Potential opportunities for improved town and city bushfire protection across Australia.

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Contents

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Acknowledgements.

An earlier draft of this document has been issued in a forestry newsletter, in the NSW VFFA volunteer fire fighter newsletter and to a number of fire authorities, councils and individuals, seeking comment. Comments have been received and addressed from Phil Cheney, the author particularly notes the comments provided by Phil.

Other comments have been received Peter Rutherford, Vic Jurskis, Geoff Morris (CFA), Craig Hearson (CFA), Greg Potts (ACT Rural Fire Service) and Danny Goldspink at Tumbarumba. These comments are all very much appreciated.

One commenter noted "It has been an interesting read, very well researched and obviously written by someone both well informed and passionate about the subject". This also was appreciated

Limitations and disclaimer.

This document has been prepared and issued in good faith and has been prepared without payment, in order to aid progression of this important issue. The focus of the document is on potential opportunities for improved town and city bushfire protection across Australia, it is up to each town and city to select the best opportunities for each town and city.

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Again, it is up to each town/ owners to meet State/ Federal/ Local government town protection and management fire requirements. It is up to each applicable authority to consider potential opportunities and strategies to best protect towns and cities from bushfires and to best protect personnel involved in fighting bushfires within and adjacent to towns and cities. Opportunities and strategies adopted would likely vary with each town/ city, taking into account a broad range of issues, fire risks, fire seasons and differing opportunities. The document focusses on potential opportunities and strategies, but doesn't get into detail in regards to area or width specifics such as firebreaks to any great degree, some of this is covered in some of the guideline documents listed in this document.

In addition, any limitations would be outlined in the final town and city bushfire protection documents, as agreed with the parties involved.

1. Introduction and background information.

After the large bushfires impacting on towns and cities in recent years, it is opportune to review potential bushfire protection opportunities for towns and cities across Australia for the following reasons:

- There is not a lot of information available focussed on town and city bushfire protection planning, organisation and opportunities, including guidelines, and there is some information scattered in bushfire inquiries and royal commissions;
- There have been large bushfire impacts on a large number of towns and cities;
- There have been a number of learnings from town and city bushfire disasters;
- There have been a number of learnings in regards to house and surrounds protection measures; and
- In some cases, town and city bushfire risk assessments have underestimated the potential risks, hazards and threats.

It is good to tease out this information into one focussed document , teasing out potential bushfire protection opportunities for towns and cities across Australia. The focus of this document is on exploring all opportunities to best protect towns and cities from bushfires, optimising resident safety and optimising firefighter safety. It is up to each town/ city/ Local Government Area to develop strategies to best protect towns/ cities from bushfires, explore opportunities and to best protect personnel involved in fighting bushfires within towns and cities, addressing applicable state requirements. Hopefully, this document will assist in exploring and teasing out potential bushfire protection opportunities for towns and cities across Australia.

The document has been issued in good faith in order to aid progression of this important issue.

Additional ideas, opportunities, comments and input will be considered, and where feasible, can be added in into this document at a later date.

Background information is provided in Appendices to this document, under the headings laid out below:

- Appendix 1. Town and city bushfire impact case studies;
- Appendix 2. Town and city bushfire protection case studies;
- Appendix 3. Reducing bushfire risks, hazards and threats to towns and cities; and
- Appendix 4. Specific at residence bushfire risk, hazard and threat management.

2. Impacts of bushfires on people, towns and cities.

Impacts of bushfires on people, towns and cities include:

- Human impacts;
- Houses and other structure losses;
- Economic impact on towns, and associated farm, forest, viticulture, tourism and other industries;
- Impact on road infrastructure, including roads, houses, outbuildings, other structures, telecommunications, electricity and fences;
- Impact on air quality from bushfire smoke. This is demonstrated in air quality data across the country between August 2019 and February 2020;
- Impact on native fauna. There is a fair amount of native fauna and large wildfires result in the loss of most of this fauna;
- Impact on water quality/ erosion/ sedimentation/ waterways; and
- Impact of bushfires on greenhouse gas emissions is huge.

There have been extensive house and other structures lost across Australia from bushfires over the last ten years. This is emphasised in Table 1 below.

Table 1. House and other structures lost across Australia from bushfires. Note, not all these losses would have been in towns, but big numbers were. Extracted from Wikipedia 18 April 2020.

Year	Building losses
2019 2020	2,779 homes and over 2,121 other buildings
2018 2019	76 houses, 82 other buildings, best estimate.
2017 2018	94 buildings
2016 2017	58 houses, 2 other structures
2015 2016	408 houses, 500+non residential houses
2014 2015	48 houses, 160+ non residential structures.
2013 2014	371 houses, 200+ non residential structures.
2012 2013	310 houses, 330+ non residential structures.
2011 2012	39 buildings.
2010 2011	84 houses, 4+ non residential structures.

As be seen from Table 1, houses and other structure losses have been very large. It is estimated that there have been of the order of 4,200 house and also of the order of 3,400 other structure losses over the ten years, not all in towns, but many are.

Further detail on Australian bushfires involving major house losses is provided below in Table 2. This information was extracted Table 1 from Blanchi R. and Leonard L., 2005, Investigation of Bushfire Attack Mechanisms Resulting in House Loss in the ACT Bushfire 2003 Bushfire CRC Report April 2005.

Table 2. Further detail on Australian bushfires involving major house losses. Note, not all these losses would have been in towns, but big numbers were. Extracted from Table 1 from Blanchi R. and Leonard L., 2005.

Table 1. Australian bushfires involving major house loss since 1939 (Leonard & McArthur 1999)

Date	Location	House loss	Research into building loss
January 1939	Victoria	1300*	Nil
January 1944	Victoria (Beaumaris)	927 (58)	 G. Barrow, CSIR, selective survey
December 1957	Leura, NSW	123	Nil
January 1961	Dwellingup, WA	132	A. G. McArthur, general survey
January 1962	Dandenong Ranges, Victoria	454	Nil
February 1967	Hobart, Tasmania	1300+	CEBS/CSIRO, questionnaire
1967/68	Dandenong Ranges, Victoria	53	Nil
November 1968	Blue Mountains, NSW	Some	R. Cole, CEBS, selective survey
January 1969	Lara	251*	Nil
February 1977	Western District, Victoria	116	CSIRO/CFA, rate of spread only
January 1983	Victoria, SA (Mount Macedon, Victoria) (Otway Ranges, Victoria)	1511 (234) (729)	 A. Wilson, in-depth survey CSIRO, in-depth survey
January 1985	Avoca/Maryborough	61	CSIRO, general survey
January 1994	Sydney and surrounds	202	CSIRO, in-depth survey
January 1997	Dandenong Ranges, Victoria	40	CFA, in-depth survey

* 'Structures', not necessarily houses.

Appendix 1 outlines many town and city bushfire impact case studies, the scale of devastation of many of these case studies is very large. Appendix 2 outlines town protection case studies. Information extracted from the case studies has been used in developing integrated bushfire protection opportunities and measures for towns and cities in Section 7.

3. Reducing bushfire risks, hazards and threats to towns and cities.

Detail in regards to these issues is outlined in Appendix 3.

4. Understanding the importance of town and city bushfire protection and the costs of major bushfires.

Town and city bushfire protection is very important and at times under recognised at government, local government and community levels.

Reasons why town and city bushfire protection is very important and necessary include:

- Improved human and animal safety, a lot of people live in towns and cities and bushfires can and do enter these areas;
- Fire fighter safety is improved where there are good town, city and individual house bushfire defences, strong community bushfire involvement and sound training;
- Increased protection of valuable infrastructure, including residences, buildings, buildings and other infrastructure;
- Rebuilding costs are reduced, these can be huge and often are more expensive to new bushfire standards;
- Rebuilding can take time and community stresses can build up in communities;
- Reduced Government bushfire assistance requirements if town and city bushfire impacts are avoided or reduced. As an example the Western Australian State Government spent $64 million rebuilding Yarloop and the surrounding communities after the 2016 bushfires;
- Hopefully, with good town, city and home bushfire defences and systems, bushfire insurance can be reduced; and
- Reduced loss of heritage structures in bushfires.

The costs of bushfires in towns and cities can be very large. In the 2003 ACT fires, four people died, there were 435 non-fatal injuries, 488 houses were destroyed and the cost was $350 M. On 6 January 2016, the communities of Yarloop and surrounding areas in the Shires of Harvey and Waroona (south-west WA) were hit by a devastating bushfire that killed two people and destroyed 181 homes

A document titled The Hidden Cost of Bushfires by Roger Underwood on the VFFA website dated 31 August 2018 provides additional information in regards to the costs of bushfires.

The costs of bushfires in towns and cities includes many factors:

- Lost lives and injured people;
- Lost houses, infrastructure, bridges, telecommunications, electricity and fencing;
- Lost stock and fauna;
- Inadequate insurance payments to meet new house and infrastructure construction;
- Lost businesses;
- People leaving town after bushfires;
- Costs of extra people to defend bushfires such as town brigades;
- Lost town amenity; and
- Government recovery costs.

This document outlines a considerable number of opportunities to increase town and city bushfire protection and set up stronger town and city bushfire protected communities. The reasons why town and city bushfire protection is necessary and very important (as outlined above) needs to be considered in addressing opportunities to increase town and city bushfire protection. The costs of bushfires in towns and cities (as outlined above) needs to be considered in addressing opportunities to increase town and city bushfire protection.

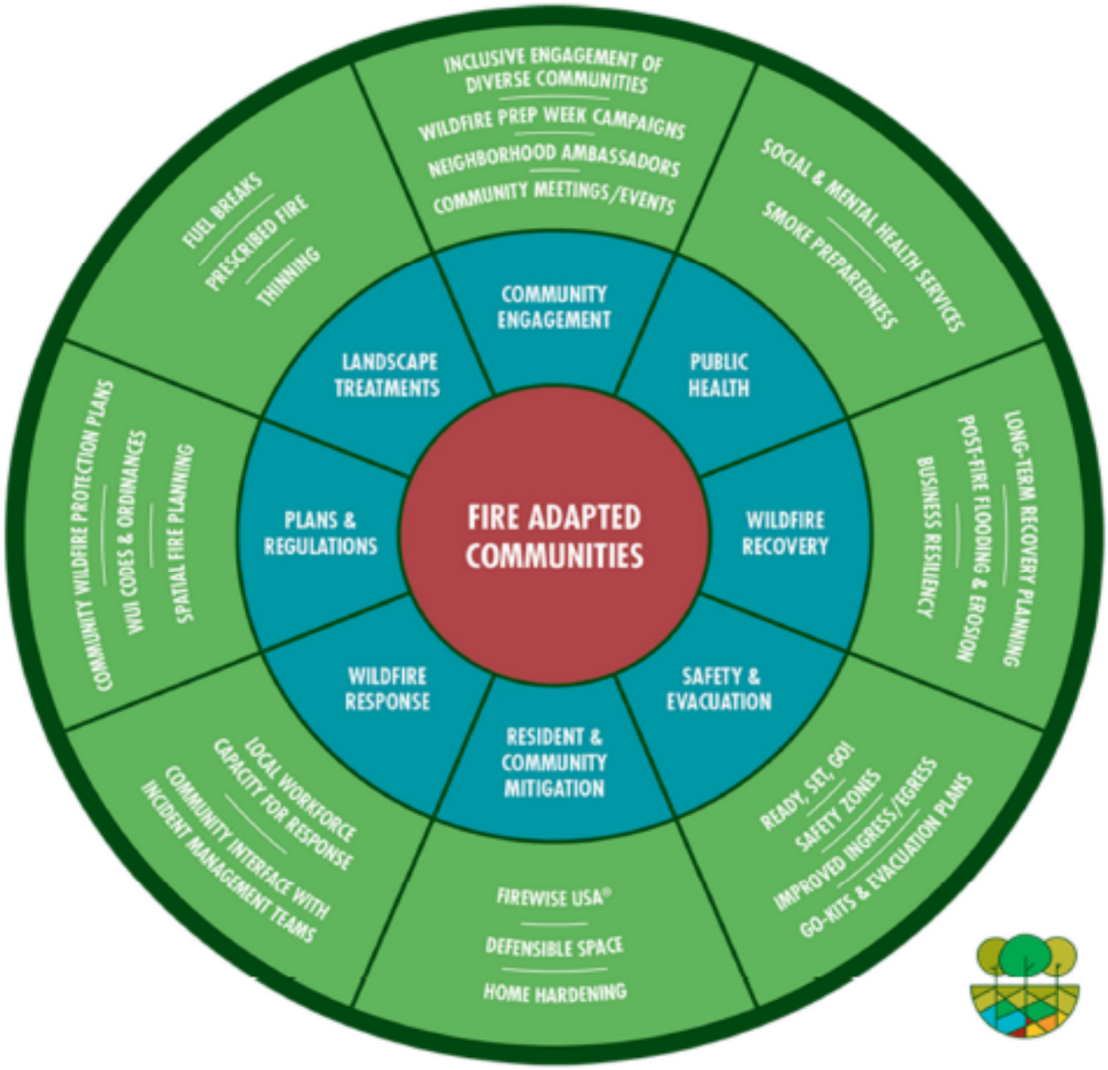
5. Community involvement and actioning to reduce bushfire risks, hazards and threats to towns and cities.

In NSW, Australia, the Kangaroo Valley Community Bushfire Committee (KVCBC) has prepared numerous submissions to the 2020 NSW Bushfire Inquiry and compiled them as one document for consideration by the Inquiry, source Kangaroo Valley Community Bushfire Committee, 2020, Compendium of Submissions to the NSW Independent Bushfire Inquiry and also a covering letter of 7 April 2020. Key points from the documents include:

- The KVCBC is a community-based organisation made up of residents from Kangaroo Valley. It was formed in September 2018, following a large public meeting called by the then Kangaroo Valley Rural Fire Service (RFS) Volunteer Brigade captain and the local police officer to discuss the risk and potential impact of bushfire in the valley;

- Work done by the KVCBC has highlighted bushfire mitigation planning deficiencies within a number of agencies. They include a local bush fire risk management plan that fails to include critical infrastructure, generic fire-fighting plans that do not address unique features within the locality and a failure to adopt recommendations from previous inquiries, such as, the 2009 Victorian Bushfire Royal Commission. One of the key recommendations from the Victorian Inquiry was to support liaison with local communities in bushfire preparation and to adopt community-based plans as part of the planning and preparation process;
- They note that the current model that is largely reactive, waiting until a major bushfire event occurs before a response plan is formulated and action taken. In comparison, the Kangaroo Valley community has sought to mitigate bushfire impact by preparing well in advance for bushfire events that, unfortunately, are inevitable and likely to become more regular;
- They note that due to KVCBC initiatives, the community has reached a point where there is now a far greater awareness of bushfire risk as well as sophisticated communication linkages and bushfire ready neighbourhood plans in many neighbourhoods. The Currowan fire experience proved that the preparations made by our community worked and, indeed, mitigated to a large degree the threat posed by this fire. Importantly, despite structures being destroyed, no lives were lost;
- In conceptualising how to formulate a resilient community plan, aviation principles of a safety management system were adopted. Aviation safety systems promote a proactive and predictive response to risk by identifying pre-existing conditions or risks and removing them or reducing their effects to a tolerable level; and
- Community information and safety. In the experience of KVCBC, bushfire emergency information systems need improvement including the Fires Near Me application. Effective and humane evacuation of vulnerable people and people with animals, both during days of Severe, Extreme or Catastrophic fire risk and during an actual bushfire, needs greater attention. The current Community Protection Program is inadequate and more needs to be done in policy-making and planning bushfire refuges. Detailed public information is needed on private bushfire shelters and household sheltering. There is a strong need to identify other safer locations and communities need guidance in this regard. Detailed guidelines are also needed on landscaping around buildings and retrofitting of buildings including last-minute retrofits.

In 2009, the Federal Land Assistance, Management and Enhancement (FLAME) Act initiated the National Cohesive Wildland Fire Management Strategy. The goals of this strategy were to create Fire Adapted Communities, create resilient landscapes, and improve wildland fire response and suppression. Fire Adapted Communities in the USA use a wide range of techniques to reduce bushfire risks, increase community involvement, reduce health risks, increase safety and increase landscape safety as emphasised in Figure 1 below. This is extracted web data from Colorado Fire Adapted Communities, 2020, Colorado State Forest Service, 6 December 2020.



Credit: Fire Adapted Communities Learning Network (FAC NET)

Figure 1. use a wide range of Techniques used by Fire Adapted Communities in the USA to reduce bushfire risks, increase community involvement, reduce health risks, increase safety and increase landscape safety. This is extracted web data from Colorado Fire Adapted Communities, 2020, Colorado State Forest Service, 6 December 2020.

The FAC Self-Assessment Tool (FAC SAT) is a tool that helps communities understand where they are in their fire adaptation journey, and identify priorities and potential actions. It aids communities in assessing their progress and tracking their capacity to live safely with wildfire over time. It can be used to assess individual neighborhoods, cities and even large counties.

The FAC SAT is designed to help community members:

- Establish their community's values at risk, such as recreational resources, tourism industries, homes, etc;
- Identify their community's capacity to implement FAC actions;
- Assess any gaps or limitations in funding, resources, partnerships, workforce, and/or volunteers;
- Prioritize future fire adaptation actions;
- Complement other work plans; and
- Increase understanding of long-term community fire adaptation needs.

Wildfire Risk to Communities is a free, easy-to-use US website managed by the USDA Forest Service with interactive maps, charts, and resources to help communities understand, explore, and reduce wildfire risk. It was created by the USDA Forest Service under the direction of Congress in the 2018 Consolidated Appropriations Act (H.R. 1625, Section 210). As wildfires increase in frequency and severity across the country, Wildfire Risk to Communities uses the best available science to not only identify risk, but also provide resources for communities to manage and mitigate risk. Wildfire Risk to Communities is designed to help community leaders such as elected officials, community planners, and fire managers understand how risk varies across a state, region, or county and prioritize actions to mitigate risk. This is the first time that maps and data about community wildfire risk are available nationwide. As a national project, Wildfire Risk to Communities is best for comparing risk among rather than within communities, and it is not designed for considering risk at the local, neighborhood, or individual home scale.

The US Community Guide to Preparing and Implementing a Community Wildfire Protection Plan, 2008, August, A supplemental resource guide to Preparing a Community Wildfire Protection Plan: A Handbook for Wildland-Urban Interface Communities. March 2004 outlines:

- Establishing and maintaining a Community Wildfire Protection Plan (CWPP) depends on widespread collaboration among landowners, emergency response agencies, and federal, state and local officials. The new Community Guide offers innovative strategies, case studies and other resources to improve coordination and communication among stakeholders as they develop, implement, and monitor the success of a CWPP;
- Healthy Forests Restoration Act (HFRA 2003) requirements for a CWPP are Collaboration; Prioritized Fuel Reduction and Measures to reduce Structural Ignitability; and
- One of the most successful tools for addressing these challenges is the Community Wildfire Protection Plan (CWPP). Through these plans (in 2008), nearly 4,800 communities across the nation have developed collaborative strategies to reduce their risk from wildfire and restore healthier, more resilient conditions in their surrounding forests. However, with at least 51,612 communities at risk across the United States, there is still much work to be done.

The US has other wildfire programs in place:

- Firewise USA sites;
- Ready Set Go; and
- Local Wildfire Safety Councils.

Considering Australian and USA community programs above and the scale of bushfire impacts in Australia, here appear to be huge opportunities to increase community involvement in bushfire planning, preparedness and actioning.

6. Town and city bushfire protection guideline and information documents.

There is some useful guideline and information in regards to town and city bushfire protection outlined in Table 3. This has been sorted into categories to assist in information sourcing.

Table 3. Useful guideline and information in regards to town and city bushfire protection.

Legend.

- F=Fuel management.
- R=Risk, hazard and threat management.
- G=General bushfire information.
- W=Weather information/ considerations.
- B=Building design for bushfires.
- C=Community awareness/ involvement.
- RC=Rebuilding costs of building and infrastructure.

Guideline and information document.	Information document coverage, Legend.
R Blanchi and J Leonard, 2005, Investigation of Bushfire Attack Mechanisms Resulting in House Loss in the ACT Bushfire 2003 Bushfire CRC Report April 2005;	F, R, G, W, B
ACT Fires January 2003, Submissions of Counsel Assisting Inquests into the Death of Dorothy McGrath, Alison Mary Tener, Peter Brabazon Brooke and Douglas John Fraser and Inquiry into the Fires of January 2003, Lex Lasry QC Ted Woodward, Counsel Assisting the Coroner 2 April 2006.	F, R, G, W
ACT Coroners Court 2006,The Canberra Firestorm Inquests and Inquiry into Four Deaths and Four Fires between 8 and 18 January 2003 Volume I Maria Doogan, Coroner, December 2006.	F, R, G, W, B, C
Ferguson, E. 2016, Government of Western Australia, 2016, "Reframing rural fire management", report of the special inquiry into the January 2016 Waroona fire. 29 April 2016.	F, R, G
Mika Peace, Jeffrey D. Kepert, Lachlan McCaw, Neil Burrows, Bradley Santos, Robert Fawcett, 2017, Lessons learned from a multidisciplinary investigation into the Waroona fire non-peer reviewed research proceedings from the Bushfire and Natural Hazards CRC & AFAC conference Sydney, 4 – 6 September 2017	G, W
CSIRO Forestry and Forest Products, 2004, by Andrew Sullivan Nature of Severe Fire Events Client Report for Fire Management Unit Department of Urban Services ACT Government CSIRO Forestry and Forest Products July 2004.	F, G, W
McLeod Ron, 2003, Inquiry into the Operational Response to the January 2003 Bushfires in the ACT, 1 August 2003	F, G
Cheney NP 2011 How can we protect residents from bushfires? March 2011.	F, R, G, C
NSW Rural Fire Service 2019. Planning for Bush Fire Protection (PBP) and the current legislated version that is adopted is PBP 2019.	F, R, G, C
Kangaroo Valley Community Bushfire Committee, 2020, Compendium of Submissions to the NSW Independent Bushfire Inquiry and covering letter of 7 April 2020	G, B, C
Fire Adapted Communities, FAC Self-Assessment Tool (FAC SAT), refer web site.	F, R, B, C
NSW Rural Fire Service, undated, Standards for low intensity bush fire hazard reduction burning (for private landholders).	F, R
Bushfire Centre of Excellence, Department of Fire and Emergency Services (WA), 2021, Burn SMART, A planned burning guide for small landholders. April 2021.	F, R, W
Bushfire Front, 2020, Protecting towns from Bushfires, includes practical approaches to protecting towns from bushfires using vegetation thinning and follow up hazard reduction burning to protect WA towns.	F, C
AFPA, 2020, Using Fire and Machines to Better Fire-Proof Our Country Towns, Australian Forest Products Association, February 2020. They note the need to also use mechanical biomass removal to reduce understory and dense forest regrowth, in conjunction with fuel reduction burns, in strategic areas to reduce the intensity of forest fires close to communities and assets.	F, G, C
Bushfire Fuel Management Guide for the Protection of Townships and Settlements, undated, Southern and Eastern Metropolitan Fuel Management Working Group (Victoria).	F, R, G, C

Guideline and information document.	Information document coverage, Legend.
Bushfire CRC, 2010, Bushfire Penetration into Urban Areas in Australia: A Spatial Analysis, January.	F, R
Bushfire Front, undated, Community Bushfire Preparedness, A Checklist for Residents in Bushfire-Prone Areas, web November 2020.	F, R, G, W, C
Bushfire Front, undated, Yarloop Case Study, A case study on the protection of rural buildings from fire- Yarloop School.	F, R
Bushfire Cooperative Research Centre, 2011, Extension: Communicating Risk - Human Behaviour Under Stress (2) Project Occasional Report Number 1: 2011 Checklist Items for Researchers: Householder Preparations for Bushfires Jim McLennan & Glenn Elliott July.	R, B
BDAA, 2020, Stepping Up: Australia Must Improve Bushfire Protection Measures – Building Design Association of Australia. Web.	G, B
VBA, undated, Bushfire Protection, Victorian Building Authority.	B
CFA and Building Commission Victoria (undated), A guide to retrofit your home for better protection from a bushfire Prepare. Act. Survive. Building and renovation ideas to better prepare your home in a bushfire situation.	R, B
Building Commission, Department of Commerce, Government of WA, Building for better protection in bushfire areas A homeowner's guide	R, B
NSW Rural Fire Service, 2012, Bush Fire and Your Home Prepare your home and property for bush fires, E 2.	F, R, B
CFS, 2020 (web), Building in bushfire-prone areas.	F, R, B
Think Brick Australia, Building in bushfire-prone areas, undated.	R, G, B
US Forest Service, undated, Fire Adapted Communities 4 pp.	F, R, C
USDA Forest Service, Wildfire Risk to Communities (free, easy-to-use US website).	R
US Forest Service, 2012, Best Management Practices for Creating a Community Wildfire Protection Plan General Technical Report NRS-89, January.	G, C
Colorado Fire Adapted Communities, 2020, Colorado State Forest Service, 6 December 2020.	F, R, B, C
Community Guide to Preparing and Implementing a Community Wildfire Protection Plan, 2008, August. A supplemental resource guide to Preparing a Community Wildfire Protection Plan: A Handbook for Wildland-Urban Interface Communities. March 2004.	F, R, G, B, C
Headwaters Economics, 2016, Land Use Planning to Reduce Wildfire Risk: Lessons from Five Western Cities, January.	R, R, G, W, C
VFFA website, 2018, The Hidden Cost of Bushfires by Roger Underwood dated 31 August 2018.	F, R, B, C, RC

It is recommended that local government, house owners and businesses access applicable documents and consider them in their local bushfire risk management plans/ residence management.

7. Key principles in regards to town and city bushfire protection.

Key principles in regards to plantation bushfire protection are outlined in a 2020 document by Ferguson E and Saunder G, (2020) titled "The Pillars of Plantation Fire Management" dated 4 November 2020. 15 pillars are listed in that document.

These pillars have been refined by the author into 24 key principles in regards to town and city bushfire protection principles:

1. Sound development/ town planning controls in regards to new developments in bushfire prone areas. Undertake well thought out new subdivisions, roads set up for safe firefighting access, suitable access tracks and buffers, heavy vegetation areas thinned/ treated as per requirements to reduce bushfire risks, breaks adjoining forested areas, well located fire hydrants. Set up water supply pipes, hydrants and overhead stand pipes for tankers and slip on units in areas both inside and outside towns. Install signage for all fire accesses, stand pipes and water fill up points;
2. Undertake annual risk, hazard and threat assessment to assess and manage risks, hazards and threats inside and outside towns/ cities. Develop town and city bushfire actions based on annual risk assessment: Knowing, analysing and acting on the risk and developing treatment options based on the likelihood and consequence of bushfires. Actions change and adapt based on the changes in risk;
3. Undertake annual review of Bush Fire Management Plan/ fire protection plan/ bushfire risk management plan in place for all towns and cities;
4. Address safety, including the preservation of life, health, welfare and fatigue management, is the foremost considerations for all responders and in the design of towns and cities, water resources, access, equipment, communication and training of firefighters. Quick and safe fire management is recognised as a goal at board, executive, organisational, individual and industry levels;
5. Increase access tracks/ breaks inside towns to increase speed of access. Breaking the town/ city into zones can assist in defending the town/ city;
6. Set up stand pipes and water supply dams, bores and tanks throughout towns and cities and boundaries. Consider innovations to use/ transfer water to strategic areas to assist with firefighting outside towns;
7. Encourage and set up fire safe houses, outbuildings and gardens, with any mulch beds away from houses. Undertake voluntary Council/ fire authority house/ structure/ garden bushfire safety reviews/ audits to make these areas safer in bushfires. Consider measures as outlined in Appendix 4 of this document;
8. Apart from assessing risks, threats and hazards, also consider town, city and structure rebuilding costs, overall rebuilding costs, timeframes in rebuilding after wildfires, costs of rebuilding to new bushfire standards will be greater and delays in rebuilding likely considerable;
9. Manage and reduce fuel loads. Everything hinges on fuels management within and around towns and cities. Fuel risk assessment should be an annual and recurring consideration. Undertake dangerous bushfire tree removal program in towns, maybe annually. Local government undertake annual slashing of all non-mown properties in towns/ cities, where required slashing/ fuel management hasn't been completed, before the start of the bushfire season. Undertake annual hazard reduction burns in timbered areas at the town boundary, strategic areas inside towns and outside towns. Remember the importance of cool burning across landscapes to assist in town and city bushfire protection;
10. Encourage bushfire community groups, alliances, street fire safety groups and community meetings in regards to bushfire risks, hazards and threats and increase house and structure bushfire defendability. Consider using information from the US Fire Adapted Communities;
11. Set up alliances for coordinated fire management. Conduct regular meetings with local bushfire brigades and other parties to increase cooperation, optimise training, outline available resources, ideas, concerns, optimise speed of initial attack and planning upcoming hazard reduction burning;
12. Prevent and minimise the risks of new fires starting. Carrying out silvicultural and mitigation actions to reduce risk and also so as to reduce damage risk when (inevitably) fires occur;
13. Set up equipment, tools and gear that support firefighting tactics. This includes equipment for the transport, delivery and application of water for fire suppression. Optimise slip-ons/ pumps on as many Local Government vehicles as possible in Very High and higher Bush Fire Danger Periods. Consider innovations in fire tanker design;
14. Establish efficient systems to quickly detect, locate, report and geo-reference new and incipient fires for quick coordinated initial attack. Camera and satellite systems have advantages but fire towers can cover large areas;
15. Set up systems and triggers for the escalation of available and competent firefighting resources as the risk increases. Identify and update safe emergency location areas;
16. Ensure a safe, fast and determined initial attack to new fires utilizing all available firefighting resources. This includes provision of information and warnings to the community,

neighbours, industry partners and key stakeholders. Consider early use of retardant aircraft after lightning strikes and fire outbreaks;

17. Ensure the initial coordinated attack can be extended and escalated as the risk increases. Additional resources of competent firefighters are able to be concentrated where they will have the best effect. Firefighting operations can be sustained throughout the first work period;
18. Establish competent people for forest fires: Crews and tactical leaders are confident and competent in safe fire suppression techniques. They have the skill and judgement to recognise when to advance and when to fall back. All firefighters in forests must have good training and be led by experienced forest firefighters;
19. Set up unity of command, as fires do not recognise boundaries. Therefore, the approach to town and city fires is cooperative, with agencies and organisations working together in a collective and collaborative manner with a common purpose and a common plan;
20. Fire leadership in bushfires is critical. A culture that promotes the establishment of a leader's intent, then enables delegation of tasks to subordinate personnel. Distributed leadership requires team understanding, trust, balanced risk taking and the exercise of considered initiative;
21. Consider classification of all critical infrastructure in towns and cities. Town and city owners get involved in State, Regional and local bushfire planning to ensure due consideration is given to the economic and social value of the towns and cities and protection of these areas;
22. Increase town and city protection measures and preparedness in years likely to be extreme fire danger years using specialised climate services;
23. Encourage all firefighting personnel and interested community to have access to bushfire apps; and
24. Set up processes for continuous improvement, with a culture of inquiry and discovery, lessons identified and lessons learned in regards to bush fire assets protection and bush re fighting. Reporting and checking on whether we have done what we said we would do.

8. Potential bushfire protection opportunities and measures to reduce bushfire risks, hazards and threats to towns and cities.

In regards to specific widths of fire breaks and specific protection measures, actual widths/ distances aren't used as a lot of factors need to be considered, including adjacent vegetation type and height, adjacent land ownership, willingness to undertake hazard reduction burning, land slope and other factors.

Potential town/ city bushfire protection opportunity areas are outlined in Table 4.

Table 4. Potential town/ city bushfire protection opportunity areas.

Note 1. Legend.

- R=Risk, hazard and threat assessment approaches and assessment of all bushfire issues for each town and city, preferably annually.
- D = Design protection and management measure.
- HR = Hazard reduction measure.
- HRB = Hazard reduction measure.
- S = Safety bushfire protection and management measure, including bushfire coordination and forest bushfire training.
- C = Community bushfire cooperation measure.
- INT = Quick initial bushfire identification and bushfire attack measure.
- REC = Reducing town and city recovery cost measure where possible following bushfires.
- IMP = Highlighting the importance of town and city protection measure and the need to protect this key infrastructure.
- RC=Rebuilding costs of building and infrastructure consider in bushfire opportunity planning.

Note 2. Another form of sorting, used in Table 4.

- Risk assessment to tease out major bushfire risks to towns and cities and the scale of those risks.
- Planning.

- Town/ city design bushfire protection and management measure.
- House design bushfire protection and management measure.
- Town/ city fire protection.
- Audit.
- Alliances.
- Access and breaks.
- Water supply.
- Fuel management.
- Hazard reduction burning (HRB).
- Quick initial attack
- Infrastructure.
- Rebuilding costs of building and infrastructure consider in bushfire opportunity planning.

Note 3.

This includes assessment of such matters as if bushfire protection measures in place, risks, if the opportunity is an option, opportunity effectiveness, cost, infrastructure replacement cost and time and season issues.

Note 4.

This assessment could be based on a quick assessment of the Benefit : Cost or feasibility of each selected opportunity or based on the total selected bushfire opportunity costs. The town/ city could assess Benefit : Cost over 1 year or longer periods and for different town and city losses, possibly at 1 %, 5 %, 10 %, 20 %, 30 %, 40 % , 50 % and higher losses.

Potential town/ city bushfire protection opportunity area.	**Legend. Note 1.**	**Primary single issue. Note 2.**	**Assessment. Opportunity assessment. Note 3.**	**Quick assessment of Benefit: Cost. Note 4.**
Undertake risk, hazard and threat assessment to assess and manage risks, hazards and threats inside and outside towns/ cities, preferably annually. Because threat involves the intensity of the bushfire, fire protection planning should be based on the bushfire threat that involves under the "worst possible" or "worst recorded" fire weather conditions. While the risk may be low, the threat can be very high in Australian towns and cities, depending on the amount of fuel both in the environs and importantly within the township and the individual home gardens	R, HR, S, REC	Risk assessment		
Local government have a Bush Fire Management Plan/ fire protection plan/ bushfire risk management plan in place for all towns and cities, preferably each town/ city. Fire services and town brigades would need to be included. Hazard reduction, audits, non-compliances, community training, access to hydrants, land owner fire plans etc would be discussed annually. Annual updates of plans would be required. Improved fire planning and coordination of hazard reduction for town defences, including access tracks, permanent breaks	R, D, HR, S, C	Planning		

Potential town/ city bushfire protection opportunity area.	Legend. Note 1.	Primary single issue. Note 2.	Assessment. Opportunity assessment. Note 3.	Quick assessment of Benefit: Cost. Note 4.
that are seeded after fires, steel fencing, designated hazard reduction zones etc.				
Well thought bushfire requirements/ town planning, including new subdivisions/ developments, roads set up for safe firefighting access, suitable access tracks and buffers, heavy vegetation areas thinned/ treated as per requirements to reduce bushfire risks, breaks adjoining forested areas, well located fire hydrants.		Town/ city design.		
Encourage fire safe houses, outbuildings and gardens, with any mulch beds away from houses. As noted in the 2003 Canberra bushfire case study, it is desirable to have a fuel-reduced area around a building to reduce the level of hazard, in particular the risk of attack by flame contact and radiant heat. Suggest the benefits of retrofitting basic firebrand protection provisions to homes as defined in AS 3959. Encourage vent protection systems in older houses, using metal mesh with holes smaller than 2mm. Review house eves and under floor space. In the 1967 Hobart fires, houses were generally ignited by wind driven embers lodging in the eaves or beneath the house. In many instances doors and windows were left open and the interior of the house ignited. Review outbuildings as these represent a significant additional attack on the main structure through flame radiation and ember source, with many more gaps due to cheap construction and therefore more susceptible to ember attack. Sheds and garages often also contain a large number of readily combustible items like stored timber, paint tins and so on. Consider the costs of rebuilding and delays, better to focus on protecting current assets from bushfires. Consider measures as outlined in Appendix 4 of this document.	D, R, HR, S, C, REC, RC	House design (Also Rebuilding costs)		
Increase town and city protection measures and preparedness in years likely to be extreme fire danger years using specialised climate services. This could be ploughed or graded brakes around houses or at strategic points.	R, D, HR, S, C	Town/ city fire protection.	.	
Undertake dangerous bushfire tree removal program in towns, maybe annually. This would need to meet any Council	R, HR, S, C	Town/ city fire protection.		

Potential town/ city bushfire protection opportunity area.	Legend. Note 1.	Primary single issue. Note 2.	Assessment. Opportunity assessment. Note 3.	Quick assessment of Benefit: Cost. Note 4.
requirements and state vegetation clearance distances/ requirements that apply in regards to bushfire risks e.g. such as under the 10/ 50 metre. Vegetation too close to houses, some conifers, some old trees etc.				
Identify and update safe emergency location areas.	D, HR, S, C	Town/ city fire protection.		
Undertake regular bushfire training days between Councils, bush fire brigades, town brigades, farmers and volunteers. This training can also be completed with hazard reduction burning operations.	HR, S, C	Town/ city fire protection		
Optimise slip-ons/ pumps on as many Local Government vehicles as possible in Very High and higher Bush Fire Danger Periods.	R, HR, S	Town/ city fire protection		
Trial/ use fire retardant in slip-on/ tanker units in strategic areas before bushfires arrive to slow the spread or intensity of a fire to help fire fighters on the ground to control and contain a fire and help protect properties. Also, consider trial/ use of fire retardant on nominated higher risk houses to reduce bushfire risks to houses. Consider short- and longer-term fire retardants.	R, HR, S, C	Town/ city fire protection		
Consider innovations in fire tanker design. One option could be using 20,000 litre tankers (or water supply trucks) with 2-3 water cannons on top, manoeuvrable from the cabin.	D, HR, S	Town/ city fire protection		
Undertake voluntary Council/ fire authority house/ structure/ garden bushfire safety reviews/ audits to make these areas safer in bushfires.	R, HR, S, C	Audit		
Encourage bushfire community groups, alliances, street fire safety groups and community meetings in regards to bushfire risks, hazards and threats in and outside towns/ cities/ across the landscape and increase house and structure bushfire defendability. Initiatives underway include i.e. Kangaroo Valley in NSW, fire adapted communities in the USA and Safer Together in Victoria. A critical issue is training newcomers in bushfire issues and fire safe gardens. Another is addressing town and city bushfire fuels and safety across landscapes. This could be tied in with insurance premiums, with lower premiums with street fire safety groups and individual town and city bushfire protection plans/ community bushfire groups in place. This creates	R, HR, S, C, REC	Alliances. Town/ city fire protection		

Potential town/ city bushfire protection opportunity area.	Legend. Note 1.	Primary single issue. Note 2.	Assessment. Opportunity assessment. Note 3.	Quick assessment of Benefit: Cost. Note 4.
incentive. The problem is non active members, this can be sorted over time.				
Ensure safe bushfire accesses around town boundaries preferably with no dead ends. Review opportunities to improve layout of accesses. This has other advantages in speed of fire attack and fire safety.	R, D, HR, S, C	Access and breaks		
Set up strategic bushfire break buffers around towns/ cities and improve access and protection in those buffer zones. Fire break widths calculated adjacent fire hazard, slope, land ownership etc Strategic areas ploughed fire breaks/ raked annually in December or just before the peak fire danger period. As noted in AFCA, 2020, federal, state and local governments should work more closely with rural communities to create buffers within a 5km radius of at-risk towns and strategic assets. This will reduce fuel loads and improve access for firefighters, which in turn will reduce the risk of bushfires developing and engulfing towns and important rural assets.	R, D, HR, S, C	Access and breaks		
Increase access tracks/ breaks inside towns to increase speed of access. Breaking the town/ city into zones can assist in defending the town/ city.	D, HR, S, C	Access and breaks		
Set up water supply pipes, hydrants and overhead stand pipes for tankers and slip on units in areas both inside and outside towns. This may seem expensive, but over the life of 50-60 years, this would be relatively inexpensive considering the impacts and costs of bushfires. Utilise town water supply networks where available. Seek approval to integrate with town supply networks where they exist, with the water used only for fire suppression. If not available, may need the setting up of additional water supply network.	D, HR, S, REC	Water supply		
Install or set up firefighting water supply dams in central locations, for slip on, tanker and helicopter water supply. Could set up hydrants next to these so dams can be filled up in quiet times in fire danger periods, at a time they can start drying up. These locations would need to be safe.	D, HR, S, C, REC	Water supply		
Local government undertake annual slashing of all non-mown properties in towns/ cities, where required slashing/ fuel management hasn't been completed, before the start of the bushfire season. Residents would likely be charged for works where not completed on time.	R, HR, S	Fuel management		

Potential town/ city bushfire protection opportunity area.	Legend. Note 1.	Primary single issue. Note 2.	Assessment. Opportunity assessment. Note 3.	Quick assessment of Benefit: Cost. Note 4.
Encourage grazing in high risk/ hazard and threat bushfire areas beside towns/ cities that aren't grazed.	R, HR, S, C	Fuel management		
Undertake vegetation thinning/ weed removal in high risk, hazard and threat areas, with mulch stacked away from trees and burnt or mulched.	R, HR, S	Fuel management		
Undertake blackberry control at fire breaks, town boundaries and waterways. Biological control of blackberries needs to be ramped up as an issue of national importance.	HR, S, C	Fuel management		
Undertake annual hazard reduction burns in timbered areas at the town boundary and strategic areas inside towns. Steep slopes near/ beside towns/ cities would likely have regular hazard reduction operations to reduce bushfire risks, hazards and threats. The document NSW Rural Fire Service, undated, Standards for low intensity bush fire hazard reduction burning (for private landholders) is useful in regards to planning for cool burning. This can also be used to assist in removal of weeds. Cool burns are also important for native forest health.	R, HR, HRB, S, C	HRB		
Undertake regular hazard reduction burns in timbered areas outside town boundaries across landscapes (up to 10-30 kms out) to reduce risks, hazards and threats of massive bushfires getting into or close to towns or from firebrand entry into towns/ cities. These hazard reduction burns won't stop fire in high bushfire danger periods, but will increase opportunities for bushfire defence. This issue cannot be ignored in town and city bushfire protection planning. A very important finding from the ACT Coroners Court 2006,The Canberra Firestorm Inquests and Inquiry into Four Deaths and Four Fires between 8 and 18 January 2003 Volume I Maria Doogan, Coroner, December 2006: "that there be an ongoing program of back-burning and fuel-load management across the ACT, to ensure that at all times forestry and other access roads are kept clear and are accessible to emergency personnel and vehicles and to ensure that fuel loads are kept at a level that will minimise the risk of a recurrence of the firestorm"	R, HR, HRB, S, C	HRB		
Undertake the use of drones to assist on ground performance in hazard reduction burning and at wildfires. Also in regards to assessment of town fire hazards.	HR, S	HRB		

Potential town/ city bushfire protection opportunity area.	Legend. Note 1.	Primary single issue. Note 2.	Assessment. Opportunity assessment. Note 3.	Quick assessment of Benefit: Cost. Note 4.
In addition to manned fire towers, install cost effective fire detection technology in all telecommunication and fire towers across local government areas to assist in identifying all fires as early as possible. There are a number of new technologies available. Up to date satellite technology for early detection of bushfires is also available.	R, D, HR, S, INT	Quick initial attack		
Install signage for all fire accesses, stand pipes and water fill up points.	S	Quick initial attack		
Encourage all firefighting personnel and interested community to have access to the app My Fire Watch is a good app that Brigade and others aren't aware of in the field. It identifies hot spots, giving a better indication of fire location and covers all over Australia, by Landgate. This app covers Hot spots at 0-12 hours old (great), 12-24 hours, 24-48 hours and 48-72 hours; Vegetation greenness; Lightning. Last 24 hours, 24-48 hours, 48-72 hour and also Burnt areas.	R, HR, S, C, INT	Quick initial attack		
Encourage all firefighting personnel and interested community to have access to other apps, including Fires Near Me, Wildfire Map, Firewatch Australia and Lightning (tracker),	R, HR, S, C	Quick initial attack		
Review telecommunication and electricity infrastructure in regards to bushfire risks, hazards and threats and also consider rebuilding costs. In regards to bushfire risks/ hazards/ threats, concrete/ steel electricity poles/ underground need to be considered in timbered areas, communication shed design reviewed, cable design reviewed and trees kept well away from the towers/ sheds. In wildfires, telecommunication and electricity infrastructure can be out for a considerable number of days, most of the bushfire period, reducing flow of information to the fire fighters and community.	R, D, HR, S, REC, IMP, RC	Infrastructure		
Consider classification of all critical infrastructure in towns and cities. Telecommunication towers and associated accesses, large businesses e.g. sawmills, hospitals and schools, Council administration, telecommunication facilities be classified as significant fire infrastructure protection zones. Annual audits could be undertaken by the utility authorities, applicable government departments and applicable industries. Another option is to undertake audits by Council on all these zones.	R, D, HR, S, REC, IMP	Infrastructure		

9. Town/ city bushfire management plan and review.

It is beneficial for communities in towns and cities to regularly meet and discuss bushfire protection, preferably annually. Potential issues that could be discussed include:

- High risk/ hazard/ threat fire areas;
- Ongoing risk assessment and actioning;
- Town/ city fire layout, design and resources;
- Water supply arrangements;
- Upcoming hazard reduction burning;
- Reducing smoke pollution risks;
- Learnings/ areas that didn't go well/ went well in recent bushfires relating to towns/ cities;
- Bushfire detection and bushfire response;
- Bushfire safety issues and new apps;
- Planning to consider impacts and costs if a major town/ city bushfire occurred;
- Refinement of potential opportunities and strategies relating to towns/ cities; and
- Areas where research is needed.

It is suggested that after each bushfire season that the town/ city bushfire protection plan is reviewed, and if necessary, improvements made. The town/ city bushfire protection plan should be available publicly.

10. Comment and further input.

Additional comments, ideas and opportunities, will be considered, and where feasible, added in into this document at a suitable time.

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Appendices.

Appendix 1. Town and city bushfire impact case studies.

There have been many bushfires that have had major impacts on towns and cities. A small number of the larger impact bushfires are highlighted below:

ACT Canberra fires in 2003.

As another example, the 2003 Canberra bushfires caused severe damage to the suburbs and outer areas of Canberra, the capital city of Australia, during 18–22 January 2003. As a note, information in Wikipedia. On 8 January 2003, lightning strikes started four fires in New South Wales, over the border but in close proximity to Canberra. Despite their proximity and very small initial sizes, low intensity, and low rate of spread, these fires were not extinguished or contained by New South Wales emergency services personnel. Subsequent inquiries into the bushfires, including the Roche report, the McLeod inquiry, and the Coroner's Report, identified poor management of the initial response as a key contributor to the disaster that unfolded on 18 January 2003.

Almost 70% of the Australian Capital Territory's (ACT) pastures, pine plantations, and nature parks were severely damaged (Wikipedia). Four people died, there were 435 non-fatal injuries, 488 houses were destroyed and the cost was $350 M. The ACT Government McLeod Inquiry to examine and report on the operational response to the ACT bushfires of 8 to 21 January 2003 found amongst a number of issues that management of fuel load in parks and adequate access to remote areas were both lacking (August 2003).

In summary, it appears the major factors in relation to these wildfires were:

- poor management of the initial response as a key contributor to the disaster;
- management of fuel load in parks; and
- inadequate access to remote areas.

Canberra had the best protected perimeter of any city in Southern Australia (Cheney, 2020, pers comm). The planning meant that suburban blocks were largely completed so there were no shoestring development; maintenance of public parks by mowing was high and the western perimeter was mostly grazed grassland with a small section of pine plantation.

As noted in Blanchi and Leonard, 2005, it appears that in Duffy most houses were ignited by either ember attack or house-to-house ignition. The initial vegetation and structural fires in Duffy created an even more concentrated and enduring ember attack for those further downwind. The ember attack caused by persistent winds blowing over structural fires played a role in the spread of fire deep into urban areas. Some of the structural fires provided direct flame attack and radiation impact on adjacent structures. This effect was exacerbated by the placement of relatively large houses on medium sized blocks, and the presence of timber fences and vegetation between the closely aligned structures.

Figure 1 below highlights destroyed house incidents for all of Canberra (extracted Figure 4 from Blanchi R. and Leonard L., 2005).

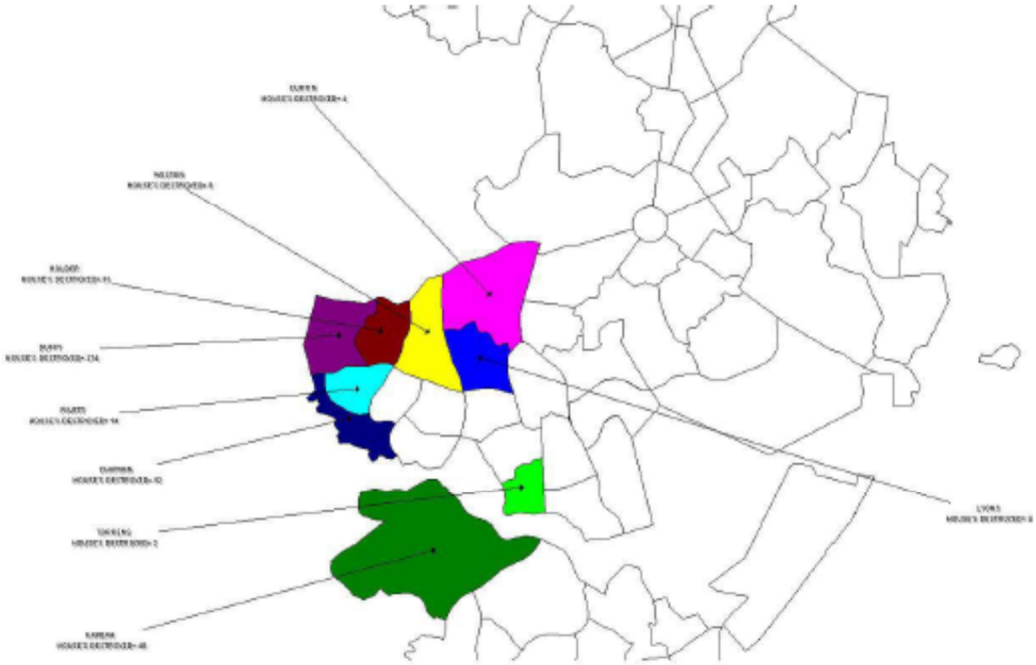

Figure 4. Destroyed house incidents, all Canberra
(produced by S/Constable Paul N. Turk Actomis, 20 January 2003)

Figure 1. Destroyed house incidents all Canberra. Extracted Figure 4 from Blanchi R. and Leonard L., 2005, Investigation of Bushfire Attack Mechanisms Resulting in House Loss in the ACT Bushfire 2003 Bushfire CRC Report April 2005. Note, there was no detail on the colours and was impossible to read the small writing with the various colours.

As noted in Blanchi and Leonard, 2005, the amount and type of vegetation around the house was found to be an important factor in previous bushfire survey investigations (Ramsay et al. 1987). Houses were more likely to be damaged or destroyed as the vegetation around them became thicker and the proportion of trees to shrub increased (Ramsay et al. 1987). It is desirable to have a fuel-reduced area around a building to reduce the level of hazard, in particular the risk of attack by flame contact and radiant heat.

Blanchi and Leonard, 2005, made recommendations to mitigate bushfire impact at the urban interface following investigations of the serious Canberra bushfires, a number of these being:

- Implement the provisions of AS 3959 to the Canberra urban interface. In virtually all cases, the exposure level will be deemed to be medium in accordance with the provisions of AS 3959 requiring the provision of basic ember protection at little additional cost to construction. This zoning may also lead to increased voluntary adoption of these mitigation measures;
- Encourage the community to become bushfire aware and suggest the benefits of retrofitting basic ember protection provisions to their homes if they are deemed to be in a medium level zone as defined in AS 3959;
- Continue the strategy of using perimeter roads as radiation and flame buffers for urban assets;
- Utilise the knowledge collected in the Canberra fires to influence the priorities on which all regulatory reform and community education are based;
- Provide risk assessment methodologies that identify both the risk of a bushfire attack and the susceptibility of an urban and peri-urban area;
- Encourage the use and positioning of outbuildings around residential structures that reduce their potential ignition and impact on the main structure; and

- Ensure that house losses many hours after a bushfire front has impacted an urban area is a consideration when allocating firefighting resources to the event. Note, the practical reality is that firefighting resources will likely be overwhelmed.

As extracted from ACT Fires January 2003, Submissions of Counsel Assisting Inquests into the Death of Dorothy McGrath, Alison Mary Tener, Peter Brabazon Brooke And Douglas John Fraser and Inquiry into the Fires of January 2003, Lex Lasry QC Ted Woodward, Counsel Assisting the Coroner 2 April 2006:

- The Ellis Report contains a statistical analysis of a total of 779 houses allocated into the three categories referred to above. The results of the survey demonstrated that there was a significant statistical association between house loss and garden type, with houses with more unkempt or fuel heavy gardens (type 1) more likely to be destroyed as a result of ember attack from a bushfire. Dr Ellis also gave evidence that the statistical tests pointed out that cypress trees in general and conifers in particular, were a factor in house loss and damage. The Ellis Report includes a general estimate that 50% of the impact of the fires in the suburbs came from ember attack directly out of the neighbouring forests and the other 50% of impact was likely to have been caused by fire spread within the urban area, either ember attack from fuels within other houses or direct house to house flame contact. Among other things, he concluded that land management agencies cannot stop fire brands reaching residential properties and igniting any ignitable fuel on that property;
- The Leonard Report includes a general discussion of mechanisms of bushfire impact on urban assets. In particular, the report notes that: Survey work has revealed that many houses are ignited from radiation and flame contact from adjacent buildings or features such as timber fences. The duration of the radiation and flame exposure from adjacent burning structures may be for a significantly longer period (an hour or more) compared to the exposure to the fire front itself (a few minutes). Embers are the major cause of ignition, as they can attack a building for some time before a fire front arrives, during the passage of the fire front and for many hours after the fire has passed. As with the work undertaken by Dr Ellis and his colleagues, Mr Leonard's research also confirmed that there was no evidence from the survey of houses impacted in the Duffy area of damage caused by direct flame contact or radiant heat out of the forest: What was very evident when we performed our initial investigation of the area was that the road and clearing zone that formed the perimeter of the Duffy area between the continuous forest fuel and the structures were significant enough to prevent radiation and flame in themselves causing damage to the structures; and
- Also noted in the Leonard Report. In the course of discussing further the aspects of house design that make houses more susceptible to ember attack and, therefore destruction, Mr Leonard referred to a fairly clear statistical verification of the impact of protected versus non-protected vent systems in houses, with houses with vents that were not protected by a metal mesh with holes smaller than 2mm more likely to be destroyed during bushfire. Mr Leonard also noted a strong statistical bias to show that a destroyed building has a much higher chance of having a destroyed out building associated with it. He concluded that it could be presumed that a component of the statistical bias was due to the fact that the outbuilding represented a significant additional attack on the main structure through flame radiation and ember source. He added that an out building is designed with many more gaps due to cheap construction and is therefore more susceptible to ember attack. Sheds and garages often also contain a large number of readily combustible items like stored timber, paint tins and so on. Mr Leonard confirmed that timber fences, because they represent a large component of the dried timber load usually very close to the main structure, and gas lines, were other issues identified in the Leonard Report. However, Mr Leonard did note that, while you can detect some evidence of the effect of a ruptured gas line on a damaged house, once a house is reduced to rubble, it is virtually impossible to determine that its loss was due to a gas line.

Victorian fires of 2009 (Extracted from Wikipedia).

The 2009 Victorian bushfires also called Black Saturday, where more than 400 bushfires that started in Victoria, Australia on February 7, 2009.

Many houses in the Victorian towns of Steels Creek, Humevale, Wandong, St Andrews, Callignee, and Koornalla were also destroyed or damaged. There were people killed at each town. The fires

affected 78 towns and left about 7,500 people homeless. More than 4,000 firemen and women worked to control and stop the fires.

In regards to the Kinglake area (Kilmore East fire), the fire was fanned by extreme north westerly winds, and travelled 50 km (31 mi) southeast in a narrow fire front through Wandong and Clonbinane, into Kinglake National Park, and then onto the towns of Humevale, Kinglake West, Strathewen and St Andrews (I was advised for reference by Craig Hearson that the Kilmore East fire did not impact the Kinglake National Park or Strathewen district on the southern run, the majority of the damage and life loss was in the period after the wind change come through that afternoon). The cool change passed through the area around 5:30 pm, bringing strong south westerly winds. The wind change turned the initial long and narrow fire band into a wide fire front that moved in a northeast direction through Kinglake, Steels Creek, Dixons Creek, Chum Creek, Toolangi, Hazeldene, Broadford and Flowerdale. The area became the worst-impacted in the state, with a total of 120 deaths and more than 1,200 homes destroyed.

Marysville is a small town which previously had a population of over 500 people, was devastated by the Murrindindi Mill bushfire on 7 February 2009. On 19 February 2009 the official death toll was 45. Around 90% of the town's buildings were destroyed. Prior to the Black Saturday fire, the population in 2006 was 519. At the 2011 Census, the population had reduced to 226, by the 2016 Census it had risen to 394.

Hobart, Tasmania, 7 February 1967.

In total 62 people were killed as a result of these fires, 20 as a result of a single fire that burnt through the western suburban fringe of Hobart burning an area of 6680 ha. A total of 226,500 ha were burnt in the 5½ hours between 1030 hrs and 1600 hrs, 85% of the final area burnt. In all, 1446 major buildings were destroyed and 795 square miles were burnt out. Damage costs were in excess of $40 million.

As noted in CSIRO Forestry and Forest Products, 2004, on the morning of 7 February 1967, in excess of 80 uncontrolled fires were burning in and around Hobart but, until that time, had only burnt a total of 1500 ha (or 0.6 of the total area that would eventually burn (Cheney 1976)). Some fires were pre-existing; some were lit on the day, some within the suburbs and some up to 100 km from the city. Dry conditions had prevailed from October 1966 throughout southern and eastern Tasmania. Grass was prolific due to above average rains in September/ October. However, the winter had been relatively mild and not very wet. Grass growth was further enhanced by above average temperatures and the low incidence of frost during the spring growth period. By early February this grass had become fully cured. On the morning of the 6 February, a high pressure system that had been located in the Tasman Sea since early on the 3 February, merged with a new high pressure system that had passed over Tasmania on the 5 February, resulting in steadily increasing maximum air temperatures during this period. On the 7 February, a low-pressure system that had moved into the area on the 6 February from the Southern Ocean and which contained a number of cold fronts pushed the isobars tighter over southern Victoria and Tasmania. This resulted in air temperatures rising from 29℃ at 0900 hrs to 39℃ at 1200 hrs. Temperatures remained above 35℃ for a period of almost 5 hours. Relative humidity had dropped to 14% by 1200 hrs and remained almost constant for 3 hours. Mean wind speed increased from 11-13 km/h between 0900 and 1000 hrs to 37-41 km/h between 1000 and 1100 hrs. After this time, the wind became gusty and after 1200 hrs gusts frequently exceeded 93 km/h, the maximum recorded being 120 km/h at 1330 hrs. Mean wind speeds between 1200 hrs and 1500 hrs were between 41 and 67 km/h. The GFDI reached a maximum of 96 and remained at the extreme rating for 7 hours. The main cold front arrived at 1930 hrs and was preceded by a gradual diminishing of fire weather conditions.

Wikipedia (20 July 2020) provides information in regards to the causes of the bushfires. The late winter and early spring of 1966 had been wet over south eastern Tasmania, resulting in a large amount of vegetation growth by November. However, in November, Tasmania began its driest eight-month period since 1885, and by the end of January 1967 the luxuriant growth in the area had dried off. Though January was a cool month, hot weather began early in February, so that in the days leading up to 7 February 1967, several bush fires were burning uncontrolled in the areas concerned. Some of these fires had been deliberately lit for burning off, despite the extremely dry conditions at the time. Reports into the causes of the fire stated that only 22 of the 110 fires were started accidentally.

In the McArthur AG, 1967 report in relation to the Hobart fires, McArthur assessed fire behaviour in urban areas:

- At times the fires burning through mixed forest and grassland fuels ignited large numbers of houses in various western suburbs of Hobart and in towns and villages such as Taroona, Kingston, Snug, Richmond, New Norfolk, Boyer, Colebrook and Rokeby;
- In the main, these areas could be called fringe urban development where streets followed creek bottoms or ridges and were separated by open grassland areas or poor quality eucalypt bush. No large continuous built-up area was seriously involved by fire;
- Houses were generally ignited by wind driven embers lodging in the eaves or beneath the house. In many instances doors and windows were left open and the interior of the house ignited. In some cases garages or wood heaps caught alight and fire then spread to the house by flame contact;
- Once alight, most houses burnt out extremely rapidly and destruction was almost invariably complete;
- From a cursory examination there did not appear to be any significant relationship between type of house construction and chances of survival. House construction was generally of brick or brick veneer, timber or asbestos cement. A more detailed investigation of this aspect was carried out by CSIRO and the final details of the survey are not known;
- The percentage (house) loss in any particular area ranged from 18 percent in Olinda Grove Road to 78 percent in Summerleas Road. The percentage loss in a particular street varied accordingly to its location in respect of the main head fire, and losses were certainly greatest in an area where two fires merged, such as in Bracken Land and Summerleas Road; and
- One feature of housing losses in these fringe developments was the fact that groups of houses tended to survive in some localities, notably along Waterworks Road. When these situations were investigated, it was found that in all cases a group of people under strong leadership had stayed and fought the fires with garden hoses, wet bags and any other rough and ready means available. This proved that houses could be saved and people survive in an environment of fire which few other people in the world have ever experienced.

Victoria, 1939. Wikipedia, 18 July 2020.

The Black Friday bushfires of 13 January 1939, in Victoria, Australia, were part of the devastating 1938–1939 bushfire season in Australia, which saw bushfires burning for the whole summer, and ash falling as far away as New Zealand. It was calculated that three-quarters of the State of Victoria was directly or indirectly affected by the disaster, while other Australian states and the Australian Capital Territory were also badly hit by fires and extreme heat. As of 3 November 2011, the event was one of the worst recorded bushfires in Australia, and the third most deadly.

Fires burned almost 2,000,000 hectares (4,900,000 acres) of land in Victoria, where 71 people were killed, and several towns were entirely obliterated. Over 1,300 homes and 69 sawmills were burned, and 3,700 buildings were destroyed or damaged. In response, the Victorian state government convened a Royal Commission that resulted in major changes in forest management. The Royal Commission noted that "it appeared the whole State was alight on Friday, 13 January 1939".

The subsequent Victorian Royal Commission investigation of the fires recorded that Victoria had not seen such dry conditions for more than two decades, and its rich plains lay "bare and baking; and the forest, from the foothills to the alpine heights, were tinder". Fires had been burning separately across Victoria through December, but reached a new intensity and "joined forces in a terrible confluence of flame..."[2]:Introduction - Part 1...on Friday, 13 January.

The subsequent Royal Commission, under Judge Leonard Edward Bishop Stretton (known as the Stretton Inquiry), attributed blame for the fires to careless burning, campfires, graziers, sawmillers and land clearing.

Prior to 13 January 1939, many fires were already burning. Some of the fires started as early as December 1938, but most of them started in the first week of January 1939. Some of these fires could not be extinguished. Others were left unattended or, as Judge Stretton wrote, the fires were allowed to burn "under control", as it was falsely and dangerously called. Stretton declared that most of the fires were lit by the "hand of man".

As a consequence of Judge Stretton's report, the Forests Commission Victoria gained additional funding and took responsibility for fire protection on all public land including State forests, unoccupied Crown Lands and National Parks, plus a buffer extending one mile beyond their boundaries on to private land. Its responsibilities grew in one leap from 2.4 to 6.5 million hectares (5.9 to 16.1 million acres). Stretton's recommendations officially sanctioned and encouraged the common bush practice of controlled burning to minimise future risks.

Its recommendations led to sweeping changes, including stringent regulation of burning and fire safety measures for sawmills, grazing licensees and the general public, the compulsory construction of dugouts at forest sawmills, increasing the forest roads network and firebreaks, construction of forest dams, fire towers and RAAF aerial patrols linked by the Commissions radio network VL3AA to ground observers.

The most damage was felt in the mountain and alpine areas in the northeast and around the southwest coast. The Acheron, Tanjil and Thomson Valleys and the Grampians, were also hit. Five townships – Hill End, Narbethong, Nayook West, Noojee (apart from the Hotel), Woods Point – were completely destroyed and not all were rebuilt afterwards. The towns of Omeo, Pomonal, Warrandyte (though this is now a suburb of Melbourne, it was not in 1939) and Yarra Glen were also badly damaged.

Towns damaged or destroyed:

Central

- Dromana
- Healesville
- Kinglake
- Marysville
- Narbethong – destroyed
- Warburton
- Warrandyte
- Yarra Glen

East

- Hill End – destroyed
- Nayook West – destroyed
- Matlock – 15 died at a sawmill
- Noojee – destroyed
- Omeo
- Woods Point – destroyed

West

- Pomonal
- Portland

Waroona fire including Yarloop, WA, January 2016 (extracted from AFCA, 2020 and Ferguson, E. 2016).

Extracted from AFCA, 2020:

On 6 January 2016, the communities of Yarloop and surrounding areas in the Shires of Harvey and Waroona (south-west WA) were hit by a devastating bushfire that killed two people and destroyed 181 homes. An independent report found that fuel management was the cornerstone of every issue relating to the fire.

The inquiry noted that localised areas of long unburnt fuel within and adjoining Yarloop played a significant contribution to the damage by generating very high fire intensities and mass ember attack that resulted in extensive damage to buildings.

The inquiry recommended that more regular, effective fuel management practices be employed, with a focus on biomass removal and hazard reduction burning.

Extracted from Ferguson, E. 2016, Government of Western Australia "Reframing rural fire management" Report of the special inquiry into the January 2016 Waroona Fire:

Some details in relation to the fire:

- The total area burnt was 69,165 hectares Private property area burnt: 31,180 hectares Public land area burnt: 37,985 hectares Forest Products Commission plantation burnt: 3,300 hectares;
- Fatalities: 2; and
- Buildings 181 (166 dwellings in Yarloop).

Yarloop was significantly affected by the fire with two fatalities of residents and the destruction of 166 houses and residential buildings. It is the view of the Special Inquiry that localised areas of long unburnt fuel within and adjoining Yarloop played a significant contribution to the damage in town by generating very high fire intensities and mass ember attack that resulted in extensive damage to buildings.

In relation to a question in regards to the defendability of the town, a witness advised at the Inquiry: *Given what I know of Yarloop and in terms of its preparedness and its setting and the nature of most of the buildings and the fire, the nature of the fire that came through there, I would agree with that. It was undefendable, certainly on the eastern side – yes – the eastern side of the town that took the brunt of the impact.*

The inquiry made an important recommendation in regards to fuel management. Recommendation 5: The Department of Fire and Emergency Services, utilising the Office of Bushfire Risk Management, to develop a simplified and fast track hazard reduction burn (and other fuel mitigation techniques) planning and approval process to ensure the timely conduct of township and asset protection burns by Bush Fire Brigades and individual property owners. The process is to be agile and adaptable for the range of stakeholders which may participate in low risk, small scale, low complexity burn planning and approvals.

South Australia and Victoria, Ash Wednesday, 16 February 1983.

As noted in CSIRO Forestry and Forest Products, 2004, Ash Wednesday, 16 February 1983, brought the worst fire disaster in Australia since Black Friday in 1939. A total of about 370,000 ha were burnt, 76 people were killed, and some 2500 structures were destroyed.

Ash Wednesday is a prime example of particularly severe fire weather conditions in south-eastern Australia. Timing of the passage of the cold front was such that, as it swept across southern Australia during daylight hours, extreme fire weather extended from Port Lincoln in South Australia to east of Melbourne, Victoria, a distance of 800 km. At most locations, hot strong northerly winds started blowing early in the morning (0900 hrs EDST), and increased to average mean speeds of 45-50 km/h for several hours preceding the front. Unusually strong westerly winds were associated with the frontal change, which reached Ceduna at 1230 hrs, Adelaide at 1445 hrs and Melbourne at 2030 hrs. Mean wind speeds were in excess of 70 km/h, with gust speeds up to 110 km/h. Much of south-eastern Australia was experiencing severe drought at the time, and most of the damage occurred in forested areas. However, a number of severe grassfires occurred in South Australia and Victoria in areas where the drought was not extreme.

Bushfires with lesser detailed case studies.

Dunalley, Tasmania, January 2013 (extracted from AFCA, 2020).

In January 2013, major fires ravaged areas around Forcett, Lake Repulse and Bicheno in south-eastern Tasmania. More than 200 homes were lost. An independent inquiry identified fuel reduction practices as a high priority and recommended a strategic fuel management plan be developed and implemented with measurable targets, and that the planning should happen across all land tenures. The Inquiry noted that the rapid spread of the fire was attributable, in part, to high fuel loads, combined with wooded and inaccessible terrain.

Mallacoota, Victoria, December 2019, extracted from Wikipedia July 2020.

Thousands of people fled to the lake and ocean in Mallacoota, as bushfires hit the Gippsland town on Tuesday. The out-of-control fire reached the town in the morning and about 4,000 people fled to the coastline, with Country Fire Authority members working to protect them. Dec 30, 2019 Authorities have estimated that more than 120 structures in Mallacoota were destroyed, including at least 100 homes. Another estimate provided in the Guardian noted some 150 houses were destroyed in the fire.

Eden. Jurskis V, 2020, Black Summer Whitewash – A Preview of Armageddon.

As Vic Jurskis notes "After the winds once again came from the southwest, there was massive destruction of forests and wildlife to the south of our town. Homes and infrastructure were needlessly incinerated. People in Eden were urged to evacuate. I continued clearing, pruning and raking around my home. As the Border Fire approached on 4th January, it became completely dark at 4 pm. There was a constant rain of scorched and burnt eucalypt leaves from forests far to the south. I patrolled around my block until 4 am. If we'd had embers from the northwest instead of ashes from the south, I wouldn't be here to tell". "We were lucky because we didn't get the hot, dry north-westerly winds, changing to south-westerly, that have driven the inevitable firestorms in eastern Australia since Aboriginal management was disrupted. But the explosive 3-Dimensionally continuous fuel is still there in a broad swathe from far to the northwest, right into the middle of Eden. We had no peace of mind until the rains came to break the drought. Despite our temporary reprieve, the forest is still declining and the scrub is still booming".

Cabramurra, NSW, 4 January 2020 (extracted from About Regional News, Snowy 2.0 work begins again after fire, despite major losses, Elka Wood 23 January 2020.

Despite suffering "major losses" in their operational township of Cabramurra after the Dunns Road fire passed through it, the Snowy Hydro 2.0 team re-started work this week, saying that the project will be a key part of the region's recovery. A total of 36 houses were destroyed in the 4 January fire, along with several of the unit blocks, the school and the old ski club.

"Thankfully the main buildings housing the bistro and general store, the fuel depot and other buildings are all standing and will be a great base to rebuild from. Services have been restored to the township including power, water and sewerage," says a spokesperson.

Balmoral, NSW, December 2019 (extracted from AFCA, 2020).

The village in the NSW Southern Highlands was hit hard by multiple fire fronts just before Christmas, with 18 homes destroyed and 90 per cent of the surrounding bush burnt. The local fire captain, Brendon O'Connor, who has decades of firefighting experience, has been hailed as a hero for saving much of the town from the catastrophic fires. He attributed the intensity of the Balmoral fire to the lack of fuel removal in the forest surrounding the village, and says that there needs to be a much more aggressive program of fuel reduction – including through mechanical removal – to avoid a repeat.

Appendix 2. Town and city bushfire protection case studies.

Blue Mountains 2019 and 2020 bushfires.

Using information provided by NPWS in the Final Report of the NSW Bushfire Inquiry, 31 July 2020:

The Ruined Castle fire burnt over 17,000 ha, including 15,000 ha of Blue Mountains National Park. Started by lightning, it burnt for 72 days between November 2019 and February 2020, threatening the Blue Mountains townships of Katoomba, Leura and Wentworth Falls as well as Sydney's drinking water catchment. The Ruined Castle fire posed a significant threat to important tourism attractions such as Scenic World and Echo Point in Katoomba. Both places were closed for an extended period, significantly reducing tourist numbers over what would normally be the busy Christmas holiday season.

NPWS completed two hazard reduction burns south of the townships – Pitts Amphitheatre (800 ha) in May 2016, and Mount Solitary (3,500 ha) in June 2018, refer Figure 1. Those hazard reduction burns were deliberately situated in known fire paths to protect community values and assets.

The objectives of the Pitts Amphitheatre hazard reduction were to:

- reduce the spread of wildfires which may impact townships of Katoomba, Leura and Wentworth Falls;
- reduce the risk of wildfires affecting catchment raw water supply; and
- reduce fuel loads along ridge lines down to mid slopes from high-very high to low-moderate.

Without those burns effectively reducing fuel in the fire's path, the Ruined Castle fire would most likely have impacted on residential properties and tourism infrastructure. The hazard reduction burns were used as part of the containment strategy that successfully prevented asset impacts, reduced firefighting requirements and decreased the risk to firefighters.

Post-fire analysis of the Ruined Castle fire indicated the location of the hazard reduction burns (as shown in the extracted Figure 2-10) proved crucial in suppressing the fire and protecting property and tourism assets. It shows that whilst the Ruined Castle fire burnt into the fuel reduced area in places, these areas where largely rainforest that does not burn in the hazard reduction burns.

The Mount Solitary hazard reduction contributed to decreasing the fire's intensity and also protected environmental values of the national park, leaving a small but significant area of unburnt refugia. When the fire burnt into the hazard reduction area the fire behaviour and subsequent rate of spread was significantly reduced, providing firefighters with a strategic advantage in suppression efforts.

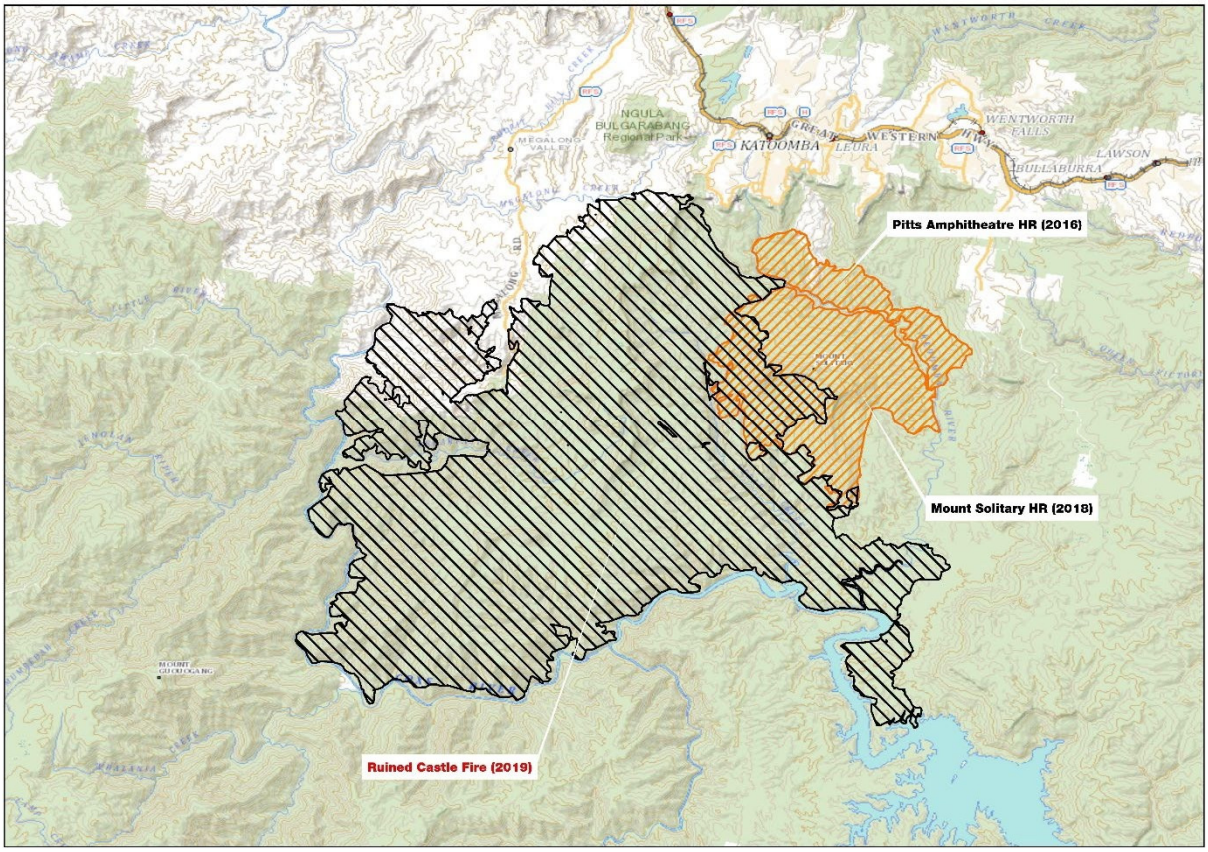

Figure 1: Ruined Castle fire in 2019 and hazard reduction burns in 2016 and 2018 (prepared by NPWS), extracted Figure 2-10 of NSW Bushfire Inquiry Report.

Perth. 2005 Perth Hills bushfire.

An outstanding example of the contribution of fuel reduction burning in the control of a fierce forest wildfire was on the 15-25 January 2005, in the Perth Hills, also known as the Pickering Brook fire. Bushfire Front undated, Effectiveness of prescribed burning by Rick Sneeuwjagt. Example of effectiveness of a prescribed burning programme in controlling major forest fires—the 2005 Perth Hills fire.

The report noted that in the absence of a fuel reduction burning program conducted over many years, hundreds of homes would have been destroyed and lives threatened. The prescribed burns saved the day. The fire was started by seven separate ignitions lit by an arsonist in State forests in the hills east of Perth. Despite a massive suppression effort, these fires joined up on the first night under the influence of strong easterly winds, and continued to expand over the next couple of days taking fire onto the outskirts of densely populated suburbs. However, before the fire reached the suburbs, the front ran into extensive bands of two, three and four year old fuels resulting from prescribed burns. Firefighters were able to readily suppress relatively mild intensity fires in the low fuel areas, and then focus on direct attack on those sections of the fire perimeter where fuels had not been reduced.

The map of the bushfire is outlined In Figure 2.

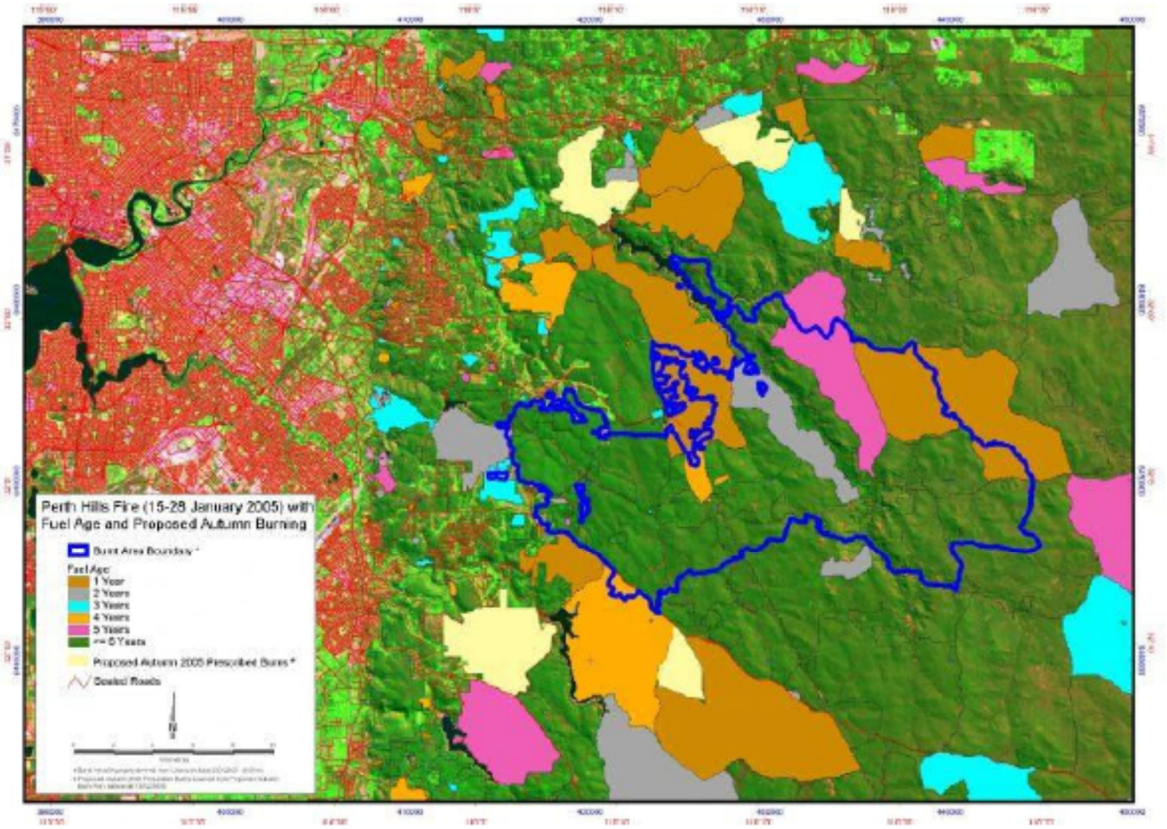

Figure 2: Perimeter of the Pickering Brook fire in relation to fuel reduced areas and the Perth metropolitan area, extracted Figure 2 from the report.

A detailed assessment of the behaviour of the Pickering Brook fire was undertaken by fire scientist Dr Phil Cheney of the CSIRO (Cheney 2010). He reconstructed the fires during the initial westerly and south-westerly spread on 15-17 January 2005. The analysis showed that the fires burnt vigorously in fuels that ranged in age from 16 to 26 years old. The main tongues of the head fire were observed to spread rapidly at rates ranging from 600 to 1,600 m/hour with episodes of crown fires.

Cheney found that under the fire weather conditions that prevailed on the 17 January, the rate of spread in the 20 year-old fuel was six times faster than that in three year-old fuels; the intensity of the fire in the 20 year-old fuel was more than 20 times that in three year-old fuel.

Given a record of the weather conditions and fuel types at the time, Cheney was able to project the perimeter of the Pickering Brook fire, had there been no fuel reduction burning in the past 20 years in its path. His projection revealed that effective suppression would have not been possible due to the severe and erratic fire behaviour with the head fire burning at speeds of between 1,800 and 5,000 m/hour. He estimated that the fire would have burnt into suburban areas in less than 24 hours after ignition His conclusion was that in the absence of the fuel reduction burning program, the Pickering Brook fire would have resulted in extensive damage to homes and loss of life in these suburbs.

Appendix 3. Reducing bushfire risks, hazards and threats to towns and cities.

Constanza Gonzalez-Mathiesen and Associate Professor Alan March, titled paper Nine design features for bushfire risk reduction via urban planning, Australian Journal of Emergency Management I Volume 29, No. 3, July 2014 University of Melbourne, share their view of international planning jurisdictions and how they deal with bushfire threats and outline nine design features for bushfire risk reduction via urban planning:

Reducing vulnerability:

- Consideration of the overall context and landscape impacts on exposure from overall fire likely behaviour;
- Determination of adequate separation from heat and flame sources, given topography, vegetation, likely weather and any other relevant factors;
- Management or modification of vegetation, landscaping or other fuel sources such as outbuildings;
- Management of the density, location and design of structures, including reducing vulnerability to ember attack, and integration of building and planning standards appropriate to context and siting; and
- Protection of infrastructure, and care for land uses with greater vulnerability e.g. kindergarten's.

Co-ordinating and improving response:

- Consideration of the availability, capacity, location and travel times of emergency services, if available;
- Facilitation of the efficient access and egress of emergency services, including integration of separation spaces as spaces for active defence or evacuation locations;
- Ensure water availability for firefighting, including appropriate location, supply, connectivity and signage; and
- Deal with civilian response actions, including the range of possible actions such as finding refuge, actively defending, or evacuating properties.

Different states use different approaches to bushfire plans. Using NSW information, as outlined in NSW Rural Fire Service 2019. Planning for Bush Fire Protection (PBP) and the current legislated version that is adopted is PBP 2019, they use a Bush Fire Risk Management Plan (BFRMP) which is the responsibility of the Bush Fire Management Committee (BFMC). Also used are local Bushfire Risk Management Plans; a Bush Fire Management Plan (BFMP) is recommended for developments in bush fire prone areas and in some cases a Community Protection Plan (CPP) program is used to improve the community and firefighters' capacity to prepare for, act during, and survive bush fires.

As defined in NSW local Bushfire Risk Management Plans:

- Bush Fire Hazard: the potential severity of a bush fire, which is determined by fuel load, fuel arrangement and topography under a given climatic condition;
- Bush Fire Risk: the chance of a bush fire igniting, spreading and causing damage to the community or the assets they value;
- Bush Fire Threat: potential bush fire exposure of an asset due to the proximity and type of a hazard and the slope on which the hazard is situated; and
- Bush Fire Risk Management: a systematic process that provides a range of treatments which contribute to the well-being of communities and the environment, which suffer the adverse effects of wildfire/ bush fire.

In this document, all the four factors are considered important, noting Bush Fire Risk is the one factor used to assess bushfire risks in towns, at least in NSW. Because threat involves the intensity of the bushfire, it is suggested that fire protection planning consider using bushfire threat levels that involves under the "worst possible" or "worst recorded" fire weather conditions. While the risk may be low, the threat can be very high in Australian towns and cities, depending on the amount of fuel both in the

environs and importantly within the township and the individual home gardens. And because fuel is the only factor affecting bushfire behaviour that can be managed, that is the important factor that can reduce the threat. One can reduce the damage by preventing ignition of say a particular structure but this should not be considered as reducing the bushfire threat.

From an individual's perspective, potential issues of concern in relation to NSW Local Bushfire Risk Management Plans (LBRMPs) include:

- In relation to Risk Acceptability, risks below a certain level are assessed as not requiring treatment within the life of plans. This is due to a combination of risk priority and capacity to undertake the works. Within a number of BFMC areas, the level of acceptability is Medium, areas of Medium or Low, and cultural and environmental assets are likely to be managed by routine procedures and so do not require a specific application of resources (where possible and practicable the BFMC will treat medium and low risks. This is likely a major concern in extreme bushfire years, there is no discussion in ramping up mitigation measures). In the 2019/ 20 bushfires, bushfires burnt into many NSW towns at Medium risk levels. If routine procedures aren't underway, nor effective, disaster awaits;
- Community involvement in LBRMPs is very limited in the preparation of LBFRMPs and actioning. The USA approaches to Fire Adapted Communities have much merit in Australia and the LBFRMP process needs to be adapted to increase community involvement;
- LBFRMP's cover 5 year periods to much longer periods, this can be too long, plans need annual review and simple updating (addenda, web information etc), best in relation to each town and city;
- There is very limited discussion of town/ city mitigation measures for each year of the plan;
- Under the LBFRMPs, The Australia/New Zealand Standard AS/NZS 4360: 2004 Risk Management was used as the basis for the risk assessment process. For a detailed description of the process undertaken see the Bush Fire Risk Management Planning Guidelines for Bush Fire Management Committees on the RFS website: www.rfs.nsw.gov.au. This may not comply with the international standard for risk management (ISO 31000) or NERAG and this matter needs to be reviewed/ audited. Risks are reviewed in a number of state reviews of bushfires, including the SA 2020 bushfire review;
- The LBFRMPs do not include assessment or spatial representation of landscape scale risk. Fuel loadings are critical;
- Apparent discrepancies between risk assessments and the bushfire hazard assessments, and the lack of integration of these processes, need to be addressed;
- Unsure if there is an effective system to monitor implementation of strategies to ensure there are clear lines of accountability for mitigating risks;
- Under Section 4.3, the BFMC is required to report annually to the BFCC on its progress in implementing the bush fire risk management activities identified in this plan. It is unclear if this process occurs for each LBFRMP annually, or on time. This information would best be publicly available to the community;
- Inadequate landscape hazard reduction burning is a massive issue risking communities and landholders. The focus town and city risk based approach in Victoria failed and this failed system is being introduced in NSW following the 2020 NSW bushfire inquiry;
- If RFS and state agencies are not addressing HRB on their lands, risks to communities increase;
- The LBFRMP system and RMS process fails to adequately consider extreme bushfire impacts on fauna, ecosystems, heritage, erosion, WQ etc;
- The LBFRMP system and RMS process fails to adequately consider ecosystem health using cool burning across landscapes; and
- Innovation isn't encouraged under the plans nor the process. Satellite fire watch systems have massive benefits providing early bushfire warning to communities.

Communities, lives, ecosystems and fauna are at stake. I suggest that revision of the LBFRMP process is critical.

In regards weather conditions, CSIRO Forestry and Forest Products, 2004, outlines common factors have been identified in the case histories and other significant fire events that characterise a severe fire event:

- Antecedent rainfall deficit, although not necessarily in case of extensive grass fires;
- Synoptic weather pattern that directs strong, hot gusty wind from centre of continent over region in question. Unstable atmosphere that is conducive to mixing of strong upper winds to the surface and the development of strong fire convection;
- Low fuel moisture contents resulting from high diurnal air temperature and low relative humidity sustained for long periods throughout the day, associated strong gusty winds; and
- Fires burning prior to the arrival of extreme fire weather or ignitions, generally multiple ignitions, resulting from the passage of dry summer thunderstorms, arson or spotting from existing fires.

The result of the combination of the above factors is severe high-intensity, at times erratic fire behaviour (including sustained periods of rapid fire spread and massive spotting in certain fuel types), and extreme difficulty of suppression (CSIRO Forestry and Forest Products, 2004). Fires burning under these conditions will burn out considerable areas of land, travel considerable distances, threaten homes, lives and other assets and be uncontrollable until the weather abates.

There are some current practices used to reduce bushfire risks, hazards and threats in towns and cities across different areas:

- Slashing;
- Mulching;
- Strategic hazard reduction burning in towns and adjacent areas;
- Landscape hazard reduction burning outside of towns and cities;
- Vegetation thinning/ cool burning.
- Access roads;
- Firebreaks;
- Dams for water supply; and
- Hydrants and standpipes.

These practices can be effective, but as expected, do have limits, as the Forest Fire Danger Indices increase:

- Have reduced effectiveness in extreme bushfires;
- Can fail where inadequate bushfire protection measures are in place/ used;
- Can fail where inadequate bushfire protection measures are not maintained;
- Can fail where inadequate bushfire protection plans and risk/ hazard/ threat assessments are in place;
- Can fail where fuel levels in surrounding and inside towns and cities aren't reduced;
- Can fail where resident and fire fighter safety is not adequately assessed; and
- Can fail where protection is provided over limited areas only.

Considering the points directly below, there appear to be inadequate town and city bushfire protection measures in many locations across Australia, as evidenced in:

- House loss numbers over the last 10 years outlined in Table 1;
- Further detail on Australian bushfires involving major house losses in Table 2;
- As outlined in a number of Bushfire Inquiries, some detail on this is outlined in Appendix 1;
- As outlined in the cases studies outlined in this document in Appendix 1. The huge house loss numbers outlined above in Australian towns and cities is very large;
- A number of town/ city bushfire risk assessments, with at some towns marked as medium risks that had major bushfire impacts; and
- Driving through towns and viewing poorly designed house surrounds and high fuel loads.

Many larger bushfires impact on towns and enter these areas and it is critical to plan for these fires. This is amply demonstrated in the Canberra bushfires of 2003, refer the case study on this bushfire in Appendix 1. As noted in Blanchi and Leonard, 2005, it appears that in Duffy (Canberra, 2003 fires) most houses were ignited by either ember attack or house-to-house ignition. The initial vegetation and

structural fires in Duffy created an even more concentrated and enduring ember attack for those further downwind. The ember attack caused by persistent winds blowing over structural fires played a role in the spread of fire deep into urban areas.

This is an important factor missing in protecting many towns and cities across Australia, it is important not only to focus on edge and internal town and city fuel loads and defences, but fuel reduction measures across landscapes surrounding towns and cities. It is critical that there is adequate hazard reduction/ hazard reduction burning on government and freehold land to reduce risks, hazards and threats associated with large bushfires growing to such a size they the impact on towns/ cities that become totally unstoppable under extreme fire danger until the fire runs out of fuel.

Landscape bushfire protection is highlighted in the USA under Fire Adapted Communities Learning Network in the USA:

- Forest Schafer, California Tahoe Conservancy. *We realized that there isn't a line where fire adapted communities stop and fire resilient landscapes begin; and*
- Jeremy Bailey, The Nature Conservancy. *We need a dedicated prescribed fire workforce. Imagine if for every firefighter poised and ready to extinguish any start, we also had a fire lighter.*

On information available, the average fuel reduction burning in NSW between 2010 to 2019 was 153,291 hectares, extremely low considering 27 million hectares of forests in NSW, this is similar in many other states. The current approach does not focus on hazard reduction burning across landscapes, using cool hazard reduction burning. This policy environment reinforces the shift towards more widespread high intensity fire regimes in these same areas where fires are restricted. Hence the importance of managing this issue to better protect towns and cities, not only focussing on edge and internal protection measures.

In NSW, local Bushfire Risk Management Plans include use of fire restrictions in different vegetation types, this in many cases restricts hazard reduction burning frequency and more frequent cool hazard reduction and ecological maintenance burning.

A critical issue is the importance of Councils, apart from Local Bushfire Risk Management Plans, to take responsibility for vegetation in urban areas, monitor and act on land that has not been slashed in towns/ cities, not creating hazards by unreasonable tree preservation orders and monitor 10/ 50 rule requirements in NSW. Another critical area is the responsibility of citizens to maintain gardens in a low flammable state. This was an issue identified in the Canberra fires of 2003. This is addressed in in Appendices 1 and 2. As outlined above, fuel loads outside of towns and cities need to be monitored and hazard reduced where required.

Cheney NP 2011 in his document "How can we protect residents from bushfires? Considers protection for residences on <0.2 ha blocks in settlements and villages. These are vulnerable because they depend on community co-operation. Even where an individual takes all the requisite steps to reduce fuel, their efforts can be thwarted by the inaction of their neighbours who have excessive fuel close enough to be a direct threat. In this situation, it is important that local government has to take the lead and enforce activities that limit the amount of fuel that can accumulate the type of vegetation and the separation between houses.

Cheney (pers comm, 17 July 2020), notes pine bark mulch was very much a source of wind-blown firebrands in the 2003 Canberra fires (Embers which are by definition "the last residual component of combustion). Smouldering mulch burst into flames during gusts of strong winds sending cascades of firebrands down the street into adjacent homes and gardens. Pine bark mulching was suspended for about a month after the fires but then resumed and is still evident around homes on the western perimeter that weren't burnt down.

As a suggestion, a good approach would be to restrict flammable native trees and shrubs, conifers, flammable ground cover and mulch and use deciduous trees, species of low flammability, trees/ shrubs away from houses, cultivated gardens and lawns.

Appendix 4. Specific at residence bushfire risk, hazard and threat management prior to bushfires.

As noted above, this document focusses on town/ city bushfire protection and not building fire design requirements, covered in other documents and standards and addressed by local governments. However, some brief detail is included below in relation to building/ residence bushfire design measures.

Building/ residence bushfire design measures.

As noted in Loveridge R, 2020, national building requirements for residences in bushfire-prone areas were improved after the 2009 "Black Saturday" bushfires in Victoria, in which 173 people died and more 2,000 homes were destroyed. Buildings are regulated by states and territories but governments have recognised the value of nationally consistent building codes through the National Construction Code. This code, among other things, sets minimum standards for the design and construction of new buildings on bushfire-prone land. (What land is deemed "bushfire prone" is defined by state and territory legislation.)

As noted in BDAA, 2020, the primary performance requirement stated in the National Construction Code (NCC) in regards to bushfire risk is Performance Requirement P2.3.4 of Volume Two in NCC 2019 (GP20 applies in relation to Volume 1). This pertains to Class 1 and Class 10a buildings (single-storey homes, private garages, carports and sheds) constructed in areas designated as bushfire prone. It mandates that these homes be designed and built to alleviate the risk of bushfire in accordance with both (a) the potential for fire ignition to be prompted by burning embers, radiant heat or flame and (b) the probable intensity of a bushfire attack. To adhere to these mandates, buildings must stand in compliance with Australian Standard AS 3959 (Construction of buildings in bushfire prone area) or apply a performance solution that adheres to these requirements. To meet AS 3959, buildings must meet requirements that vary in accordance with the Bushfire Attack Level (BAL) rating that the property is given. These guidelines concern material specification, construction elements and building systems. They pertain to home areas like floors, roofs, walls, windows, verandas and carports.

As noted in VBA, undated, Victoria is one of the areas most at risk of bushfires in the world. Domestic buildings and some residential buildings (such as boarding houses) constructed in Victoria must comply with the Australian Standard AS 3959-2018 – Construction of buildings in bushfire-prone areas or the NASH Standard 2014 – Steel Framed Construction in Bushfire Areas . This applies to all new domestic buildings, alterations and additions in Victoria, including associated garages and sheds.

As outlined in Hersher R, 2020, Australian Fires Prompt Questions About Protecting Houses from Embers : NPR, January the most recent Australian building standards were adopted in May 2019. "One of the things we improved for 2019 was the size of gaps in the envelope of a building," explains Ian Weir, one of the authors of the standards, and a researcher at Queensland University of Technology who studies bushfire responsive architecture. Weir says Australian research makes clear that embers are an overwhelming threat to homes, but American research has been crucial for figuring out how to make houses more resilient to flaming debris. Weir and his regulatory colleagues relied heavily on research conducted by the U.S. National Institute of Standards and Technology, which looked at how embers get lodged in gaps around doors, windows, roof vents and other architectural features. "They've done some great research on exactly what is the dimension of the gaps at which we start to lose houses," Weir says, "and they've found that anything greater than 2 millimeters, we enable the embers sufficiently large to ignite wall cavities and furniture and so on."

House and surrounds protection measures.

As noted in VBA, undated, there are many ways to improve house protection from bushfires:

- Seal gaps with joining strips, silicon weather strips, draught excluders on side-hung doors;
- Seal vents and weep holes in external walls with corrosion resistant steel, bronze or aluminium mesh;
- Seal around roofing and roof penetrations;
- If an evaporative cooler is installed, protect it with a mesh screen;
- Clear leaves from gutters and considering installing an appropriate leaf guard product;
- Check that your gutters are in good condition and will hold water if you block the downpipes;

- Enclose the subfloor of your home with a non-combustible material;
- Install shutters or metal flyscreens to doors and windows;
- Remove any overhanging tree branches, take out shrubs over one metre high next to or below windows, keep grass short and clean up other debris near your home that could easily catch fire; and
- It is also important to make sure your property is accessible for emergency vehicles and has a water supply for firefighting. If you have a rainwater tank near your home, ensure it is accessible.

As noted by the City of Whittlesea, 2020, measures to reduce fire risks around homes include:

- regularly mowing the grass and raking up leaves;
- removing weeds and pruning bushes and trees;
- non-flammable ground covers like pebbles; Note, "keeping garden beds moist through mulching" has been removed, as mulch/ bark is a major fire risk;
- regularly clearing leaves from gutters, roofs, downpipes and around the base of trees;
- maintaining a well-watered lawn (complying with water restrictions);
- storing flammable or combustible materials such as woodpiles and rubbish away from your house;
- ensuring that your garden hoses are long enough to reach all areas of your property;
- making sure that any fire hydrants near your home are accessible and unobstructed; and
- creating a personal protection kit (goggles, gloves, hat, boots and cotton trousers and long sleeved shirt) • storing mops and buckets together.

There are also measures to reduce fire risks around homes as outlined in NSW Rural Fire Service Bush Fire and Your Home Prepare your home and property for bush fires Number 02, 2012. Further information to reduce fire risks is outlined in the document NSW Rural Fire Service, undated, Get Ready for a Bush Fire Four Simple Steps to Making your Bush Fire Survival Plan.

As extracted from The Parliament of the Commonwealth of Australia, A Nation Charred: Report on the inquiry into bushfires House of Representatives, 2003. Select Committee into the recent Australian bushfires, Tables 1 and 2 (extracted Tables 7.4 and 7.5 outline important house/ building protection measures), both in regards to building design and maintenance:

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Table 7.4 Individual preparedness – building maintenance

Area	Preparedness measures
Building surrounds	• Removing, thinning and pruning vegetation, particularly if highly flammable and within close proximity to building structures. • Removing hazardous material such as timber, clippings, dead leaves, twigs and rubbish. • Stripping and disposing of loose bark on trees. • Maintaining lawns and raking grounds. • Maintaining timber fences (ie, replacing rotted crossbeams, staining and securing loose posts). • Ensuring access points are not obstructed including those to hoses. • Clearing powerlines. • Storing gas tanks, bottles and other combustible substances at a distance from the expected fire path and main building and covering in metal mesh. • Storing firewood in metal or brick boxes. • Ensuring water reserve tanks are full and hoses are in working order.
Building	• Clearing gutters, under the house and in the ceiling. • Closing doors and windows and sealing any crevices. • Cleaning chimney. • Maintaining paint work on timber. • Replacing rotten boards and loose roof tiles. • Positioning furnishings a good distance from windows and doors. • Purchasing commercial products such as fire blankets and chemical technology.

Source *Better Living DCP for Single Dwellings and Subdivision Developments, C4.1: Bushfire, pp. 1–8; CSIRO, Submission 434, pp. 65–66, and Joan Webster, Essential bushfire safety tips, 2001, chapters 13 and 19.*

Table 7.5 Individual preparedness – building design

Item	Design
Windbreaks	• Incorporating a series of windbreaks into the design of the building to reduce the speed at which fires travel including planting low combustible trees around buildings (that would also capture embers) and positioning non-combustible outbuildings on the likely fire front side of the main building.
Radiant heat barriers	• Installing non-combustible radiant heat barriers (ie, masonry walls, steel panel fences, earth mounds, dense non-combustible trees, etc) between the building and likely direction of hazards.
Vegetation	• Providing appropriate vegetation barriers using fire resistant species.
Building construction	• Using simple designs throughout (to limit crevices) with non-combustible materials and easy access points. • Erecting low walls to avoid wind turbulence. • Constructing and enclosing decks, trellises and other decorative structures with non-combustible materials. • Sanding and painting or staining external timber structures and surfaces. • Installing leaf guards on gutters or rather than gutters, installing surface drain collectors at ground level. • Using downpipes of a minimum of 100mm x 75mm. • Using solid core timber external doors with metal framed wire security doors. • Installing draught seals on external doors and screening vents and other openings. • Glazing glass to enhance protection against radiant heat cracking. • Installing wire mesh or close-fitting metal shutters on all opening windows to reduce the levels of radiant heat impacting in the glazing, prevent ember entry and contain broken glass. • Erecting colour bond or masonry fences.
Access and egress	• Positioning and, where appropriate, signposting gates to allow efficient access and egress for fire fighting personnel and evacuees.
Water	• Installing exterior sprinkler systems, hoses sufficient in length to reach all ends of the building and a static water supply of around 10 000 litres (ie, pool, dam or tank).

Source *Blue Mountains City Council, Better Living DCP for Single Dwellings and Subdivision Developments, C4.1: Bushfire, pp. 1-8; CSIRO, Submission 434, pp. 66-69 and Joan Webster, Essential bushfire safety tips, 2001, chapters 10, 12, 16, 17 and 19.*

CFA and Building Commission Victoria (undated) provide an effective document, titled A guide to retrofit your home for better protection from a bushfire Prepare. Act. Survive. Building and renovation ideas to better prepare your home in a bushfire situation. Other useful information is contained within Tasmania Fire Service, 2009, Bushfire, Prepare to Survive, a guide to preparing yourself and your property for bushfires; DFES, 2014, The Homeowner's Bushfire Survival Manual, Government of Western Australia, Department of Fire and Emergency Services, September and also Allianz Australia undated, Preparing your home for a bushfire.

CFA, 2011, Landscaping for Bushfire Garden Design and Plant Selection, 2011 outlines landscaping for bushfire involves planning, designing, planting and managing the area around a house. The aim is to keep the area around a house and other structures (such as carports and sheds) free of plants that can easily catch fire and then ignite the buildings. Landscaping for bushfire can be used to create new – or modify existing – gardens. It takes into account a number of factors that include: understanding how fire behaves creating defendable space the location of plants within the garden the flammability of individual plants the need for ongoing maintenance.