Biological Conservation*, vol 12, pp 339-354

51 Whetton, P., Karoly, D., Watterson, I., Webb, L., Drost, F., Kirono, D. and McInnes, K. 2011, *Australian climate at four degrees or more of global warming* Presented at *Four Degrees or More?* Conference, Melbourne, 12-14 July 2011

52 State of the Environment 2011 Committee, *Australia State of the Environment 2011*, Independent report to the Australian Government Minister for Sustainability, Environment, Water, Population and Communities, Canberra, DSEWPaC, 2011

53 Driscoll D.A., Felton, A., Gibbons, P., Felton, A.M., Munro, N.T., and Lindenmayer, D.B., 2011, *Priorities in policy and management when existing biodiversity stressors interact with climate-change*. In press.

54 Climate Commission, 2011, *The critical decade: Climate science risks and responses.* Climate Commission Secretariate, Department of Climate Change and Energy Efficiency, Canberra

55 Steffen, W., Burbidge, A.A., Hughes, L., Kitching, R., Lindenmayer, D., Musgrave, W., Stafford Smith, M. and Werner, P.A., 2009, *Australia's Biodiversity and Climate Change: a strategic assessment of the vulnerability of Australia's biodiversity to climate change*, CSIRO Publishing, Australia.

56 CES (2008). State of the Environment Victoria 2008. Commissioner for Environmental Sustainability, Victoria.

57 Australian Bureau of Statistics, 2010, *Australia's Environment: Issues and Trends 2010, ABS Catalogue No. 4613.0*, Australian Bureau of Statistics, Canberra; Booth, D., Edgar, G., Figueira, W., Jenkins, G., Kingsford, M., Lenanton, R. and Thresher, R., 2009, 'Temperate Coastal and Demersal Fish and Climate Change', in Poloczanska, E.S., Hobday, A.J., and Richardson, A.J., eds., *Marine Climate Change Impacts and Adaptation Report Card for Australia 2009*, NCCARF Publication 05/09; Burrows, M.T., Schoeman, D.S., Buckley, L.B. *et al.*,2011, 'The pace of shifting climate in marine and terrestrial ecosystems', *Science*, 334 (6056); Chambers L.E., Congdon B.C., Dunlop N., Dann P. and Devney C., 2009, 'Seabirds', in Poloczanska, E.S., Hobday, A.J., and Richardson, A.J., eds., *Marine Climate Change Impacts and Adaptation Report Card for Australia 2009*, NCCARF Publication 05/09; Chessman, B., 2009, 'Climatic changes and 13-year trends in stream macroinvertebrate assemblages in New South Wales, Australia', *Global Change Biology* (2009) 15, pp. 2791 – 2802; Climate Commission, 2011, *The critical decade: Climate science risks and responses. Climate*, Climate Commission Secretariate, Department of Climate Change and Energy Efficiency, Canberra; CSIRO, 2011, *Climate Change: Science and Solutions for Australia*, Cleugh, H., Stafford Smith, M., Battaglia, M. and Graham, P. eds, CSIRO Publishing; Department of Climate Change, 2009, *Australia's biodiversity and climate change: A strategic assessment of the vulnerability of Australia's biodiversity to climate change. Summary for policy makers 2009*, Summary of a report to the Natural Resource Management Ministerial Council commissioned by the Australian Government. Department of Climate Change, Canberra; Department of Sustainability Environment, 2007, Climate *Change in Victoria: A Summary*, Department of Sustainability and Environment, Melbourne; Edmunds, M., Mustoe, S., Stewart, K., Sheedy, E. and Ong, J., 2009, *VNPA Nature Conservation Review: Marine Conservation Priorities and Issues for Victoria*. Report to Victorian National Parks Association. Australian Marine Ecology Report 405, Melbourne; Hobday A.J., Griffiths S. and Ward T., 2009, 'Pelagic Fishes and Sharks', in Poloczanska, E.S., Hobday, A.J., and Richardson, A.J., eds., *Marine Climate Change Impacts and Adaptation Report Card for Australia 2009*, NCCARF Publication 05/09; Howard W.R., Havenhand J., Parker L., Raftos D., Ross, P., Williamson J. and Matear R., 2009, 'Ocean acidification', in Poloczanska, E.S., Hobday, A.J., and Richardson, A.J., eds., *Marine Climate Change Impacts and Adaptation Report Card for Australia 2009*, NCCARF Publication 05/09; Hughes, L., Cawsey, E.M., and Westoby, M., 1996, 'Climatic range sizes of Eucalyptus species in relation to future climate change', *Global Ecology and Biogeography Letters* 5, pp. 23 – 29; Kingsford, R.T., 2011, 'Conservation management of rivers and wetlands under climate change – a synthesis', *Marine and Freshwater Research* 62(3), pp. 217-222; Koehn J.D., Hobday, A.J., Pratchett, M.S. and Gillanders, B.M., 2011, 'Climate change and Australian marine and freshwater environments, fishes and fisheries: synthesis and options for adaptation', *Marine and Freshwater Research* 62, pp. 1148-1164; Leahy, P., Robinson, D., Patten, R., and Kramer, A., 2010, *Lakes in the Western District of Victoria and Climate Change*, Environment Protection Authority Victoria; Lough J.M. and Hobday A.J., 2011, 'Observed climate change in Australian marine and freshwater environments', *Marine and Freshwater Research*, 2011, 62, pp. 984–999; Nicholls, N., 2005,

'Climate variability, climate change and the Australian snow season', *Australian Meteorological Magazine,* 54, pp. 177-185; Poloczanska E.S., Babcock R.C., Butler A., Hobday A.J., Hoegh-Guldberg O., Kunz T.J., Matear R., Milton D., Okey T.A. and Richardson A.J., 2007, 'Climate Change and Australian Marine Life', *Oceanography and Marine Biology Annual Review* 45, pp. 409-480; Poloczanska, E.S., Hobday, A.J., and Richardson, A.J., eds., *Marine Climate Change Impacts and Adaptation Report Card for Australia 2009*, NCCARF Publication 05/09; Richardson A.J., Hobday, A.J. and Poloczanska E.S., 2009, 'Australia's Marine Life', in Poloczanska, E.S., Hobday, A.J., and Richardson, A.J., eds., *Marine Climate Change Impacts and Adaptation Report Card for Australia 2009*, NCCARF Publication 05/09; Victorian Coastal Council, 2006, *Emerging Scientific Issues on Victoria's Coast Science Panel Victorian Coastal Council*, August 2006; Victorian Coastal Council, 2011, *Emerging Scientific Issues on Victoria's Coast 2011: Update*, Victorian Coastal Council Science Panel October 2011; Victorian National Parks Association, 2010, *Protecting our seas and shores – Priorities for marine conservation in Victoria*, Victorian National Parks Association; Wernberg, T., Russell, B.D., Moore, P.J., Ling, S.D., Smale, D.A., Campbell, A., Coleman, M.A., Steinberg, P.D., Kendrick, G.A., Connell, S.D., 2011, 'Impacts of climate change in a global hotspot for temperate marine biodiversity and ocean warming', *Journal of Experimental Marine Biology and Ecology* 400 (2011), pp. 7–16; Wernberg, T., Russell, B.D., Thomsen, M.S., Gurgel, C.F.D., Bradshaw, C.J.A., Poloczanska, E.S., Connell, S.D., 2011, 'Seaweed communities in retreat from ocean warming', *Current Biology*, 21, pp. 1828-1832

58 Australian Bureau of Statistics, 2010, *Australia's Environment: Issues and Trends 2010, ABS Catalogue No. 4613.0*, Australian Bureau of Statistics, Canberra; Booth, D., Edgar, G., Figueira, W., Jenkins, G., Kingsford, M., Lenanton, R. and Thresher, R., 2009, 'Temperate Coastal and Demersal Fish and Climate Change' in Poloczanska, E.S., Hobday, A.J., and Richardson, A.J., eds., *Marine Climate Change Impacts and Adaptation Report Card for Australia 2009*, NCCARF Publication 05/09; CSIRO, 2011, *Climate Change: Science and Solutions for Australia*, Cleugh, H., Stafford Smith, M., Battaglia, M. and Graham, P. eds, CSIRO Publishing; Department of Primary Industries, 2009, *South-Eastern Australia Program: Adaptation of fishing and aquaculture sectors and fisheries management to climate change in South-Eastern Australia program plan*, Department of Primary Industries, Victoria; Department of Sustainability Environment, 2007, *Climate Change in Victoria: A Summary*, Department of Sustainability and Environment, Melbourne; Hobday, A.J., Poloczanska, E.S., Matear, R.J., eds., 2008, *Implications of Climate Change for Australian Fisheries and Aquaculture: a preliminary assessment*, Department of Climate Change; Koehn J.D., Hobday, A.J., Pratchett, M.S. and Gillanders, B.M., 2011, 'Climate change and Australian marine and freshwater environments, fishes and fisheries: synthesis and options for adaptation', *Marine and Freshwater Research* 62, pp. 1148-1164; Sands, A., 2011, *Fisheries and climate change: potential challenges and opportunities for Commonwealth fisheries*, ABARES technical report 11.1, Canberra

59 Victorian National Parks Association, 2010, *Protecting our seas and shores – Priorities for marine conservation in Victoria*. Victorian National Parks Association.

60 Victorian Auditor-General (2011). *Environmental Management of Marine Protected Areas. Victorian Auditor-General's Report*. Victorian Auditor-General's Office; Department of Primary Industries, 2011, *Annual report 2010–11*, Department of Primary Industries, Victoria

61 Bureau of Meteorology, 2012, *State of the Climate 2012*. Bureau of Meteorology, Australian Government

62 Wernberg, T., Russell, B.D., Moore, P.J., Ling, S.D., Smale, D.A., Campbell, A., Coleman, M.A., Steinberg, P.D., Kendrick, G.A., Connell, S.D., 2011, 'Impacts of climate change in a global hotspot for temperate marine biodiversity and ocean warming', *Journal of Experimental Marine Biology and Ecology*, 400, pp. 7–16; Poloczanska, E.S., Hobday, A.J., and Richardson, A.J., eds., 2009, *Marine climate change: impacts and adaptation report card for Australia 2009*, National Climate Change Adaptation Research Facility Publication 05/09.

63 Booth, D., Edgar, G., Figueira, W., Jenkins, G., Kingsford, M., Lenanton, R. and Thresher, R., 2009, 'Temperate Coastal and Demersal Fish and Climate Change', in Poloczanska, E.S., Hobday, A.J., and Richardson, A.J., eds., *A Marine Climate Change Impacts and Adaptation Report Card for Australia 2009*, NCCARF Publication 05/09.

64 Department of Primary Industries, 2009, *South-Eastern Australia Program: Adaptation of fishing and aquaculture sectors and fisheries management to climate change in South-Eastern Australia, program plan,* Department of Primary Industries, Victoria

65 Lough J.M. and Hobday A.J., 2011, 'Observed climate change in Australian marine and freshwater environments', *Marine and Freshwater Research*, 2011, 62, pp. 984–999

66 Wernberg, T., Russell, B.D., Moore, P.J., Ling, S.D., Smale, D.A., Campbell, A., Coleman, M.A., Steinberg, P.D., Kendrick, G.A., Connell, S.D., 2011, 'Impacts of climate change in a global hotspot for temperate marine biodiversity and ocean warming', *Journal of Experimental Marine Biology and Ecology*, 400 (2011), pp. 7–16

67 Department of Primary Industries, 2009, *South-Eastern Australia Program: Adaptation of fishing and aquaculture sectors and fisheries management to climate change in South-Eastern Australia, program plan*. Department of Primary Industries, Victoria; Lough J.M. and Hobday A.J., 2011, 'Observed climate change in Australian marine and freshwater environments' *Marine and Freshwater Research*, 2011, 62, pp. 984–999; Wernberg, T., Russell, B.D., Moore, P.J., Ling, S.D., Smale, D.A., Campbell, A., Coleman, M.A., Steinberg, P.D., Kendrick, G.A., Connell, S.D., 2011, 'Impacts of climate change in a global hotspot for temperate marine biodiversity and ocean warming', *Journal of Experimental Marine Biology and Ecology*, 400 (2011), pp. 7–16

68 Richardson A.J., Hobday, A.J. and Poloczanska E.S., 2009, 'Australia's Marine Life' in Poloczanska, E.S., Hobday, A.J., and Richardson, A.J., eds., *A Marine Climate Change Impacts and Adaptation Report Card for Australia 2009*, NCCARF Publication 05/09; Wormworth, J. and Sekercioglu, C.H., 2011, *Winged Sentinels Birds and Climate Change,* Cambridge University Press, New York

69 Burrows, M.T., *et al.* 2011, 'The pace of shifting climate in marine and terrestrial ecosystems', *Science*, 334 no. 6056, pp. 652-655

70 Poloczanska E.S., Babcock R.C., Butler A., Hobday A.J., Hoegh-Guldberg O., Kunz T.J., Matear R., Milton D., Okey T.A. and Richardson A.J., 2007, 'Climate Change and Australian Marine Life', *Oceanography and Marine Biology Annual Review* 45, pp. 409-480; Wernberg, T., Russell, B.D., Moore, P.J., Ling, S.D., Smale, D.A., Campbell, A., Coleman, M.A., Steinberg, P.D., Kendrick, G.A., Connell, S.D., 2011, 'Impacts of climate change in a global hotspot for temperate marine biodiversity and ocean warming', *Journal of Experimental Marine Biology and Ecology* 400, pp. 7–16

71 Richardson A.J., Hobday, A.J. and Poloczanska E.S., 2009, 'Australia's Marine Life', in Poloczanska, E.S., Hobday, A.J., and Richardson, A.J. eds., *Report Card of Marine Climate Change for Australia 2009,* NCCARF Publication 05/09.

72 Wernberg, T., Russell, B.D., Thomsen, M.S., Gurgel, C.F.D., Bradshaw, C.J.A., Poloczanska, E.S., Connell, S.D., 2011, 'Seaweed communities in retreat from ocean warming', *Current Biology*, 21, pp. 1828-1832

73 Wernberg, T., Russell, B.D., Moore, P.J., Ling, S.D., Smale, D.A., Campbell, A., Coleman, M.A., Steinberg, P.D., Kendrick, G.A., Connell, S.D., 2011, 'Impacts of climate change in a global hotspot for temperate marine biodiversity and ocean warming', *Journal of Experimental Marine Biology and Ecology* 400 (2011), pp. 7–16

74 Hobday, A.J., Poloczanska, E.S., and Matear, R.J., eds., 2008, *Implications of Climate Change for Australian Fisheries and Aquaculture: a preliminary assessment*. Department of Climate Change; Wernberg, T., Russell, B.D., Moore, P.J., Ling, S.D., Smale, D.A., Campbell, A., Coleman, M.A., Steinberg, P.D., Kendrick, G.A., Connell, S.D., 2011, 'Impacts of climate change in a global hotspot for temperate marine biodiversity and ocean warming', *Journal of Experimental Marine Biology and Ecology* 400 (2011), pp. 7–16

75 Booth, D., Edgar, G., Figueira, W., Jenkins, G., Kingsford, M., Lenanton, R. and Thresher, R., 2009, 'Temperate Coastal and Demersal Fish and Climate Change', in Poloczanska, E.S., Hobday, A.J., and Richardson, A.J., eds., *Marine Climate Change Impacts and Adaptation Report Card for Australia 2009*, NCCARF Publication 05/09

76 Nicholson, A.D., Jenkins, G., Sherwood, J. and Longmore, A., 2008, 'Physical environmental conditions, spawning and early-life stages of an estuarine fish: climate change implications for recruitment in intermittently open estuaries', *Marine and Freshwater Research* 59, pp. 735–749

77 Department of Sustainability and Environment, 2011, *Gippsland Region Sustainable Water Strategy,* Department of Sustainability and Environment

78 Booth, D., Edgar, G., Figueira, W., Jenkins, G., Kingsford, M., Lenanton, R. and Thresher, R., 2009, 'Temperate Coastal and Demersal Fish and Climate Change', in Poloczanska, E.S., Hobday, A.J., and Richardson, A.J., eds., *Marine Climate Change Impacts and Adaptation Report Card for Australia 2009*, NCCARF Publication 05/09

79 Department of Sustainability and Environment, 2011, *Gippsland Region Sustainable Water Strategy,* Department of Sustainability and Environment

80 Department of Primary Industries, 2009, *South-Eastern Australia Program: Adaptation of fishing and aquaculture sectors and fisheries management to climate change in South-Eastern Australia program plan,* Department of Primary Industries, Victoria; Booth, D., Edgar, G., Figueira, W., Jenkins, G., Kingsford, M., Lenanton, R. and Thresher, R., 2009, 'Temperate Coastal and Demersal Fish and Climate Change', in Poloczanska, E.S., Hobday, A.J., and Richardson, A.J., eds., *Marine Climate Change Impacts and Adaptation Report Card for Australia 2009*, NCCARF Publication 05/09; Sands, A., 2011, *Fisheries and climate change: potential challenges and opportunities for Commonwealth fisheries*, ABARES technical report 11.1, Canberra.

81 Alistair J. Hobday, Elvira S. Poloczanska, Richard J. Matear, eds., 2008, *Implications of Climate Change for Australian Fisheries and Aquaculture: a preliminary assessment*. Department of Climate Change

82 Hobday A.J., Griffiths S. and Ward T., 2009, 'Pelagic Fishes and Sharks', in Poloczanska, E.S., Hobday, A.J., and Richardson, A.J., eds., *Marine Climate Change Impacts and Adaptation Report Card for Australia 2009*, NCCARF Publication 05/09

83 Hobday, A.J., Poloczanska, E.S., Matear, R.J., eds., 2008, *Implications of Climate Change for Australian Fisheries and Aquaculture: a preliminary assessment*, Department of Climate Change

84 Booth, D., Edgar, G., Figueira, W., Jenkins, G., Kingsford, M., Lenanton, R. and Thresher, R., 2009, 'Temperate Coastal and Demersal Fish and Climate Change', in Poloczanska, E.S., Hobday, A.J., and Richardson, A.J., eds., *Marine Climate Change Impacts and Adaptation Report Card for Australia 2009*, NCCARF Publication 05/09; Richardson A.J., Hobday, A.J. and Poloczanska E.S. (2009) 'Australia's Marine Life', in Poloczanska, E.S., Hobday, A.J., and Richardson, A.J., eds., *Marine Climate Change Impacts and Adaptation Report Card for Australia 2009*, NCCARF Publication 05/09

85 Booth, D., Edgar, G., Figueira, W., Jenkins, G., Kingsford, M., Lenanton, R. and Thresher, R., 2009, 'Temperate Coastal and Demersal Fish and Climate Change', in Poloczanska, E.S., Hobday, A.J., and Richardson, A.J., eds., *Marine Climate Change Impacts and Adaptation Report Card for Australia 2009*, NCCARF Publication 05/09; Eadie, L. and Hoisington, C., 2011, *Stocking Up: Securing our marine economy*; Wernberg, T., Russell, B.D., Moore, P.J., Ling, S.D., Smale, D.A., Campbell, A., Coleman, M.A., Steinberg, P.D., Kendrick, G.A., Connell, S.D., 2011, 'Impacts of climate change in a global hotspot for temperate marine biodiversity and ocean warming', *Journal of Experimental Marine Biology and Ecology* 400 (2011), pp. 7–16

86 http://www.usanpn.org/about/phenology/ retrieved 24 Sept 2012

87 CfES adapted from Stenseth N.C., and Mysterud, S., 2002, 'Climate, changing phenology, and other life history traits: Nonlinearity and match-mismatch to the environment', *Proceedings of the National Academy of Sciences* 99(21), pp. 13379-13381, National Academy of Sciences, USA

88 Based on an unpublished analysis by Lynda Chambers, Bureau of Meteorology, of the following literature - Keatley, M.R., Fletcher, T.D., Hudson, I.L., Ades, P.K., 2002, 'Phenological studies in Australia: potential application in historical and future climate analysis', *International Journal of Climatology* 22, pp. 1769-1780; Keatley, M.R., Hudson, I.L., 2007, 'Shift in flowering dates of Australian plants related to climate: 1983-2006'. MODSIM 2007, 10-13 December 2007, Christchurch, New Zealand; Chambers, L.E., Gibbs, H., Weston, M.A., 2008, 'Spatial and temporal variation in Masked Lapwing breeding', *Emu* 108, pp.115-124; Chambers, L.E., Quin, B., Menkhorst, P, Franklin, D., Smales, I., 2008, 'Climate as a driver for breeding in the Helmeted Honeyeater', *Emu* 108, pp. 15-22; Rumpff, L., Coates, F., Messina, A., Morgan, J., 2008, *Potential biological indicators of climate change: evidence from phenological records of plants along the Victorian coast*, Arthur Rylah Institute for Environmental Research Technical Report No. 175; Cullen, J.M., Chambers, L.E., Coutin, P.C., and Dann, P., 2009, 'Predicting the onset and success of breeding of Little Penguins, *Eudyptula minor*, on Phillip Island from ocean temperatures off south east Australia', *Marine Ecology Progress* Series 378, pp. 269-278; Gallagher, R.V, Hughes, L., Leishman, M.R., 2009, 'Phenological trends among Australian alpine species: using herbarium records to identify climate-change indicators', *Aust. J. Botany,* 57, pp. 1-9; Chambers, L.E., 2010, 'Altered avian seasonal movements in a peri-urban environment: climate related?', *Emu* 110, pp. 48-53; Chambers, L.E., and Keatley, M.R., 2010, 'Australian bird phenology – a search for climate signals', *Austral Ecology* 35, pp. 969-979; Gibbs, H., Chambers, L.E., Bennett, A.F., 2011, 'Temporal and spatial variability in breeding in Australian birds: potential implications of climate change', *Emu* 111, pp. 283-291

89 Petrie, P.R., Sadras, V.O., 2008, 'Advancement of grapevine maturity in Australia between 1993 and 2006: putative causes, magnitude of trends and viticultural consequences', *Australian Journal of Grape and Wine Research* 14, pp. 33-45; Webb, L. B., Whetton, P. H., and Barlow, E.W. R., 2011, 'Observed trends in winegrape maturity in Australia', *Global Change Biology* (2011), doi: 10.1111/j.1365-2486.2011.02434.x; Webb, L. B., Whetton, P. H., Bhend, J., Darbyshire, R., Briggs, P. R. and Barlow, E.W. R., 2012, 'Earlier wine-grape ripening driven by climatic warming and drying and management practices', *Nature Climate Change*, published online 26 February 2012 | DOI: 10.1038/NCLIMATE1417

90 Webb, L. B., Whetton, P. H., Bhend, J., Darbyshire, R., Briggs, P. R. and Barlow, E.W. R., 2012, 'Earlier wine-grape ripening driven by climatic warming and drying and management practices', *Nature Climate Change*, published online 26 February 2012 | DOI: 10.1038/NCLIMATE1417

91 Department of Sustainability and Environment, 2007, *Climate Change in Victoria: A Summary*, Department of Sustainability and Environment

92 Cullen, J.M., Chambers, L.E., Dann, P., Coutin, P.C, 2009, 'Predicting the onset and success of breeding of Little Penguins *Eudyptula minor*, on Phillip Island from ocean temperatures off south east Australia', *Marine Ecology Progress Series* 378, pp. 269-278; Chambers, L.E., Congdon, B.C., Devney, C., Dunlop, N., Woehler, E.J., Dann, P., 2011, 'Observed and predicted impacts of climate on Australian seabirds', *Emu* 111, pp. 235-251; Chambers, L.E., Dann, P, 2011, 'Seabirds and environmental change: understanding the impacts and increasing resilience', *ECOS online, 7/11/2011* http://www.ecosmagazine.com/?paper=EC11093; Chambers, L.E., Renwick, L., Dann, P., 2011, 'Climate, fire and Little Penguins', in Richardson, K., Steffen, W., and Liverman, D., eds, *Climate Change: Global Risks, Challenges and Decisions*, Cambridge University Press, pp 275-276;

93 http://mesh.biology.washington.edu/penguinProject/Little/ retrieved 12 July 2012

94 Keatley M.R., Hudson I.L., 2007, 'A comparison of the long-term flowering patterns of Box-Ironbark species in Havelock and Rushworth forests', *Environmental Modeling and Assessment* 12, pp. 279-92; Mac Nally R., Bennett, A.F., Thomson, J.R., Radford, J.Q., Unmack, G., Horrocks, G., Vesk, P.A., 2009, 'Collapse of an avifauna: climate change appears to exacerbate habitat loss and degradation', *Biodiversity and Distributions* 15, pp. 720-30; Hudson, I.L., Keatley, M.R., Kang, I., 2010, 'Wavelet characterization of eucalypt flowering and the influence of climate', *Environmental and Ecological Statistics*, 18, pp. 513-533

95 Data provided by Department of Sustainability and Environment, Victoria, 2012

96 Booth, D., Edgar, G., Figueira, W., Jenkins, G., Kingsford, M., Lenanton, R. and Thresher, R., 2009, 'Temperate Coastal and Demersal Fish and Climate Change', in Poloczanska, E.S., Hobday, A.J., and Richardson, A.J., eds., *Marine Climate Change Impacts and Adaptation Report Card for Australia 2009*, NCCARF Publication 05/09; Victorian Coastal Council, 2011, *Emerging Scientific Issues on Victoria's Coast 2011: Update*, Victorian Coastal Council Science Panel October 2011

97 Data and material provided by Parks Victoria.

98 Edgar G. J. and Stuart-Smith R. D., 2009, 'Ecological effects of marine protected areas on rocky reef communities – a continental-scale analysis', *Marine Ecology Progress*, Series vol 388; Koss, R. S., Miller, K., Wescott, G., Bellgrove, A., Boxshall, A., McBurnie, J., Bunce, A., Gilmour, P. and Ierodiaconou, D., 2009, 'An evaluation of Sea Search as a citizen science programme in Marine Protected Areas', *Pacific conservation biology*, 15, pp. 116-127

99 Herald Sun, 14 January 2011. Victorians brace for major floods as more rain forecast http://www.heraldsun.com.au/ipad/victorians-brace-for-major-floods-as-more-rain-forecast/story-fn6bfmgc-1225987551876

100 http://www.bom.gov.au/climate/data/index.shtml

101 The Age, 2 April 2011. Red arrows point to Grampians devastation www.theage.com.au/victoria/red-arrows-point-to-grampians-devastation-20110401-1crrf.html

102 http://www.insurancecouncil.com.au/industry-statistics-data/disaster-statistics/historical-disaster-statistics retrieved 18 October 2012; The Telegraph, 8 March 2010. Super storm and giant hailstones lash Melbourne http://www.telegraph.co.uk/news/worldnews/australiaandthepacific/australia/7394608/Super-storm-and-giant-hailstones-lash-Melbourne.html

103 Herald Sun, 7 Marc 2010. Storms hit Melbourne http://www.heraldsun.com.au/news/huge-hailstorm-strikes-melbourne/story-e6frf7jo-1225837662827

104 http://www.seasprayslsc.com/flood-damage.html retrieved 18 October 2012; Herald Sun, 10 July 2007. Surf club's a cliff hanger http://www.heraldsun.com.au/news/victoria/surf-clubs-a-cliff-hanger/story-e6frf7kx-1111113922748

105 CSIRO, Maunsell Australia, Phillips Fox 2007, *Infrastructure and climate change risk assessment for Victoria: Report to the Victorian Government*

106 Infrastructure UK 2010, *National Infrastructure Plan 2010*, p 19

107 Engineering the Future 2011, *Infrastructure, Engineering and Climate change Adaptation – ensuring services in an uncertain future*, Royal Academy of Engineering, London, p 24

108 The information in these graphics has been compiled from a range of news articles of actual occurrences and assessments of projected risks. The need for greater research into cascading impacts from infrastructure failure, and how these are likely to be linked to extreme weather, has been identified by the National Climate Change Adaptation Research Facility: Thom B, Cane J, Cox R, Farrell C, Hayes P, Kay R, Kearns A, Low Choy D, McAneney J, McDonald J, Nolan M, Norman B, Nott J, Smith T, 2010: *National Climate Change Adaptation Research Plan for Settlements and Infrastructure*, National Climate Change Adaptation Research Facility, Gold Coast; p39

109 CSIRO 2010 Ch*ange: Adapt now for the future (*http://www.csiro.au/files/files/pxqa.pdf); NCCARF 2010, Impacts and adaptation responses of infra*structure and communities to heatwaves: the southern Australian experience of 2009; Department of Primary Industries 2007, 16 January 2007 electricity supply interruptions in Victoria: what happened and why, and Opportunities and recommendations.*

110 UK Trade & Investment 2011, *Adapting to an Uncertain Climate: A World of Commercial Opportunities*

111 UK Trade & Investment 2011, *Adapting to an Uncertain Climate: A World of Commercial Opportunities*

112 Mercer 2012, *Through the looking glass: how investors are applying the results of the climate change scenarios study*

113 CSIRO 2011, *Climate Change: Science and Solutions for Australia*, CSIRO Publishing, Collingwood, p 65

114 Department of Defence, Australian Government, *Defence White Paper, 2009, Defending Australia in the Asia Pacific Century: Force 2030*

115 Australian Government 2010, *Critical Infrastructure Resilience Strategy*

116 http://www.environment-agency.gov.uk/homeandleisure/floods/104695.aspx retrieved 18 October 2012

117 Hallegatte, S., 2009, 'Strategies to adapt to uncertain climate change', *Global Environmental Change*, 19:240-247

118 Bliss, D.J., Neufield, R.D., and Ries, R.J. 2009, 'Storm Water Runoff Mitigation Using a Green Roof', *Environmental Engineering Science* 26(2): 407-418; Mentens, J., Raes, D. and Hermy, M. 2006 'Green roofs as a tool for solving the rainwater runoff problem in the urbanized 21st Century?', *Landscape and Urban Planning* 77: 217-226

119 Pedruco, P. and Watkinson R. 2010, *The impact of climate change on urban flooding in the Melbourne area using existing flood models,* Melbourne Water

120 City of Melbourne 2009, *City of Melbourne Climate Change Adaptation Strategy*, p 66

121 http://www.pixelbuilding.com.au/FactSheet.pdf retrieved 18 October 2012

122 http://www.melbourne.vic.gov.au/Sustainability/CH2/aboutch2/Pages/Factsandfigures.aspx retrieved 18 October 2012

123 http://e360.yale.edu/feature/green_architecture_building_retrofits_tap_energy_saving_potential/2461/ retrieved 18 October 2012

124 http://www.hafencity.com/en/overview/hafencity-facts-and-figures.html retrieved 18 October 2012 http://www.worldchanging.com/archives/011536.html retrieved 18 October 2012

125 http://www.dpcd.vic.gov.au/__data/assets/pdf_file/0003/41727/53-Managing-coastal-hazards-and-the-coastal-impacts-of-climate-change-PN53.pdf retrieved 12 Oct 2012

126 Department of Climate Change and Energy Efficiency 2010, *Developing a national coastal adaptation agenda: A report on the national climate change forum*, DCCEE, Canberra, p7

127 http://www.defra.gov.uk/environment/climate/sectors/reporting-authorities/reporting-authorities-reports/ retrieved 18 October 2012

128 Population data comes from ABS; Electricity consumption data comes from Bureau of Resources and Energy Economics, http://www.bree.gov.au/publications/aes-2012.html <http://www.bree.gov.au/publications/aes-2012.html

129 Department of Resources, Energy and Tourism 2011, *Draft Energy White Paper: Strengthening the Foundations for Australia's Energy Future*, Commonwealth of Australia, Canberra, p 172

130 Australian Bureau of Statistics 2011, *Environmental issues: Energy Use and Conservation*, cat. no. 4602.0.55.001

131 http://www.bom.gov.au/climate/data/

132 http://www.aemo.com.au/Electricity/Data/Price-and-Demand/Aggregated-Price-and-Demand-Data-Files/Aggregated-Price-and-Demand-2006-to-2010#2009 retrieved 19 October 2012

133 Australian Energy Market Operator 2011, *Victorian Annual Planning Report: Electricity and Gas Transmission Network Planning for Victoria*, p70

134 NCCARF 2010, *Impacts and adaptation responses of infrastructure and communities to heatwaves: the southern Australian experience of 2009*, p72

135 McGann, M. and Moss, J. 2010 *Smart Meters, Smart Justice? Energy, Poverty and the Smart Meter Rollout*, Social Justice Initiative, University of Melbourne

136 http://www.climatechange.qld.gov.au/pdf/factsheets/1energy-b1.pdf retrieved 28 November 2011

137 Department of Climate Change and Energy Efficiency 2011, *The Role of Regulation in Facilitating or Constraining Adaptation to Climate Change for Australian Infrastructure*, para 3.51.21

138 Australian Energy Market Commission 2011, *Strategic Priorities for Energy Market Development*, p 25

139 Australian Energy Regulator, press release 29 September 2011 'Regulator proposes changes to price setting rules'

140 Australian Energy Market Commission 2012, *Power of choice review - giving consumers options in the way they use electricity* (Final report); http://www.aemc.gov.au/news/announcements/final-determination-made-on-network-regulation-rule-changes.html <http://www.aemc.gov.au/news/announcements/final-determination-made-on-network-regulation-rule-changes.html

141 Commissioner for Environmental Sustainability Victoria, 2012, *Many Publics: Inventiveness, Participation and Change*

142 Pardeep and Aina, Stone, Stott, Nozawa, Hilberts, Lohmann, Allen, 2011, 'Anthropogenic greenhouse gas contribution to flood risk in England and Wales in autumn 2000' *Nature*, vol. 470; Zaffos, J., 2011, 'Extreme measures: The push to make climate research relevant' *The Daily Climate*, re-published in Climate Spectator

143 CSIRO 2011. *Climate variability, climate change and drought in eastern Australia*, factsheet, 22 January 2010, updated 14 October 2011

144 ibid.

145 CSIRO 2011. *Frequently asked questions about the causes of Australia's recent floods*, factsheet, 31 January 2010, updated 14 October 2011.

146 ibid.; IPCC, 2012: Summary for Policymakers. In: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, and New York, NY, USA, pp. 1-19.

147 CSIRO 22 January 2010, op. cit.

148 IPCC 2012, op. cit.

149 Department of Sustainability and Environment 2011, *Drought Management– Lessons for the Victorian Water Management Frameworks*, unpublished report

150 Gallant, A.J.E. and Karoly, D.J., 2010, 'A combined climate extremes index for the Australian region' *Journal of Climate*, 23: 6153–6165.

151 Gergis, J., Gallant, A.J.E., Braganza, K., Karoly, D.J., Allen, K., Cullen, L., D'Arrigo, R., Goodwin, I., Grierson, P., McGregor, S., 2011, 'On the long-term context of the 1997–2009 'Big Dry' in South-Eastern Australia: insights from a 206-year multi-proxy rainfall reconstruction', *Climatic Change*, 111: 923-944; Verdon-Kidd, D.C. and Kiem, A.S., 2009, 'Nature and causes of protracted droughts in southeast Australia: Comparison between the Federation, WWII, and Big Dry droughts' *Geophysical Research Letters*, 36, doi: 10.1029/2009GL041067

152 Department of Sustainability and Environment 2011, op. cit.

153 CSIRO, 22 January 2010, updated 14 October 2011. Climate variability, climate change and drought in eastern Australia, retrieved 19 October 2012, http://www.csiro.au/Outcomes/Climate/Understanding/climate-and-drought-in-eastern-Australia.aspx; CSIRO and Bureau of Meteorology, 2012, 'State of the Climate 2012'

154 Kirono, D.G.C., Kent, D.M., Hennessy, K.J., and Mpelasoka, F., 2011, 'Characteristics of Australian droughts under enhanced greenhouse conditions: Results from 14 global climate models', *Journal of Arid Environments*, 75: 566–575; Hennessy, K., Fawcett, R., Kirono, D., Mpelasoka, F., Jones, D., Bathols, J., Whetton, P., Stafford Smith, M., Howden, M., Mitchell, C. and Plummer, N., 2008a, 'An assessment of the impact of climate change on the nature and frequency of exceptional climatic events' Bureau of Meteorology and CSIRO; CSIRO, 2007-2012, Climate change in Australia, retrieved 19 October 2012, www.climatechangeinaustralia.gov.au/resources.php

155 Department of Primary Industries 2012, *Climate Challenges for Victorian Agriculture*, draft discussion paper, Future Farming Systems Research Division, Victoria Bureau of Rural Sciences 2008. *Wheat and sheep production in a changing climate: Western Victoria*. Communicating Climate Change Fact Sheet, August 2008.

156 Bureau of Rural Sciences 2008, *Wheat and sheep production in a changing climate: Western Victoria*, Communicating Climate Change, factsheet

157 Department of Sustainability and Environment 2011, op. cit. p. 40

158 ibid. p. 48

159 ibid. p. 60

160 ibid.

161 Department of Sustainability and Environment, Water Restrictions, retrieved 30 Nov 2011, http://www.water.vic.gov.au/saving/restrictions

162 Wimalasuriya, R et al, Rainfall Variability and its Impact on Dryland Cropping in Victoria, *52nd Annual Conference of the Australian Agricultural and Resource Economics Society (AARES)*, 2008

163 Van Rees, H., White, B., Laidlaw, J., McKinlay, D., 2011 'Farming during a period of extreme climate variability: consequences & lessons', final report prepared for the BCG as part of the project 'Developing climate change resilient cropping and mixed cropping/grazing businesses in Australia' supported by the Australian Government under its Climate Change Research Program

164 ibid.

165 Edwards, B., Gray, M., and Hunter, B., 2009, 'A Sunburnt Country: The Economic and Financial Impact of Drought on Rural and Regional Families in Australia in an Era of Climate Change', *Australian Journal of Labour Economics*, vol. 12:1, 109-131

166 Edwards, B., Gray, M., and Hunter, B., 2008, 'Social and economic impacts of drought on farm families and rural communities', *AIFS Submission into the Productivity Commission's Inquiry into Drought Support*

167 Fannin, B., 2011, 'Texas agricultural drought losses reach record $5.2 billion', *AgriLife Today*, retrieved 19 October 2012, http://agrilife.org/today/2011/08/17/texas-agricultural-drought-losses-reach-record-5-2-billion/

168 Quiggin, J., 2010, *Drought, climate change and food prices in Australia*, Australian Conservation Foundation

169 ANZ Bank, *Economic Outlook* – 15 October 2007, www.anz.com/aus/corporate/EcoComm/Outlook.asp ibid.

170 VCOSS 2010, *Submission to the Victorian Rural and Regional Committees' Inquiry into the Extent and Nature of Disadvantage and Inequity in Rural and Regional*, Victoria

171 Walker, C., 2004, 'The Public Value of Urban Parks', *Beyond Recreation: A broader view of urban parks*, The Urban Institute

172 GHD 2007, 'Strategies for Managing Sports Surfaces in a Drier Climate', *Municipal Association of Victoria*; Driscoll, K. and Wood, L., 1999, 'Sporting Capital: Changes and challenges for rural communities in Victoria', *Centre for Applied Social Research RMIT*

173 National Rural Health Alliance Australia, 2009, *Suicide in rural Australia*, factsheet, retrieved 27 September 2011, http://nrha.ruralhealth.org.au/cms/uploads/factsheets/fact-sheet-14-suicide.pdf

174 The Climate Institute 2011, *A Climate of Suffering: Mental health and community wellbeing in the wake of extreme weather*

175 Barr, N., 2004, 'The Micro-Dynamics of Change in Australian Agriculture', *Australian Census Analytic Program, Australian Bureau of Statistics*

176 VCOSS 2010, op. cit.

177 Australian Institute of Family Studies 2011, *Migration, labour demand, housing markets and the drought in regional Australia*, Research Paper No 49

178 PMSEIC 2010, *Challenges at Energy-Water-Carbon Intersections*, Prime Minister's Science, Engineering and Innovation Council, Canberra

179 ibid.

180 Department of Sustainability and Environment 2011, op. cit.

181 CSIRO 31 January 2010, op. cit.; CSIRO and Bureau of Meteorology, 2012, op. cit.

182 Nichols, N., 2011, 'What caused the eastern Australia heavy rains and floods of 2010/11?', *President's Column in Bulletin of the Australian Meteorological and Oceanographic Society*, vol.24 p. 33; Bureau of Meteorology, 2012, *Exceptional rainfall across southeast Australia*, Special Climate Statement 39

183 Bureau of Meteorology, 2012, Special Climate Statement 39 op. cit.; McBride, J.L. and Nicholls, N., 1983, 'Seasonal relationships between Australian rainfall and the Southern Oscillation', *Mon Weath Rev.*, 111, 1998–2004; CSIRO 31 January 2010, op. cit.

184 CSIRO and Bureau of Meteorology, 2012, op. cit.

185 CSIRO and Bureau of Meteorology, 2012, op. cit.

186 Queensland Floods Commission 2012, *Queensland Floods Commission of Inquiry Final Report*

187 ABARES 2011, *Nation looks to ABARES flood analysis*, media release, 1 March 2011

188 ABARES 2011, *The impact of recent flood events on commodities*, special report, Canberra

189 Wilson, L. and Schliebs, M., 2011, 'Deluge swells wheat prices' The Age, Melbourne, 5 January 2011

190 ABARES 2011, *The impact of recent flood events on commodities*, op. cit.

191 ABARES 2011, *The impact of recent flood events on commodities*, op. cit.

192 Wilson, L. and Schliebs, M., 2011, op. cit.

193 Blackwell, R., 2011, 'Australia floods hit commodity exports' The Globe and Mail, Toronto, 3 January 2011

194 Queensland Floods Commission 2012, op. cit.

195 Queensland Floods Commission 2012, op. cit. p. 30.

196 The Natural Disaster Insurance Review report released on 14 November 2011

197 Australian Government Disaster Assist, retrieved 19 October 2012, www.disasterassist.gov.au; Bureau of Transport Economics 2001, *Economic costs of natural disasters in Australia*, report 103

198 ibid.

199 ABC News Online, 8 May 2012, retrieved 19 October 2012, http://www.abc.net.au/news/2012-05-07/suncorp-wont-offer-new-policies-for-flood-prone-towns/3994612

200 The Australian, 2 April 2012, retrieved 19 October 2012, http://www.theaustralian.com.au/national-affairs/dumped-minister-gives-government-a-blast-over-disaster-spend/story-fn59niix-1226315905936

201 Parliament of Victoria, 2009 *Victorian Bushfires Royal Commission final report* ISBN 978-0-9807408-3-7,, Summary, p 5

202 http://www.dpc.vic.gov.au/index.php/featured/reforming-victorias-crisis-and-emergency-management-framework, accessed 21 October 2012

203 CSIRO, 2011. *Bushfire in Australia.* http://www.csiro.au/resources/BushfireInAustralia.html#1 retrieved 1 August 2011:

204 Adams, M. and Attiwill, P. eds 2011. *Burning Issues. Sustainability and Management of Australia's Southern Forests*. CSIRO and Bushfire Cooperative Research Centre

205 Adams, M. and Attiwill, P. eds 2011. *Burning Issues. Sustainability and Management of Australia's Southern Forests*. CSIRO and Bushfire Cooperative Research Centre p217

206 Keith, D.A., 2002. Population dynamics of an endangered heathland shrub, *Epacris stuartii* (Epacridae): recruitment, establishment and survival. *Austral Ecology*, vol 27, pp 67-76

207 Bradstock, R.A., Williams, R.J., and Gill, M.A., 2012, 'Future fire regimes of Australian ecosystems: new perspectives on enduring questions of management' in Bradstock, R.A. Gill, M.A. and Williams R.J., eds *Flammable Australia*, CSIRO Publishing

208 Cary, G.J., Bradstock, R.A., Gill, M.A. and Williams R.J., 2012. 'Global change and fire regimes' in Bradstock, R.A. Gill, M.A. and Williams R.J., eds Flammable Australia, CSIRO Publishing

209 Karoly, D, 2009. *Bushfires and extreme heat in south-east Australia.* Real Climate http://www.realclimate.org/index.php/archives/2009/02/bushfires-and-climate/#more-654, retrieved 19 October 2012

210 Parliament of Victoria, 2009, *Victorian Bushfires Royal Commission final report* ISBN 978-0-9807408-3-7, Volume I, p 17

211 Department of Sustainability and Environment, 2011. *What Causes Bushfire on Public Land in Victoria?*: http://www.dse.vic.gov.au/fire-and-other-emergencies/fire-management/causes-of-bushfire, retrieved 01 August 2011

212 Stephenson C,. 2010, *A literature review on the economic, social and environmental impacts of severe bushfires in South eastern Australia*. *Fire and Adaptive Management Report No. 87.* Bushfire Cooperative Research Centre

213 Leak, M., Passuello, R. and Tyler, B., 2003, 'I've seen fire. I've seen rain. I've seen muddy waters that I thought would never clear again' *Waterworks*, vol 6, pp 38-44

214 Cook, P., Holland, D. and Longmore, A., 2008, *Interactions between phytoplankton dynamics, nutrient loads and the biogeochemistry of the Gippsland Lakes*, Water Studies Centre, Monash University, Melbourne.

215 GWM Water newsletter, May 2011 http://www.gwmwater.org.au/information/publications/ground-and-surface-water/west-wimmera-gma/doc_download/1285-water-quality-in-the-wimmera-mallee-pipeline, retrieved 19 October 2012

216 The Climate Institute, 2011, *A Climate of Suffering: the real cost of living with inaction on climate change.*

217 Anastatrio, M., Shehab, N. and Lawry, L. 2006, 'Increased gender-based violence among women internally displaced in Mississippi two years post-Hurricane Katrina' *Disaster Medicine and Public Health Preparedness,* vol 3(1), pp 18-26

218 Australian Women's Health Network Newsletter, February 2011. pp 3-4

219 Stephenson, C., 2010, *The impacts, losses and benefits sustained from five severe bushfires in south-eastern Australia. Fire and Adaptive Management Report No. 88.* Bushfire Cooperative Research Centre

220 Stephenson, C., 2010, *The impacts, losses and benefits sustained from five severe bushfires in south-eastern Australia. Fire and Adaptive Management Report No. 88.* Bushfire Cooperative Research Centre

221 Ministerial Taskforce on Bushfire Recovery 2007, *Report from the Ministerial Taskforce on Bushfire Recovery*

222 Fogarty, L., and Ackland., A., 2009, 'Understanding and adapting to change: What can our fire climate tell us?' Emergency Management Conference 2009

223 CSIRO, 2007 Climate Change Projections for Australia http://www.climatechangeinaustralia.gov.au/ retrieved 19 October 2012

224 CSIRO, 2007 Climate Change Projections for Australia http://www.climatechangeinaustralia.gov.au/ retrieved 19 October 2012

225 CSIRO, 2008 *Bushfire Impacts on Water Yields*. Media Release 22nd Jan 2008..

226 Lucas, C., Hennessy, K., Mills, G. and Bathols, J., 2007 *Bushfire in southeast Australia: Recent Trends and Projected Climate Change impacts*, Bushfire Cooperative Research Centre and CSIRO

227 Parliament of Victoria, 2009, *Victorian Bushfires Royal Commission final report* ISBN 978-0-9807408-3-7, Volume II, p 222

228 Adams, M. and Attiwill, P. eds 2011. *Burning Issues. Sustainability and Management of Australia's Southern Forests*. CSIRO and Bushfire Cooperative Research Centre

229 Bushfires Royal Commission Implementation Monitor, 2012, *Final Report*.

230 Department of Justice Buyback Scheme guidelines. http://www.justice.vic.gov.au/buyback retrieved 19 October 2012

231 Tolhurst, K.G., 2009, *Report on Assessing Defendable Space Around Houses 2 in Bushfire-prone Environments.* Submission to the Victorian Bushfires Royal Commission. http://www.bushfirecrc.com/managed/resource/bushfire-penetration-urban-areas.pdf <http://www.bushfirecrc.com/managed/resource/bushfire-penetration-urban-areas.pdf

232 http://www.dpcd.vic.gov.au/__data/assets/pdf_file/0003/86484/Fact-Sheet_Planning-and-building-for-bushfire-protection.pdf

233 S. Harris, S., W. Anderson, W . Kilinc, M and Fogarty, L., 2011, *Establishing a link between the power of fire and community loss: The first step towards developing a bushfire severity scale. Fire and Adaptive Management Report No. 89,* Bushfire Cooperative Research Centre

234 Stephenson, C,. 2010, *A literature review on the economic, social and environmental impacts of severe bushfires in South eastern Australia*. *Fire and Adaptive Management Report No. 87.* Bushfire Cooperative Research Centre

235 Victorian Planning Provisions 52.47 bushfire protection: planning requirements http://planningschemes.dpcd.vic.gov.au/aavpp/52_47.pdf, retrieved 19 October 2012

236 UrbAnalyst, 2011, http://urbanalyst.com/in-the-news/victoria/876-new-bushfire-planning-controls-for-victoria.html, retrieved 19 October 2012

237 Ackland, A, Salkin, O, Blackett, A, Friend, G Fogarty, L., 2010, *Future Fire Management Project. Defining and evaluating alternative fire management options to achieve improved outcomes for community protection, biodiversity and ecosystem services. Otway Pilot Study – Interim Report.* DSE

238 Texas A&M Forest Service. College Station, Texas, USA

239 Consultancy DTSwildfire: http://www.dtswildfire.com/Projects

240 Taylor, D. and Wallace, L. 2011. *Bushfire Risk Assessment Model. A quantified method of determining bushfire risk spatially Tasmania*. AFAC & Bushfire CRC Conference 2011, Darling Harbour, Australia.

241 O'Neill, S.J. and Handmer, J., 2012, Responding to bushfire risk: the need for transformative adaptation. *Environmental Research Letters*, vol 7, 014018

242 CSIRO and BoM, 2012, *State of the Climate*

243 PriceWaterHouse Coopers, 2011, *Protecting human health and safety during severe and extreme heat events – a national framework*, November 2011, p3

244 Carlson, Ann E., 2008, Heatwaves, Global Warming, and Mitigation, *University of California Los Angeles Journal of Environmental Law and Policy*, The Earth Policy Institute, 2008, p17

245 Lobell David B. 1, Sibley, Adam and Ortiz-Monasterio J. Ivan, 2012, Extreme heat effects on wheat senescence in India, *Nature Magazine*, 29 January 2012

246 CSIRO, 2007, *Climate Change in Australia – Technical Report 2007*, p48

247 Climate Commission, *The Critical Decade: Climate Change and Health*, p13

248 Victorian Centre for Climate Change Adaptation Research & LTU, 2011, *Adaptation and Infrastructure think tank report*, 17/06/11, p11

249 Howard, L, 2007, The Climate of London, London 1818, ref Foxell, S *Mapping London*

250 PriceWaterHouse Coopers, 2011, *Protecting human health and safety during severe and extreme heat events – a national framework*, November 2011, p2-3

251 PriceWaterHouse Coopers, 2011, *Protecting human health and safety during severe and extreme heat events – a national framework*, November 2011, p2-3

252 PriceWaterHouse Cooper, 2011, *Protecting human health and safety during severe and extreme heat events – a national framework*, November 2011, p2-3

253 Climate Commission, *The Critical Decade: Climate Change and Health*, p11

254 The Climate Institute, 2011, *A climate of suffering*, p259

255 The Climate Institute, 2011, *A climate of suffering*, p10

256 City of Melbourne, 2009, *Climate Change Adaptation Strategy*, p9

257 City of Melbourne, 2009, *Climate Change Adaptation Strategy*, p9

258 Department of Human Services Victoria, 2009, *January 2009 Heatwave in Victoria: an Assessment of Health Impacts*, p13

259 The Climate Institute, 2011, *A climate of suffering*, p19

260 The Age Online, February 3, 2009. *Heat-stressed possums suffer burnt feet* www.theage.com.au/national/heatstressed-possums-suffer-burnt-feet-20090203-7wgp.html

261 Low T. Department of Environment and Resource Management, Queensland Government, Brisbane, 2011, *Climate Change and Terrestrial Biodiversity in Queensland*

262 ABC News Online, 3 February 2010. Local help needed after endangered bird almost wiped out http://www.abc.net.au/local/stories/2010/02/03/2809096.htm

263 National Geographic Online, August 5 2011, *Carnaby's black cockatoo in trouble*, www.australiangeographic.com.au/journal/carnabys-black-cockatoo-in-trouble.htm

264 Department of Sustainability and Environment, 2009, *Yarra Bend Park Flying-fox Campsite: Review of the scientific research*, p12

265 Department of Primary Industries, 2010, Managing Servere Weather Events, Final Project Report, 23

266 Department of Primary Industries, Victoria, Dry seasonal conditions in rural Victoria. Report No. 86. 2009.

267 http://www.beefcentral.com/production/article/1063

268 Dairy Australia, *Cool Cows Online*, www.coolcows.com.au retrieved 18 October 2012

269 Dairy Australia, *Cool Cows Online*, www.coolcows.com.au retrieved 18 October 2012

270 Dairy Australia, *Cool Cows Online*, www.coolcows.com.au retrieved 18 October 2012

271 Lobell David B., Sibley, Adam and Ortiz-Monasterio J. Ivan, 2012, Extreme heat effects on wheat senescence in India, *Nature Magazine*, 29 January 2012

272 Extract from a paper currently under review (senior author Graeme Thomson)

273 Extreme Heat: Managing Grapevine Response, 1. School of Agriculture and Food Systems, University of Melbourne, 2. Centre for Australian Weather and Climate Research, a partnership between CSIRO and the Bureau of Meteorology, 3. John Whiting Viticulture Consulting.

274 Extreme Heat: Managing Grapevine Response, 1. School of Agriculture and Food Systems, University of Melbourne, 2. Centre for Australian Weather and Climate Research, a partnership between CSIRO and the Bureau of Meteorology, 3. John Whiting Viticulture Consulting.

275 Department of Health Victoria, 2011, *Heatwave Plan for Victoria*, p1

276 Department of Health Victoria, 2011, *Heatwave Plan for Victoria*, p10

277 The University of Melbourne, 2011, *Cool Roofs: City of Melbourne*, p4

278 The University of Melbourne, 2011, *Cool Roofs: City of Melbourne*, p4

279 City of Melbourne Online, 2012, *White roofs make for cooler Melbourne buildings*, accessed online on 18 October 2012 www.melbourne.vic.gov.au/AboutCouncil/MediaReleases/Pages/WhiteroofstomakeforcoolerMelbournebuildings.aspx

280 Bosco vertical in Milan, 2012, accessed online 18 October 2012, http://inhabitat.com/bosco-verticale-in-milan-will-be-the-worlds-first-vertical-forest/

281 Ibid.

282 http://www.water.vic.gov.au/livingvictoria/road-map accessed 23 October 2012.

Design and Artwork by Lisa Minichiello www.room44.com.au

CfES

Office of the Commissioner for Environmental Sustainability
Level 16, 570 Bourke Street | Melbourne Victoria 3000
T +61 3 8636 2197 | F +61 3 8636 2099 | www.ces.vic.gov.au | info.ces@ces.vic.gov.au