Reducing the costs and impacts of bushfires

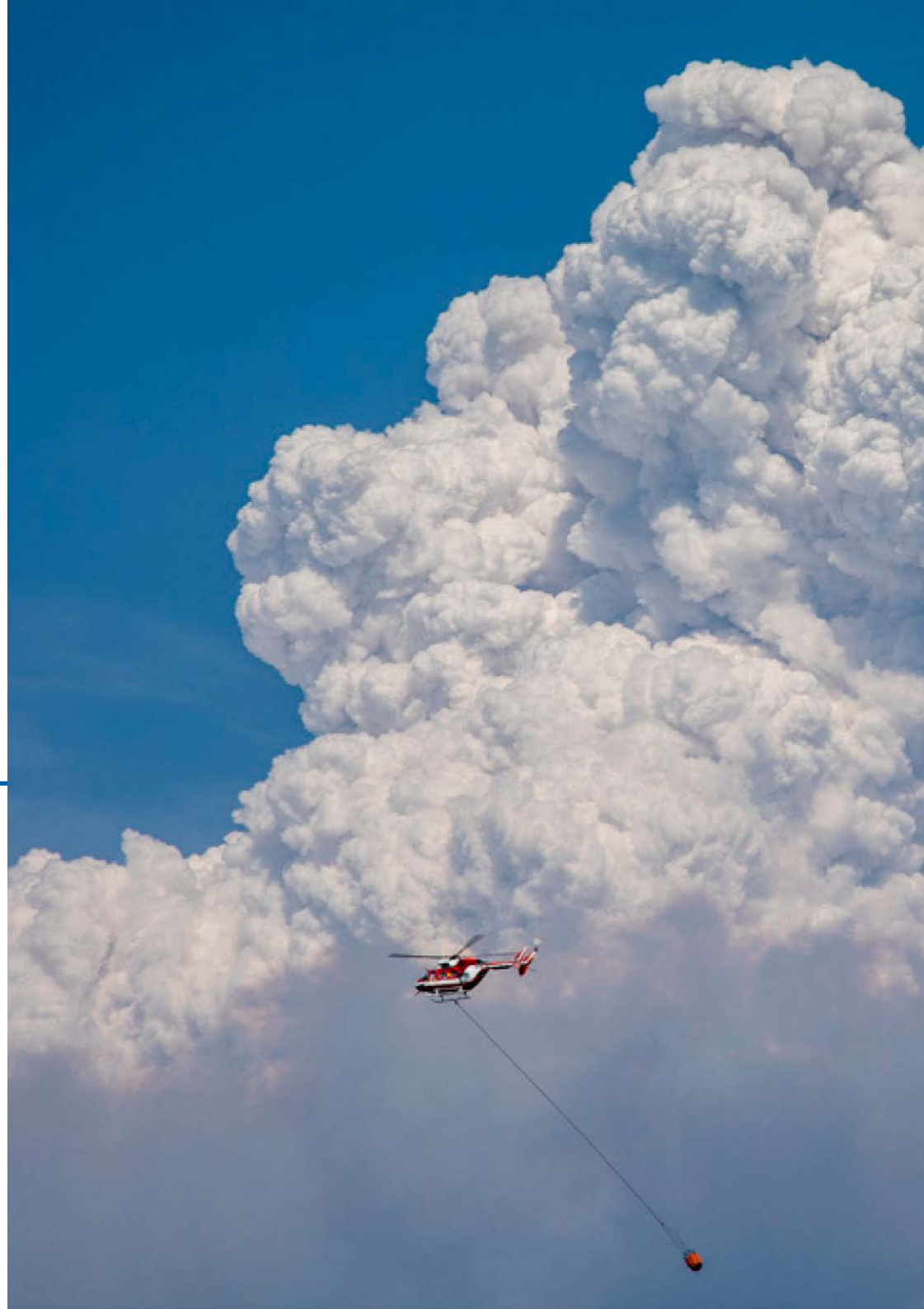
An August 2020 summary report

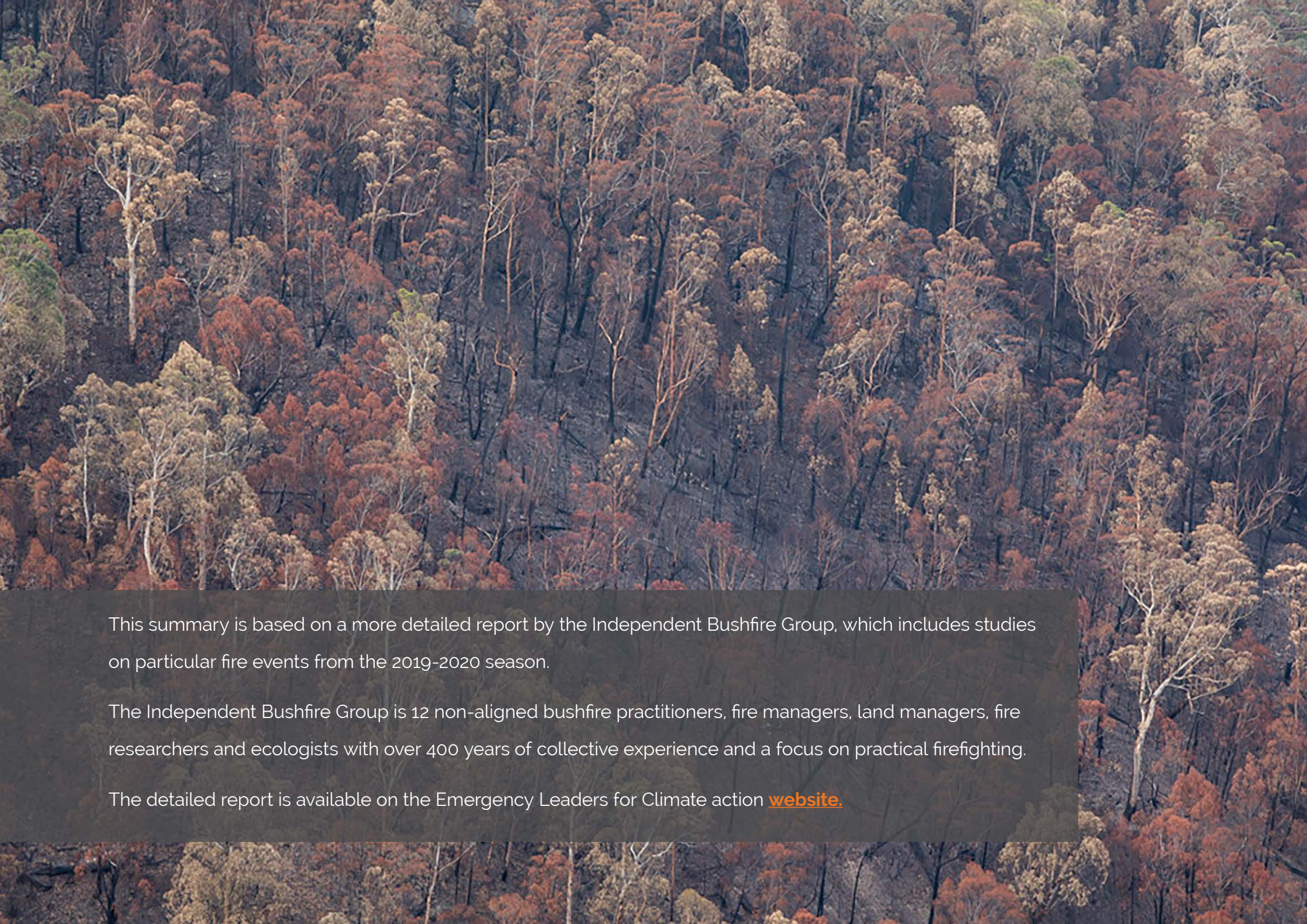
by

the Independent Bushfire Group

to

Emergency Leaders for Climate Action and the Climate Council





This summary is based on a more detailed report by the Independent Bushfire Group, which includes studies on particular fire events from the 2019-2020 season.

The Independent Bushfire Group is 12 non-aligned bushfire practitioners, fire managers, land managers, fire researchers and ecologists with over 400 years of collective experience and a focus on practical firefighting.

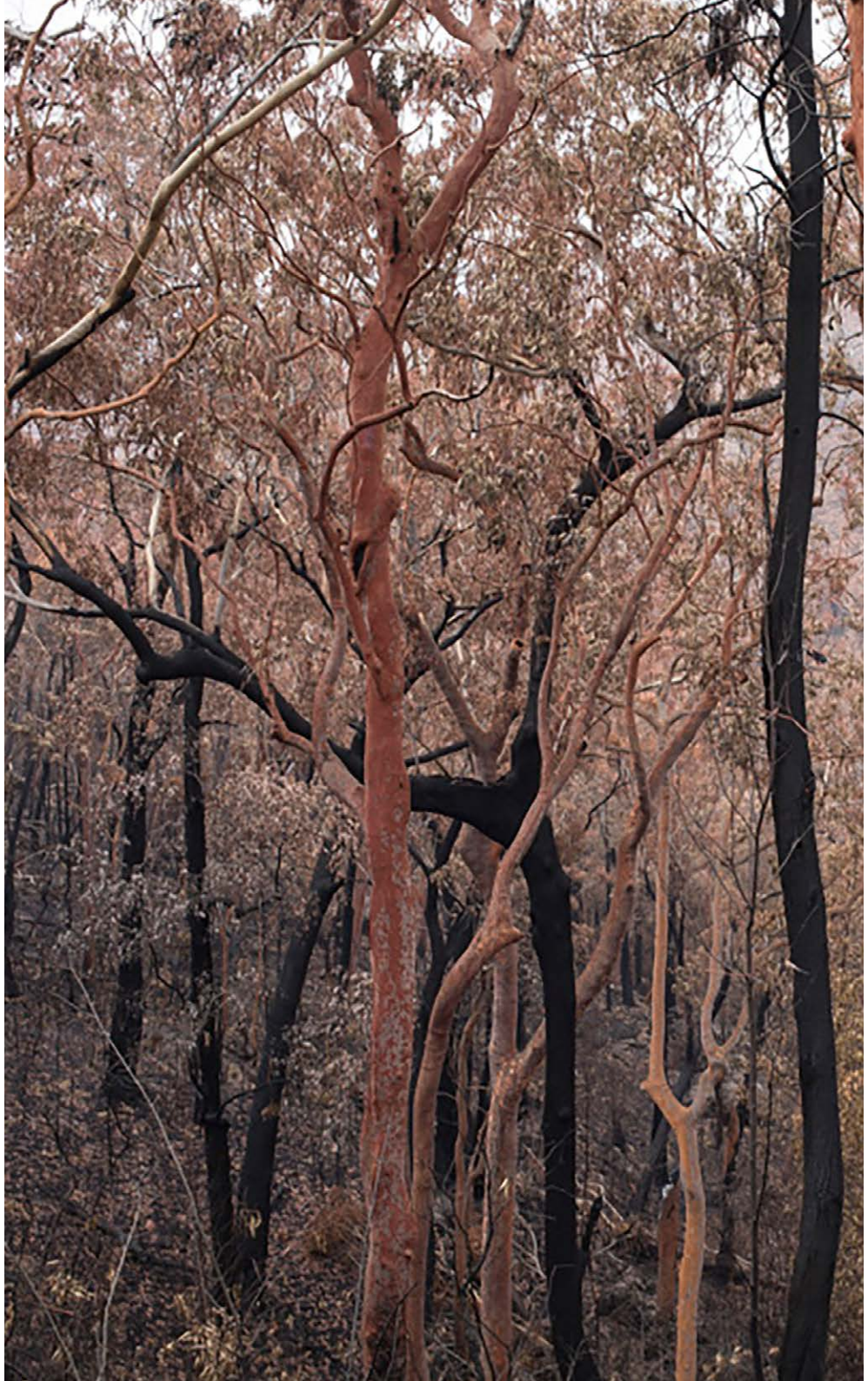
The detailed report is available on the Emergency Leaders for Climate action **website.**

Scenario:

Climate change is causing more frequent and intense bushfires across much of eastern Australia.

We must adapt to our increasingly dangerous fire climate.

We must make fires smaller and improve community resilience.



Aims:

- to better protect communities by minimising the impact of wildfires
- reduce injuries and deaths from fires and smoke
- reduce the overall risk and trauma to firefighters
- conserve our natural and cultural heritage from too much fire
- reduce costs.

1 – prevention

More varied research for better firefighting

Bushfire management is best advanced by the latest science and evidence. Australian fire research is extensive but limited by the way it is structured and often held back by prevailing opinion and culture. More researchers doing more varied research, especially into how best to control wildfires, can improve how we manage bushfires.

Use evidence to manage bushland fire risk

Managing south eastern Australian bushland for community fire risk is most effective when done at the bushland edge, as part of a mix of actions that take place regardless of who owns the land. Programs made for local conditions can both reduce fire risk and protect ecosystems.

Strengthen communities via education and planning

Communities at risk from fire can do much to protect themselves. Programs for fire awareness and community fire protection planning can be strengthened to build community resilience and self-sufficiency to reduce damage, confusion and trauma from fires.

2 – preparation

Strengthen incident management teams

More trained and capable people are needed for management teams in major fire incidents. Management works best if close to the action using local expertise. Key roles need better support. Heavy machinery work needs better control to reduce impacts.

Train more people in critical skills

Expert Fire Strategists, Aviation Specialists and Divisional Commanders are in critical short supply. These specialist roles need a lot of training and experience combined with aptitude. Training, mentoring and assessing programs for critical but scarce skills need to be strengthened across agencies.

3 – response

Improve our understanding of fire behaviour

Better fire predictions will help make firefighting more successful with less impact on people and environment. Currently predictions of how bushfires will behave are often unreliable, leading to serious problems in how they are managed. Fire behaviour models need to be reviewed and replaced.

Better risk assessment

A stronger risk-based approach, based on guidelines from the Australian Institute for Disaster Resilience, can reduce the overall impact of bushfires. The risks of all fire control options should be documented as thoroughly as time allows before acting.

Faster and stronger attack on remote fires

Some remote lightning fires that later became disasters could have been put out shortly after ignition when they were small. Changes in decision-making and investment in specialised firefighting can ensure more lightning fires are put out early, thus reducing costs and impacts.

Improve control strategies for large fires

The cost and impact of remote and large bushfires can be reduced with better training for fire strategists, more analysis of fire suppression methods, better backburning systems and more investment in other ways of controlling fires.

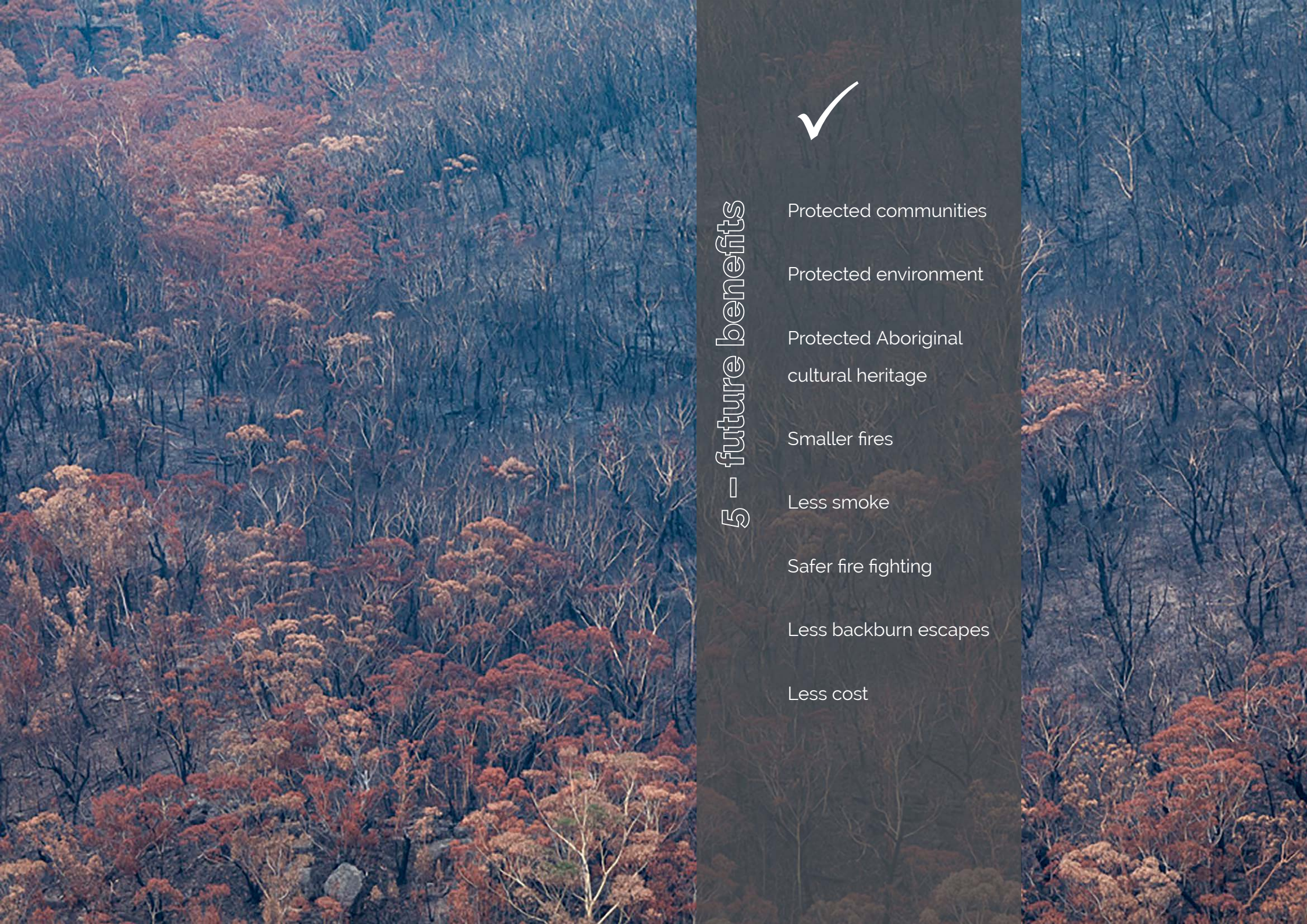
Build a lessons learned culture

What has worked in the past may not work as well in the future. Current review processes are not rigorous, systematic or transparent. Unsuccessful suppression practices continue. Post-fire review processes can be re-structured from the ground up to be inclusive, rigorous and blame-free. Communicate findings and audit their adoption.

4 – recovery

Reduce fire impacts and boost environmental recovery

Knowledge, systems and resources are inadequate for ecological recovery. Reducing the size and intensity of fires can minimise all impacts including on the environment. The way bushfires are controlled can reduce the burden of recovery, or cause unnecessary damage. Greatly expanded research on bushfire impacts, ecological baselines and fire recovery are needed, along with more investment in ecological restoration. Community-led recovery programs can be better supported by increasing resources and training.



5 – future benefits

- ✓ Protected communities
- Protected environment
- Protected Aboriginal cultural heritage
- Smaller fires
- Less smoke
- Safer fire fighting
- Less backburn escapes
- Less cost

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INTRODUCTION

We must adapt to an increasingly dangerous fire climate. This is a whole-of-community responsibility.

Fires burned for seven months in NSW. Over five million hectares of bush and rural land were burned and more than 2,400 houses were destroyed.

These are the catastrophic results of fires fueled by climate change.

Climate change is causing more frequent and intense bushfires across much of eastern Australia. Not only was 2019 the driest year on record, it was also the hottest year on record. Never before has so much of the south-eastern Australian bush been so dry. Large and dangerous fires will happen under these conditions and they did happen over seven months from July 2019 to February 2020.

Projections for climate change over coming decades indicate that intense fire seasons will become more frequent *(Climate Council 2020).* Urgent action is required to cut carbon emissions, to slow the rate of climate change and reduce the chances of fire seasons becoming worse.

We must also learn from the fires and adapt to a more dangerous future. This report looks at what we can do to manage the 'new normal' of the 2019-2020 fire season.

More than a third of the total NSW park system was burnt *(NPWS 2020b),* with an estimated 800 million native animals killed *(University of Sydney 2020a).* Twenty-five people including six firefighters died in NSW and many more were injured *(ABC 2020b).* Whole villages were nearly wiped out and residents traumatised. Toxic smoke blanketed Sydney and other centres for weeks, causing an estimated 445 deaths *(The Guardian 2020b),* over ten times more than the fires themselves.

Damage to communications, transport, tourism and electricity infrastructure and to the overall economy is in the billions of dollars *(Climate Council 2020).*

Such events will occur more often unless we achieve net zero carbon emissions to slow climate change. Until then, we must adapt to the fires that will occur in upcoming disastrous seasons that are already locked into the atmosphere.

Below: Destroyed electricity infrastructure near Mount Tomah, Blue Mountains, January 2020

We must do better in managing increasingly dangerous bushfires.

Putting out bushfires is difficult and complicated, and is becoming more so because of climate change. Operations that worked in past seasons do not always work now and may not work in the future. Throughout the extended 2019–2020 crisis, fire teams were faced with multiple difficult fires. They faced shortages of critical firefighting equipment and personnel that were geared to lesser seasons. Fires burnt in ways and in places that had never been seen before. Many firefighters and fire managers found it difficult to come to grips with what was happening. They were faced with extremely challenging and traumatic decisions, week after week.

Despite the 2019-2020 bushfire campaign being the biggest ever in NSW, a massive combined effort saved many lives and houses in very challenging circumstances. New technologies, better communications, more aircraft and new ways of doing things helped. We have looked at these fires and firefighting systems and believe further improvements can be made.

We consider that careful investment and different approaches will lead to better results. We think that it is just as important to counter simple ideas (eg focusing only on fuel, or fire trucks) that could lead to less effective fire management and greater impacts.

In the aftermath of last season there is an historic opportunity to make changes to fire operations that will:

- better protect communities by minimising the impact of wildfires
- reduce injuries and deaths from fires and smoke
- reduce the overall risk and trauma to firefighters
- conserve our natural and cultural heritage from too much fire
- reduce costs.

This report looks at how gains can be made in firefighting. It comes from applying the expertise of the author team to analysing the 2019-2020 NSW fires. Some proposals will require investment, some can be achieved with existing budgets, and some will reduce costs (eg stronger initial attack). Taken together, they can cut the total costs of firefighting.

The best ways to reduce the impact of bushfires is to keep them as small as possible, especially in dangerous times of drought, and to help communities deal with fires.

Fire management is a whole-of-community responsibility. Fire agencies* can do their best, but they need the support and commitment of communities, researchers, independent experts, non-government organisations, government and other agencies in a coordinated effort.

Above: Ruined Castle fire burning near Katoomba, Blue Mountains, 1 December 2019. This fire was a clear and present danger to local towns. After initial attack failed it was brought under control by a mix of strategies, including remote area fire teams on the ground in Kedumba Valley (to the left of this image).

There is no other reasonable response to the widespread catastrophe of 2019-2020.

We must learn from the past to confront a more dangerous future.

** 'fire agencies' in this report refers to the four official fire authorities in NSW. These are NSW Rural Fire Service (RFS), Fire and Rescue NSW (FRNSW), NSW National Parks and Wildlife Service (NPWS) and NSW Forestry Corporation (ForestCorp).*

1. PREVENTION

1.1 Use Evidence to Manage Bushland Fire Risk

Opportunity:
Managing south eastern Australian bushland for community fire risk is most effective when done at the bushland edge, as part of a mix of actions that take place regardless of who owns the land. Programs made for local conditions can both reduce fire risk and protect ecosystems.

National parks and other natural areas are more valuable than they have ever been. These areas protect species, ecosystems, geodiversity, landscapes, air quality, water catchment, aesthetics and cultural heritage, and support recreation, tourism, physical and mental health, human connections, economy, art and many other benefits.

Natural systems that support human existence and our quality of life are ever more threatened by climate change.

Much bushland in south-east Australia is flammable, creating a hazard for nearby human communities. The 'problem' of bushfire mainly exists at the bushland edge, where fires impact on people. Public discussion about this risk is hampered by the false idea that there is a conflict between fire mitigation and protecting nature. Ideological agendas, misinformation, selective evidence and simplistic solutions are widespread. Public information based on fact is required.

After severe fire seasons, parts of the community call for more prescribed burning to reduce what they see as hazardous fuels across the forested landscape. Such suggestions are simplistic and indeed may cause more problems than they solve. Misguided burning wastes effort and can damage natural fire advantages (see below).

Fire and fire mitigation are complex; simple solutions are wrong and will not help.

(Bradstock 2009)

More planned burning as a 'solution' to bushfire faces many problems. One difficulty is that only a proportion of bushland can be treated by planned burning. This is because many forest types are usually too moist to burn, except under dry summer conditions when deliberate burning is unsafe.

Analysis of vegetation across the landscape shows that the North Coast region has only 33% of 'Treatable' vegetation, nearly half that of the Sydney Basin at 62%, and a third less than the South Coast and Tablelands at 46%. If 'Somewhat treatable' vegetation is included, these percentages rise to 67%, 88%, and 84% respectively *(Gellie & Turner 2020, in press)*. Extensive clearing of forests and woodlands and convoluted land tenures makes the task of fuel management even more difficult.

In the 2019-2020 fires, planned burns three years old or less had some limited impact on slowing the progress of the main fire fronts. Older burns had even less or no effect because severe fires are mainly driven by weather.

Fire has played a part in Australian ecosystems for many millions of years. It is a key driver of where different vegetation types occur. Many plants and animals depend on fire for survival. But changes in the pattern of fire over time can change vegetation and damage wildlife populations. 'Frequent fire' is listed under NSW law as a threat to the survival of some species *(NSW TSSC 2000)*. It is important to maintain moist vegetation types that act as fire barriers by protecting them from fire where possible.

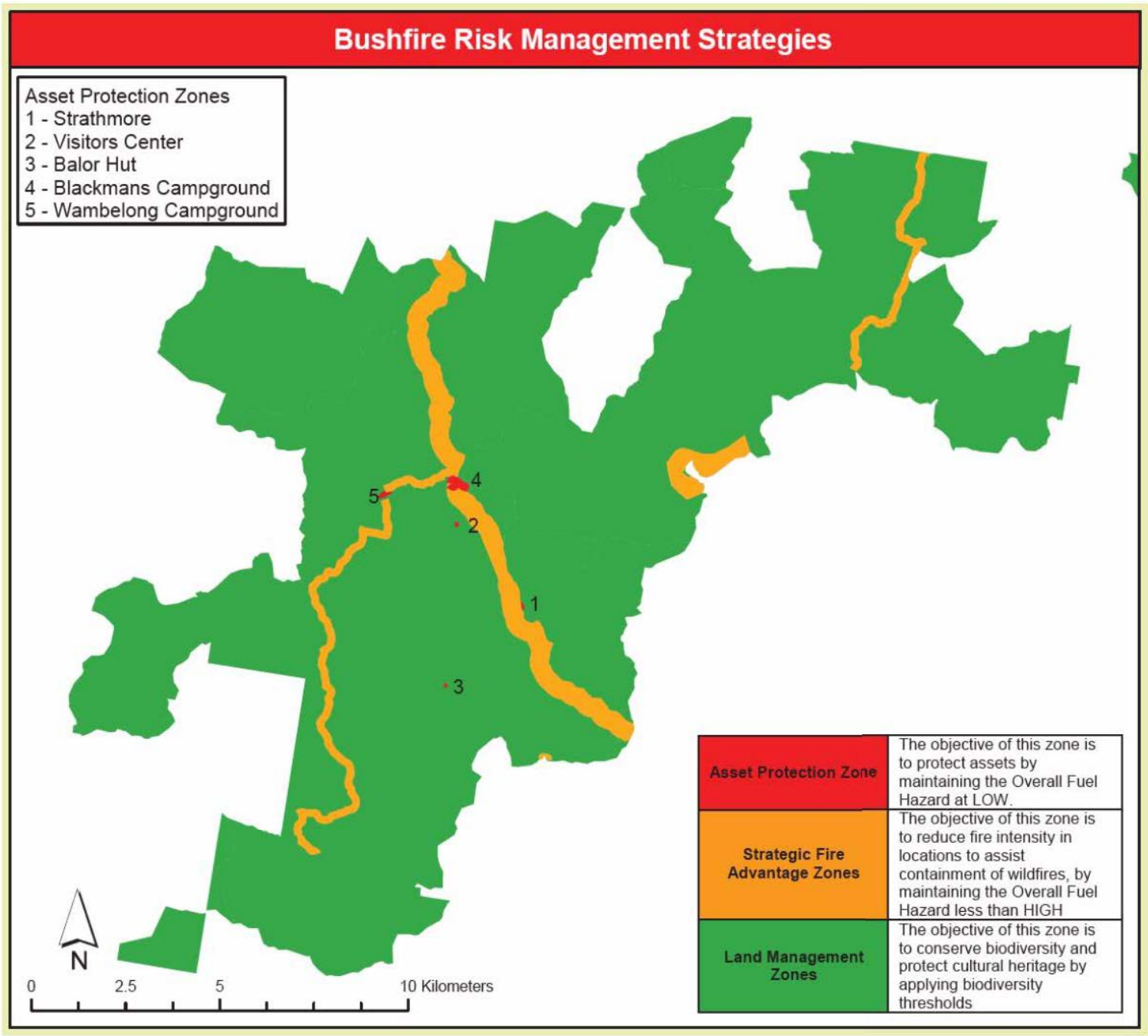
Above: Moist forest communities like this in South East Forests National Park inhibit fires naturally and should be protected.

Bushfires can damage natural areas, especially under human-induced climate change. Increasing frequency and intensity of fire is forecast for south-east Australia as climate change progresses *(Climate Council 2020).*

Conservation areas are important and complex to manage. Within their broader conservation objectives, national parks, world heritage areas, council reserves and similar areas need to manage the increasing bushfire risk to both humans and nature. The NSW NPWS bushfire strategy *(NPWS nd, reprinted 2013)* sets out to balance these needs and applies to nearly 9% of the state.

It is logical and realistic to put most effort into where the biggest risks are. In national parks this is done through zones in fire management plans. Plans for Wollemi *(NSW NPWS 2008)* and Kosciuszko *(NSW NPWS 2005)* are examples. These plans deserve support and recognition.

Fuel reduction targets measured in hectares burned will deliver just that – burned hectares – but may do little to reduce bushfire risk. This wastes limited land management resources.



Right: Fire management zones and objectives for Warrumbungle National Park.
Source: NSW NPWS 2016

Targets measuring the reduction of risk to communities would be better, if properly applied and reviewed.

Programs to reduce bushfire risk are best focused on where the risk is: the bushland interface. This is the most useful place for burning to protect human communities. The most effective policy combines fire mitigation programs across all types of private and public lands on the edge of the bush.

In the core of large bushland areas, prescribed burning is best focused on protecting ecosystems.

Burning in remote areas should aim to strengthen natural fire advantages such as rainforest gullies and moist forests. Care is needed not to reduce them. Fire can be used to protect fire sensitive communities such as the Wollemi Pine or mature forests.

At the bushland edge, prescribed burning is part of an effective fire mitigation program to reduce fire risk. But prescribed burning close to houses is often difficult. Planning controls, building standards, property management, mechanical vegetation management, clearing, water supplies, sprinkler systems, irrigation, firefighting resources and access roads all play a part. Every fire-exposed community should have a fire protection plan *(RFS 2019)* that is specific to the locality, resourced and active.

Above: Aerial image of Wytaliba (Northern Tablelands) showing residences dispersed within bushland. Source: Google Earth

The many difficulties in burning close to assets mean it is not always possible. A careful mix of strategies is needed to make communities more resilient to bushfire.

There are opportunities for Indigenous fire practices to be more recognised and utilised in bushland management, especially in areas close to assets. Traditional cultural knowledge can help to build more resilience into our forests and communities, by applying small-scale fire treatments based on deep understanding of local environments (eg Firesticks Alliance 2020).

Ongoing research into fire mitigation is also vital. Analysis of the 2019-2020 fires can add knowledge in many areas, such as a better understanding how useful various mitigation efforts were in helping to control the fires and their impact.

Opportunity:
Bushfire management is best advanced by the latest science and evidence. Australian fire research is extensive but limited by the way it is structured and often held back by established opinion and culture. More researchers doing more varied research, especially into how best to control wildfires, can improve how we manage bushfires.

Above: Vehicle-based backburn. More research is needed on suitable conditions for various firefighting strategies.
(photo: Woodford RFS/Facebook)

1.2 More Varied Research for Better Firefighting

Australia does a lot of bushfire research. This has led to a good understanding of some aspects of fire ecology, prescribed burning and fire weather. Some other issues have been less well investigated. Fire management, especially the control of wildfires, is not always based on evidence but on personal experience, opinion and culture. This is partly because research on some important issues has been very limited *(Simpson et al 2019)*. For instance, how useful have prescribed burns been in controlling fires under severe conditions? How can more backburns be successful? How useful are large air tankers? How effective is rapid aerial attack in putting out lightning strikes?

There are gaps in the scientific knowledge we need to support better bushfire management, especially fire suppression.

Most of the current fire research is funded by government agencies through a few institutions and a limited pool of researchers. The main institutions have been the Bushfire and Natural Hazards Cooperative Research Centre (BNHCRC) in Melbourne *(BNHRC 2017, 2019)* and CSIRO at the national level and, in NSW, the Centre for Environmental Risk Management of Bushfires (CERMB) at Wollongong University (now part of the larger Bushfire Risk Management Research Hub) *(CERMB 2020, BRMRH 2020)*. This system has many advantages and is achieving much useful research but has done little to look intently at how best to put out wildfires once they start.

Independent research not tied to government agendas needs to be supported.

The agency-based model has some other drawbacks. As a human activity, science can be affected by personal biases, mindsets and influence from funding bodies. Government agencies prefer to research some questions and not others. Others with interest in bushfire may prefer different priorities. Scientists as individuals and groups may narrow the range of research interests or form views that resist competing ideas.

Fire researchers should not miss out on support because they challenge established ideas. Scientists can be reluctant to pursue some research questions because they feel it could affect their funding. Prescribed burning is one example of a difficult topic because both scientists and non-scientists may want to support particular views about it. Obstacles like these get in the way of healthy and robust scientific inquiry. Peer review and healthy debate are part of the scientific method and should be encouraged in bushfire research.

Science is stronger when diverse voices are supported to investigate a wide range of research questions.

Very little work has been done to investigate bushfire suppression *(Simpson et al 2019)*, even though it is important to know what methods work and under what conditions. There is a wealth of past fires that can be analysed. The 2019-2020 fires are an enormous research opportunity, with so many fires spread over a variety of landscapes and different conditions.

Key issues that need more evidence are the effectiveness of various types of aerial firefighting, the role of prescribed burns in fire suppression and how to make backburning more effective.

Investment in bushfire research gaps should be increased, along with the independence and scope of fire research and researchers. Analysis of bushfire mitigation and suppression in the 2019-2020 season would be a great step forward. These initiatives will support bushfire management that is more evidence-based.

1.3 Make Communities Stronger through Education and Planning

Opportunity:
Communities at risk from fire can do much to protect themselves. Programs for fire awareness and community fire protection planning can be strengthened to build community resilience and self-sufficiency. This will reduce damage, confusion and trauma from fires.

Many at-risk communities do not have local protection plans and were poorly prepared for the 2019-2020 bushfires. Individuals lacked the fire understanding they needed to deal with the fires. Many believed that fire authorities would protect their communities but none came. These issues led to fear, inappropriate responses and avoidable risk to life and property. Protection from bushfires is a shared responsibility. Fire-exposed communities have a major role in protecting themselves.

Public education and community fire planning can build understanding, confidence and resilience, as well as informed support for fire management.

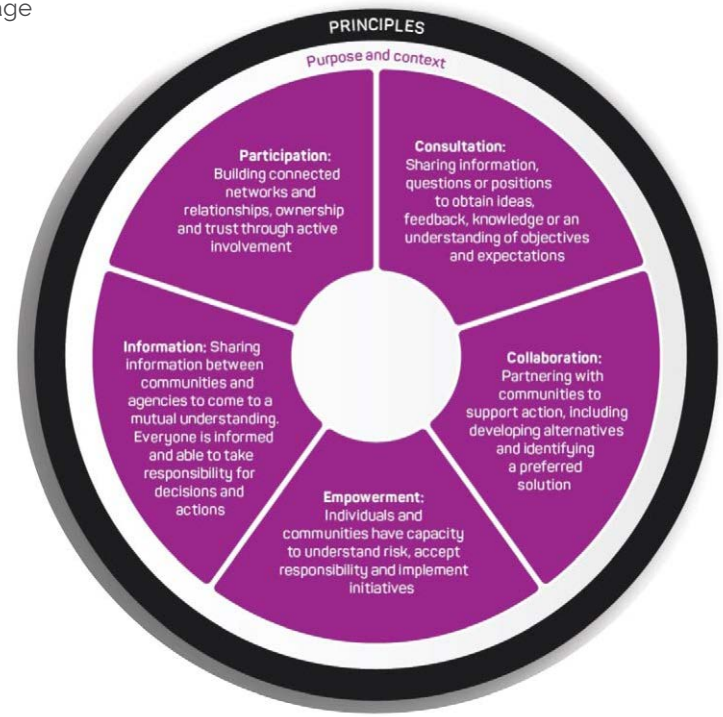
By setting themselves up for self-defence, communities can help to make fires less damaging and the overall fire response more successful. This supports and supplements the efforts of firefighting agencies and local bushfire volunteers. Local fire planning also provides a way to address issues like poorly managed land and the establishment of local firefighting resources such as Community Fire Units.

Since the 2009 Black Saturday fires in Victoria, NSW has expanded public fire awareness programs and community fire planning. These programs are based on the NSW Rural Fire Service Community Engagement Strategic Directions 2017-2021 *(RFS 2017)* and guidelines for Community Protection Plans (CPPs) *(RFS 2019)*.

Fire and Rescue NSW and the Rural Fire Service have been establishing Community Fire Units in high-risk locations. Community Fire Units both augment and support agency resources from RFS and FRNSW and encourage self-reliance and resilience.

These programs deserve to be strengthened and supported with annual rollout targets, more funding and ongoing review. This is best done while the impacts of recent fires are fresh in people's minds.

Community fire planning contributes to overall community engagement on fire on all fronts, through participation, information sharing, consultation, collaboration and empowerment.



Above: Community engagement model. Source: AIDR 2013

Formal communications such as the Fires Near Me app and the RFS website are supplemented by local RFS outreach programs. These methods provide much useful information both during fires and in the off-season. Even so, the enormity of the 2019-2020 fires left some communities feeling vulnerable and indeed scared. At times this was unavoidable when whole communities faced rapid and life-threatening fires. Even residents in some communities that were not immediately threatened were frightened. This may have been in part due to a poor understanding of fire mitigation, behaviour and suppression methods.

As the 2019-20 fire season continued the Fires Near Me app became slower to update fire news. At times, technology-based communication systems were overwhelmed as multiple fire fronts escalated. Maps and local community information became increasingly general and often lacked the precision communities needed to make decisions about safety and property protection. As good as the Fires Near Me app is, now is the time to completely rethink the information it delivers and how that information is created and uploaded. For example, automated real time uploading of fire boundary maps being used by fire crews and the management team should be implemented.

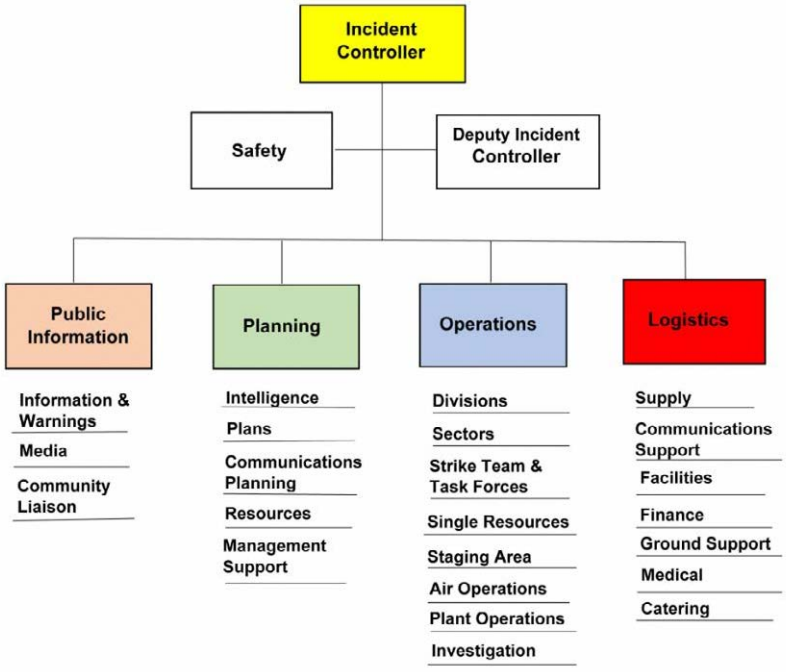
The Fires Near Me app needs to be improved to provide better advice to communities.

Many communities faced the threat of fire for the first time in recent memory. This may happen to more communities as the fires get more intense and frequent with climate change. There have been numerous stories of misinformation and uncertainty which made people's understandable fears worse. The issue was more complicated in communities which had never experienced real fire threat or where there were large numbers of summer tourists.

Much can be done before major fire seasons to inform communities on topics that will improve understanding of fire in their landscape:

- the key elements of fire behaviour
- the difference between ember attack and cold burnt leaves and ash
- the difference between spot fires and fire fronts
- the role of prescribed burning in managing risk
- the nature of fuels
- property preparation
- leaving and defending
- understanding risk
- media education.

2. PLANNING



Left: Incident Control System structure

2.1 Strengthen Fire Incident Management Teams

Opportunity:
More trained and capable people are needed for management teams in major fire incidents. Management works best if close to the action using local expertise. Key roles need better support. Heavy machinery work needs better control to reduce impacts.

We have a tried and proven system to manage major emergencies, the Australasian Inter-Service Incident Management System (AIIMS) *(AFAC 2017)*. The 2019-2020 season put this system under great stress and highlighted areas that can be improved.

On large fires there were people and skills shortages in critical Incident Management Team (IMT) roles such as Incident Controllers, Operations Officers, Planning Officers and Divisional Commanders. These shortages affected the success of operations.

With fire seasons becoming longer and more intense, now is the time to ensure there will be enough trained and experienced personnel in critical roles for the future.

An expanded program to train people for critical roles is needed. These positions should be filled predominantly from the paid professional ranks of the agencies. Across Australia many who worked in IMT roles have retired, and it can take decades to produce new people who are competent and capable. This lost resource of retired officers could be utilised as mentors to help develop the future IMT leadership. In other jurisdictions retired officers work as contractors in IMTs.

Local knowledge in key IMT and fireground roles is critical to successful fire suppression.

Professionals and volunteers with expert local knowledge need to be used to maximum benefit. The 2019-2020 fires suggest that this can be improved by moving incident command as close to the action as possible, and by avoiding clustering fires together. Greater emphasis should also be placed on continuity of people in key IMT positions. Shift patterns should be the same across all agencies.

Divisional Commanders are lynchpin people on the fireground who need the highest competency.

For Divisional Commanders to do the best in a complex job, they need support. This includes dedicated roles for Intelligence, resource tracking and communications, and at times access to a dedicated helicopter.

Despite official guidelines, bulldozer work was sometimes counterproductive or caused unnecessary damage.

Heavy machinery is commonly used to build or strengthen fire containment lines by clearing vegetation and earthmoving. These works can have high impacts on ecosystems, community assets, erosion and water quality. Restoration is difficult and expensive, and not always covered under emergency fire costs. Guidelines exist *(BFCC 2006)* but need to be followed under approvals given by the incident controller. Better systems for tracking the location and performance of plant using GPS technology would be an important step forward. IMTs should include experienced plant managers.

2.2 Train More People in Critical Skills

Opportunity:
Expert Fire Strategists, Aviation Specialists and Divisional Commanders were in critical short supply in the 2019-2020 fires. These specialist roles need a lot of training and experience combined with aptitude. Training, mentoring and assessing people for critical but scarce skills need to be strengthened across agencies.

The 2019-2020 fires revealed there were not enough skilled people for some critical roles, notably strategy, aerial firefighting and divisional command.

Big, complex bushfires are very challenging to manage. Expert specialist skills are needed in many parts of the operation. Any skill that is a weak link in the chain can lead to poor outcomes, such as failure to control the fire.

Existing systems are not producing enough people with these skills, and to then ensure they can work at an expert level. Training is a complex task for fire agencies, especially with many thousands of volunteers.

More investment in critical skills can help to avoid on-ground problems during emergencies.

Skills shortages hamper operations. Many reports from the field show that some strategies and operations were simply not able to be undertaken because the right people with the right skills were not available. Other strategies failed for the same reasons. People were unavoidably thrust into roles for which they were not fully prepared or lacked sufficient awareness of local conditions.

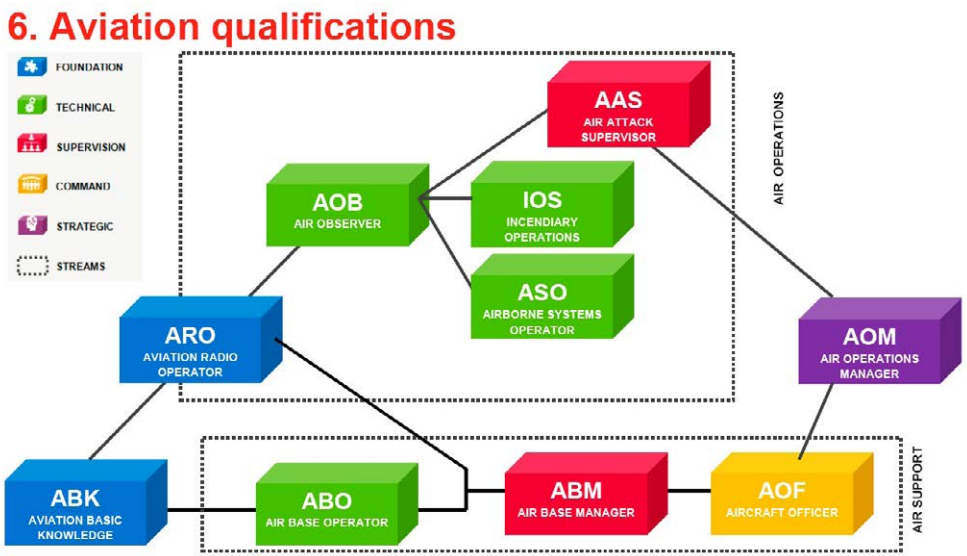
There is a lack of science and guidelines to help decisions on how to put fires out *(Simpson et al 2020)*. These decisions are mostly made by discussion amongst the most experienced or most confident officers in an IMT.

There is no program to develop expert fire strategists with experience in the local landscape. Such people should be essential in IMTs.

Aerial firefighting is becoming more important, expensive and complex. Aircraft specialists are shown in Figure 10. There was a serious shortage of expert aviation people in Australia this past season, including Aircraft Officers, Airbase Managers, Air Attack Supervisors, Air Observers and Aerial Incendiary Operators. These roles are time-consuming and expensive to train and to maintain currency.

Air Attack Supervisors direct water-bombing and other aircraft. To be effective they need to know fire behaviour, suppression strategy and how best to use various aircraft. Aerial Incendiary Operators burn out areas from the air. Both jobs are highly skilled and critical to the success of many firefighting operations.

Below: RFS pathways for aviation training. Source: RFS 2017



Shortages of aviation specialists led to ineffective use of aircraft and the failure of some strategies.

Expert Divisional Commanders are critical to successful fire control.

Divisional Commander is a lynchpin role in fire operations. They lead teams on parts of the fire, organise and direct resources, keep firefighters safe and provide advice to the control centre. Skills and leadership of Divisional Command often make the difference between success and failure.

Successful Divisional Command requires an array of skills at a high level. It takes time and a lot of experience to develop people with these skills. Agencies need a strong commitment to nurturing and mentoring expert Divisional Commanders.

Backburn, Wollemi National Park, 2013

In the 2019-2020 fires, people without the right competency had to step up to be Divisional Commanders. This led to some poorly executed strategies.

For all of these skills, courses alone will not develop high competence. On-the-job experience, mentoring and assessment by experts are essential. So is personal aptitude.

3. RESPONSE

3.1 Improve our Understanding of Fire Behaviour

Opportunity:
Better fire predictions will help make firefighting more successful with less impact on people and environment. Currently predictions of how bushfires will behave are often unreliable, leading to serious problems in how fires are managed. Fire behaviour models need to be reviewed and updated.

Strategies for putting out bushfires are guided by how fires are expected to behave. Computer models are used to predict how hot and fast fires will burn and in which direction. Critical decisions depend on these predictions, such as how to attack wildfires, planning prescribed burns and issuing public alerts.

Commonly-used fire behaviour models are based on limited data and are not reliable. They predict the wrong fire severity and spread in many forest types.

Fire behaviour analysts are advised in training to run computer model outcomes through a 'gut feel' filter for the best result. The problems are so well known that fire behaviour specialists working on real fires often use manual calculations instead of the models. Bushfire behaviour is complicated, and can never be entirely predictable. Factors include ground fuel, the type of forest, shrubs and trees, moisture in the vegetation, wind, temperature and humidity and the terrain and slope *(Zylstra et al 2016)* as well as atmospheric convection and coupling. These factors change in time and across the landscape, sometimes rapidly or in short distances.

Better fire modelling would include impacts on fauna populations

Getting fire behaviour wrong has real-world consequences. Wildfires may be attacked in the wrong way, public warnings may be misleading and planned fires may burn in unintended ways. If fire behaviour and spread can be predicted more accurately in more landscapes, then wildfire control can be more effective. Reliable fire modelling is also vital to fire research, but current models cannot be used for many purposes and are hampering advances in fire science.

Firefighting decisions based on false predictions may be ineffective or even dangerous.

With better models, firefighting options can be more fully compared. More strategies will work, with fewer failures. By avoiding actions likely to fail, resources can be more efficiently used for the best control plan. The safety of firefighters will be improved because they will get better advice on likely fire behaviour and will be carrying out fewer risky actions.

Better fire predictions can help make firefighting safer and more successful.

There is a need to review the current fire behaviour models and develop better models through peer review. By using better fire behaviour tools, more fires can be contained to a smaller size. Smaller fires mean less bushland burnt, fewer houses lost and less trauma to communities and firefighters.

3.2 Better Risk Assessment

Opportunity:
A stronger risk-based approach, based on guidelines from the Australian Institute for Disaster Resilience, can reduce the overall impact of bushfires. The risks of all fire control options should be documented as thoroughly as time allows before acting.

All bushfire management is about balancing risks. Wildfires can hurt people, communities, firefighters, infrastructure, environment and economy. Actions taken (or not taken) to control wildfires can also risk damage. Assessing the risks is critical to firefighting decisions, such as where best to focus effort and resources. Competing risks have to be compared to decide the best option. With multiple fires burning and limited resources, risk assessment can help decide which fires are the most threatening and require priority. Reliable fire behaviour predictions are an important input.

Rigorous risk assessment is needed at all stages of bushfire suppression.

Events of the 2019-2020 season suggest that good risk management did not always happen. This may have led to missed opportunities to control some fires when they were small and to unsuccessful strategies at other times. Some high-risk actions which caused more damage should probably not have been done. The risk of environmental damage was not always given enough consideration.

Both long-term threats and immediate risks need to be considered. In last season's fires this sometimes meant comparing a remote fire that could become large and dangerous with another fire that at the same time was threatening to burn down houses.

Initial attack on some remote fires either didn't take place or was not supported with enough resources.

Some fires that began as lightning strikes in remote bushland were either not attacked or attacked inadequately and went on to become very large fires with serious impacts (eg Currowan fire, Green Wattle Creek fire, Gospers Mountain fire). All of these could have been extinguished early, but went on to consume enormous firefighting resources over a long period and caused significant property damage, environmental impact and human tragedy.

For fires that 'get away' risk analysis is used to compare control options. All options have risks. Risks can include putting firefighters in serious danger, the option not working (ie fails to stop the fire), high cost or causing more damage than if the fire was allowed to run.

Avoidable damage can arise from backburn escapes that expand the fire to burn more bush or harm communities, and from earthworks or retardant drops that cause environmental impact. Sometimes the 'do-nothing' option has less risk but can be seen as irresponsible when 'action' is visible and thereby more attractive.

All fires start small: spotover, Wollemi National Park 2013.

Large backburns were used often during the 2019-2020 season. Many succeeded while others became new fires that led to avoidable damage.

Assessment of risk against threat and consequence may have been a factor in some adverse events, such as escaped backburns at Mt Wilson and Balmoral. In some cases, there was no immediate threat from the actual fire.

Bulldozer work and tree-clearing for containment lines are sometimes overdone or pointless, creating unnecessary damage. Retardant chemicals are widely dropped from aircraft but sometimes do not work. They have nutrient impacts on local ecosystems.

Some risks are unnecessary: intense uphill backburn, Blue Mountains 2013.

The recent fires led to some environmental impacts that might have been avoided.

Environmental risks are often given insufficient weight in decision-making. For example, the World Heritage listed Jenolan Caves reserve was devastated by a very hot backburn and the rainstorms that followed (eg BMG 2020). In the South East Forests, some containment lines were made much bigger than needed. Aboriginal rock art sites were permanently damaged by heat. A number of fires in the Blue Mountains and northern Gondwanan rainforests grew large to burn more World Heritage listed forest *(The Guardian 2020a)* when they could have been kept smaller. Large amounts of retardant were dropped in Sydney's water catchment, much of it to little effect.

Better risk assessment can reduce 'non-target' and unnecessary damage.

Documenting better risk processes can make decisions more effective, accountable and defendable.

The scale and consequences of fires can be reduced. Environmental impacts can be minimised.

Systematic risk assessment in fast-moving bushfires requires experience, training and techniques that are capable of being used quickly.

Risk-based management of future fires can be improved by looking at past fires.

There is a vast body of literature on risk management and how to use it in emergencies. The Australian Institute for Disaster Resilience has issued two important documents, based on the Australian risk management standard *(Standards Australia 2010)*:

- Australian Emergency Management Arrangements Handbook *(AIDR 2019)*
- National Emergency Risk Assessment Guidelines *(AIDR 2020)*.

These technical publications can be readily adapted into practical systems to help bushfire control.

Less risk means smaller, less intense fires with reduced loss of life, property and ecological assets, lower cost and less impact on the lives of firefighters and communities.

3.3 Faster and Stronger Attack on Remote Fires

Opportunity:
Some remote lightning fires that later became disasters could have been put out shortly after ignition when they were small. Changes in decision-making and investment in specialised firefighting can ensure more lightning fires are put out early, thus reducing costs and impacts.

The best time to control any bushfire is when it is small *(Victorian Bushfires Royal Commission 2010)*. As fires grow bigger, they become harder to control and cost more to put out. More firefighters are then exposed to hazards, the fire is more likely to damage towns, infrastructure and the environment, and more hazardous smoke is produced. Bigger fires strain firefighting resources, increasing the chances of property loss.

Rapid and successful attack minimises costs, risks and impacts of a fire.

The first line of defence is to find fires quickly after they start and then to attack them vigorously. This is even more important in remote bushland (away from roads) where most fires are started by lightning *(NPWS nd, reprinted 2013)*. This can happen in many places on the same day. Climate change may be making lightning more frequent. All or most of the big, destructive NSW bushfires of 2019-2020 were caused by lightning *(ABC 2020a)*. Rapid and forceful attack is well understood but did not always happen.

Below: Inserting a remote area crew, Wollemi Wilderness, 2013.

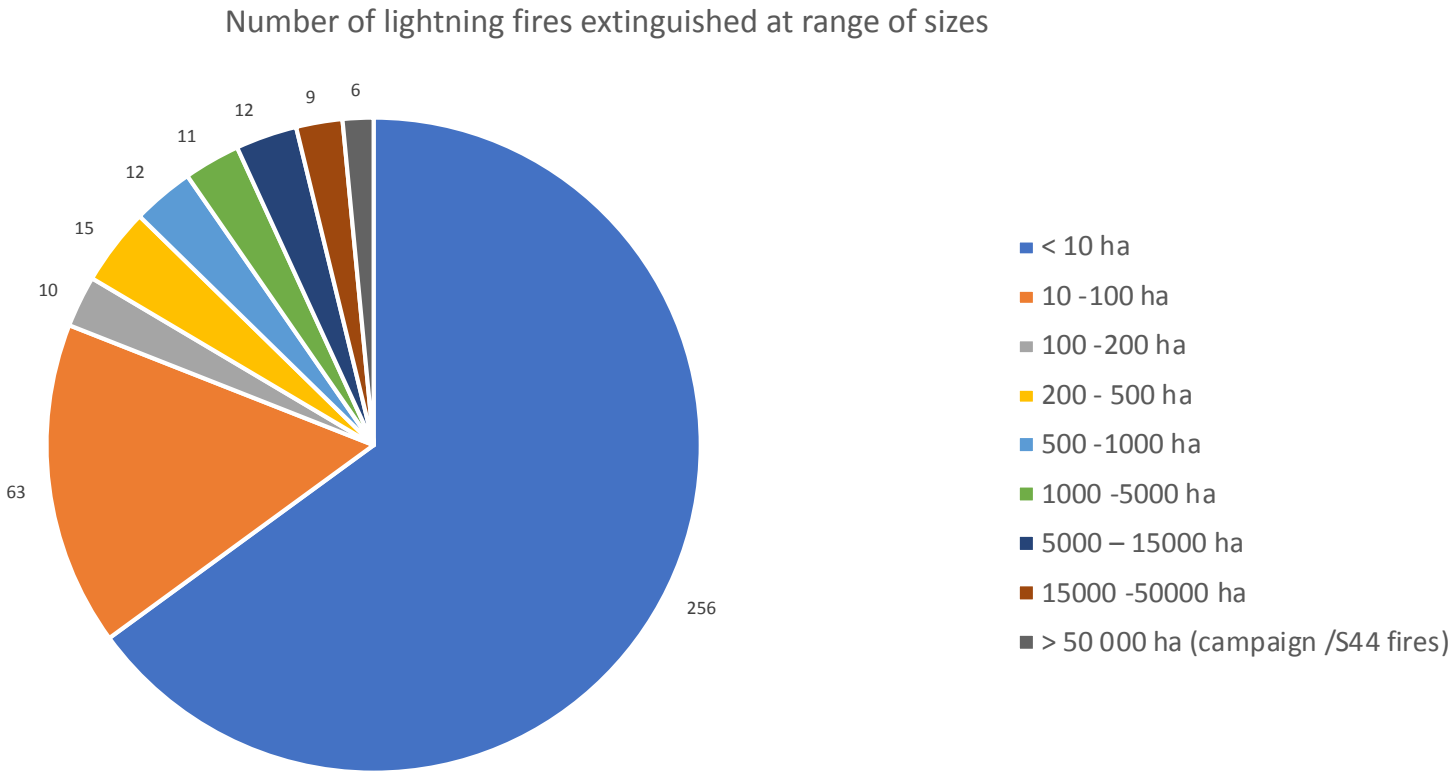
Many remote lightning fires were put out when they were small, but some were not and turned into the next disasters. Reasons why need to be looked at and fixed.

Lightning is usually forecast the day before. Most lightning fires are found by smoke sightings or by spotter aircraft during and after storms. Finding a fire and attacking it can be delayed for many reasons. When other fires are going at the same time, new fires have to compete with larger fires for critical and limited resources like suitable aircraft and skilled remote area firefighters.

Immediate threats to property were usually seen as more important than small fires that went on to become larger threats *(eg Adcock 2020)*.

Remote fires away from roads are difficult because they are hard for firefighters to reach and can grow quickly. Specialised aircraft are used for sizing up the fire, for aerial attack (eg water-bombing) and for putting firefighters on the ground. Smoke or high winds sometimes restrict the use of aircraft and prevent effective attack. Not every remote fire can be put out – but most can.

Over 10 years to 2007, two-thirds of remote fires in national parks were kept to under 10 ha in size by using rapid helicopter response, and almost 90% to less than 500 ha.



Size class distribution of 394 lightning fires in Blue Mountains parks 1997-2007.
Source: NPWS unpublished data

Remote fires occur in national parks and other large bushland areas. Most of them are put out when small *(NPWS nd, reprinted 2013)*, using the local knowledge, experience and skill of NPWS firefighters. Of 41 ignitions in the Greater Blue Mountains World Heritage Area in the 2019-2020 fire season, 20 were extinguished at an average size of 1.2 hectares *(NPWS unpub. data)*. The number of remote fires put out can be pushed closer to 100% with targeted changes:

- improve detection programs and technology (eg satellite)
- place higher priority on putting out remote fires
- in dry conditions, hold in reserve enough helicopter and specialised resources when lightning is forecast
- train more bushfire strategists
- invest in enough people with the right skills and the right aircraft for remote fires
- remove obstacles to delayed attack, night shifts and early morning attack.

With well-aimed changes to remote firefighting, many large bushfires of 2019-2020 could have been eliminated early.

3.4 Improve Control Strategies for Large Fires

Opportunity:
The cost and impact of remote and large bushfires can be reduced with better training for fire strategists, more analysis of fire suppression methods, better backburning systems and more investment in other ways of controlling fires.

The best result for any bushfire is to keep it as small as possible and to extinguish it quickly, to limit all impacts. Initial attack is crucial. If that does not work and the fire becomes large, then the best evidence-based techniques are needed.

Bearing in mind that it is not always possible to put fires out, the task for a large fire is to control its size, intensity, danger and impact. Avoiding making the fire bigger or worse seems obvious but sometimes that did not happen in 2019-20. These objectives need to be supported with the best fire analysis, risk assessment, evidence and decision tools.

What worked to control fires in the past is becoming more difficult as the climate changes.

The 2019-2020 fire operation had good success limiting the impact on property and human lives. There was less success in controlling the size of some fires and their ecological impact. Many operations were hampered by resource shortages, so important actions could not be carried out properly. At those times it is even more important to use the most effective strategies so that resources are not wasted.

Decisions on fire strategy have been based largely on people's perceptions of what worked or didn't work in the past *(Simpson et al 2019)*. But these experiences have not been well analysed and documented.

Very little science on fire suppression is available to help difficult decision-making

(SMH 2020).

A number of methods are used to suppress large fires. Mostly a mix of methods is needed. All options can be effective, with their own advantages and risks in different situations. Truck-based backburns from roads have long been favoured, and defensive property protection as the last resort. More recently aerial firefighting has increased, using helicopters and large air tankers. While often effective, aerial methods are expensive and were not always successful in the 2019-2020 season. There is little research to guide incident controllers on the optimum mix of strategies *(Simpson et al 2019)*.

Mt Wilson Road escaped backburn burning over Mt Tomah, 15 December 2019. The foreground Grose Valley (in World Heritage listed Blue Mountains National Park) burnt in this incident a few days later.

Backburning is an essential but sometimes blunt tool, and widely accepted as high risk *(ABC 2020c).* Backburns were even trickier to get right in the very dry conditions of 2019-2020. Many were lit close to the onset of bad fire weather and not mopped up in time. Some backburns were too hot because they were lit in the daytime, making them more likely to escape and needing more work to mop up. Large backburns to contain threatening fires are difficult to do safely. They need careful planning, good timing, specialist skills and thorough mopping-up.

When backburns work they stop the fire. When backburns don't work they can waste time and effort. When backburns escape containment lines they can become new fires with destructive impacts.

It is a concern that there is still no specific training program on how to carry out a backburn or to qualify people to lead a backburning team. Yet this summer thousands of fire fighters were tasked to do their best to implement hundreds of kilometres of backburns, sometimes with disastrous results.

Below: Mopping-up is hard work, and requires commitment

Escaped backburns need many trucks, planes and people to deal with them, which get taken away from other fires. Communities can get little warning that an escaped backburn is heading their way. These problems happened many times in the 2019-2020 fires. They can be reduced with research and learning, rigorous procedures and decision tools, specific training and a different mix of resources.

Firefighting has relied heavily on large-scale, high-risk backburns. Other methods do not introduce dangerous new fire but aim to keep the existing fire smaller and cooler – especially before 'blow-up' days.

Below: A remote area backburn on a track prepared with hand-tools,

A large bushfire is made up of many parts that are burning differently depending on the country they are burning in. Methods of 'closer containment' and 'partial containment' look for opportunities to 'steer' or put out parts of the fire. Despite the overall severity of the 2019-2020 season, there were times when conditions were suitable for this sort of attack. It is likely that other opportunities were missed.

Alternative strategies work from a detailed understanding of local landscape and local fire behaviour. Options other than big backburns look for advantages like rainforest creeks and low-fuel areas where the fire might stop or burn more slowly. Then techniques are used to control what the fire is doing. This might mean putting in remote area firefighting teams to extinguish a section of fire or dropping incendiaries to burn out small sections under controlled conditions, or well-targeted water-bombing.

In 2019-20 the northern flanks of the Ruined Castle fire and the southern flank of the Grose fire were managed in this way with great success. Both strategies prevented fire impacts on the vulnerable villages of the Blue Mountains.

The skills and resources needed for other firefighting methods should be given as much support as truck-based firefighting.

Available skills and resources influence strategy choice. Decision-making should follow rigorous procedures and be more evidence-based. Learning from analysis and review of past operations is essential, especially after the 2019-20 season. These changes can reduce the size, impact and cost of fires.

3.5 Build a Lessons Learned Culture

Opportunity:
Our changing fire climate means that what has worked in the past may not work as well in the future. This requires that we learn from fire events to improve future performance. Current review processes are not rigorous, systematic or transparent. This has allowed unsuccessful suppression practices to continue. Post-fire review processes can be re-structured from the ground up to be inclusive, rigorous and blame-free. A healthy "lessons learned" culture would actively communicate findings and audit their adoption.

On the evidence, NSW bushfire agencies are not yet committed to constructive and effective review of large fires. They rely on inconsistent 'nuts-and-bolts' debriefs and after action reviews (AARs). There is no public reporting, independent expert advice, objective research or outside oversight. Fire controllers report on fires they themselves have managed. Agencies are loath to comment on other agencies. For much of fire management, the RFS is both the lead agency and also the chief reporter to government on outcomes. There is no independent oversight as there is for similar government functions like policing and defence.

Aftermath of a high intensity fire

Bushfire review processes are not rigorous, systematic or transparent (even to those within the system).

The firefighting community is widely disappointed in debriefs for large fires, because the most important matters are rarely discussed, and outcomes are not obvious. There is a history of dissatisfaction from all levels of fire operations; from fireline crew to IMT members and across all NSW fire combat agencies *(SMH 2020, ABC 2015)*. Reports coming out of debriefs for the 2019-2020 fires suggest this situation has not improved.

Agency cultures do not encourage searching analysis or dealing with difficult issues. Analysis of fire operations is poor at the command and strategic level. Scientific evaluation of strategies has been almost absent *(Simpson et al 2019)*. There is little formalised documentation of time-and-event as a basis for reviewing outcomes. Reputational damage is feared, especially when firefighters are held in such high regard in the broader community.

Bushfire suppression is complicated and difficult, especially for large and challenging fires. This can make such fires difficult to properly review, but it is even more important to do so. All large fires involve strategies that worked (ie controlled the fire) and some that did not (ie failed to control the fire or caused harm). Ineffective strategies can have serious consequences and, in some cases, have led to more damage than the fire itself. This happened with some escaped backburns in the last season.

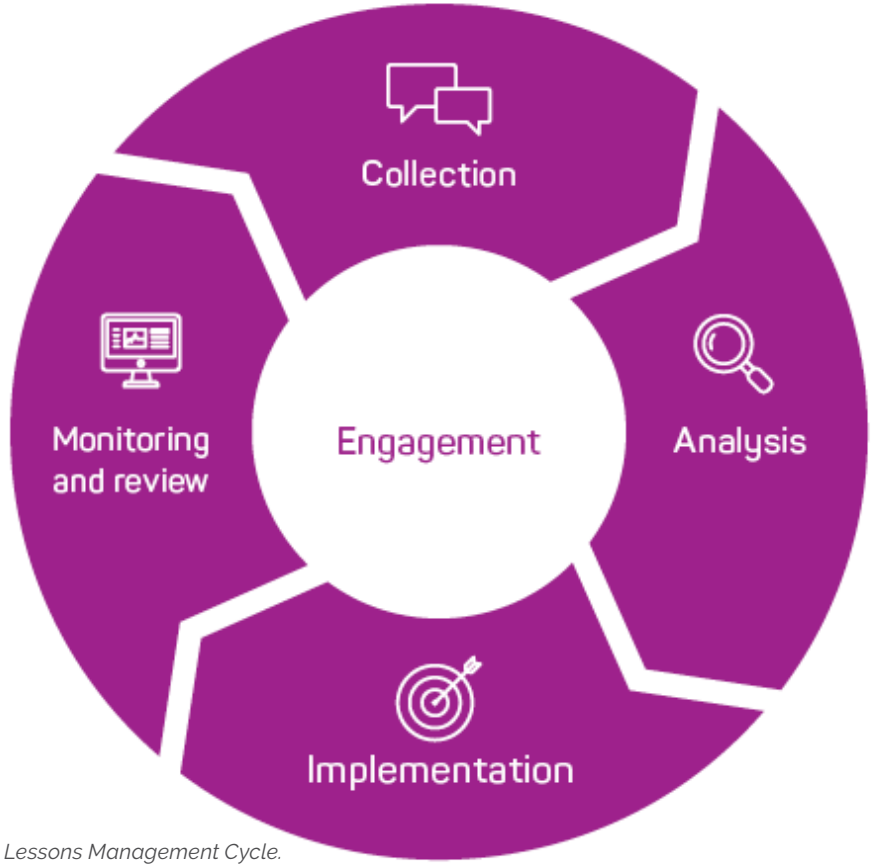
Ineffective strategies can have serious consequences.

It is important to analyse which actions and systems worked and which didn't work, and then to communicate and adopt lessons learned. Inadequate review of fires can lead to learning failures, ongoing safety issues, inappropriate actions continuing (such as unsuccessful control strategies) and continuation of flawed practices.

Bushfire agencies can learn from other industries such as aviation and medicine how to build organisational resilience, defined as: "the degree to which a system continuously prevents, detects, mitigates or ameliorates hazards or incidents" *(Queensland Health, 2014).* In these industries blame is avoided. Instead, the root cause of missteps is looked at.

The causes of adverse incidents often come down to problems in the system.

There is a wealth of global experience on how organisations can improve by reviewing actions, successes and failures. A culture of improvement is widely regarded as routine within industry and government.



Above: Lessons Management Cycle. Source: AIDR 2019, p3

For NSW, two linked documents are key. The Australian Institute for Disaster Resilience, a Commonwealth Government body, has produced the Lessons Management Handbook *(AIDR 2019).* The NSW Department of Communities and Justice has published A Lessons Management Framework for NSW Emergency Management Sector *(NSW Office of Emergency management 2018).* These excellent systems for structured lessons management have apparently not yet been taken up by fire agencies.

The objective is to learn from the past in an organised way so that problems can be avoided and performance improved.

The future lies in cultural change to support critical analysis of fire control operations. Change is hard and may need to be driven from outside the fire agencies. But public inquiries are not a substitute for processes that should be routine and expert.

Effective review of bushfire operations will:

- objectively assess operations
- rigorously research fire suppression as a key input
- avoid blaming individuals
- encourage honest feedback
- encourage the acknowledgement of errors as well as successes
- effectively communicate outcomes
- ensure change happens.

4. RECOVERY

4.1 Reduce Bushfire Impacts and Boost Environmental Recovery

Opportunity:
The 2019-20 fires had a huge impact on the natural environment of NSW. Knowledge, systems and resources are inadequate for ecological recovery. Reducing the size and intensity of fires can minimise all impacts including on the environment. The way bushfires are controlled can reduce the burden of recovery, or cause unnecessary damage. Greatly expanded research on bushfire impacts, ecological baselines and fire recovery are needed, along with more investment in ecological restoration. Community-led recovery programs can be better supported by increasing resources and training for NGOs, NPWS, Local Land Services, the Department of Agriculture and Bushcare and Landcare groups.

Above: The iconic Blue Gum Forest in Blue Mountains National Park after intense fire and flood, April 2020 (Photo: W. Jones)

More than 5.4 million hectares of NSW burnt, causing major impacts on the natural environment. Half the area burnt - 2.7 million hectares - was in national parks. This is 37% of the whole NSW park system *(NPWS 2020b)*, and a much higher proportion of parks in eastern NSW. Large areas of native State Forests were also burnt. Many affected areas in NSW had not previously burnt in historical times, including sub-tropical and temperate rainforests from the Blue Mountains to the Queensland border *(GEEBAM IMAGES 2020, University of Sydney 2020b)*.

Damaged natural assets include populations of Koala and Brush-tailed Rock Wallaby, cave reserves at Jenolan, Wombeyan and Yarrangobilly, ancient Gondwanan rainforests, the Wollemi Pine and Blue Gum Forest in the Blue Mountains.

The Greater Blue Mountains World Heritage Area (GBMWHA) was 68% burnt, with a third of this at high to extreme severity *(Smith 2020)*. Jenolan Caves and Blue Gum Forest were devastated by the fires and the severe flooding that followed. Irreplaceable Aboriginal rock art sites were severely damaged.

The fires killed 800 million native animals

(University of Sydney 2020a).

Many wildlife populations were severely reduced *(University of Sydney 2020a, DPIE 2020)* and some endangered plant and animal species may have become locally extinct. At the broader scale, many ecosystems have now been burnt more often, and more extensively in one season, than they can sustain. Major changes are likely in the way these habitats function.

Below: Koala rescued from approaching fire being released back home into Kanangra-Boyd National Park, March 2020

There have been few population surveys of species, either before or after the fires. So information is not available to predict how species might recover. Recovery estimates for individual species need to be based on climate projections rather than the more stable climate over the last 80 years.

Excessive bulldozer fireline work, which has not been drained or rehabilitated, near Numeralla. (Photo: R. Swain)

Many bushland areas are now just islands in a sea of burnt landscapes. The remaining unburnt areas are critical to the long-term recovery of biodiversity in the burnt national parks and everywhere.

The recovery program should not just focus on endangered species. It needs to take place over a long time, across the entire reserve system and adjoining land. Long term investment in NPWS staff and budgets will be necessary for recovery to succeed *(NPWS 2020a)*.

The wider public is in shock at the magnitude of wildlife loss. Despite the oft-cited 'green shoots', there is no certainty that all will be well. The fires came on top of the existing wave of climate change and other environmental stresses. Honest reporting is needed on the actual prospects of recovery for ecosystems and species. A public information campaign would assist people to understand these impacts.

Planning for environmental recovery both during and after bushfires has been poor.

Even many months after the fires, no statewide plan for environmental recovery has yet emerged (notwithstanding broadscale feral animal baiting by NPWS). The critical role of IMTs in both avoiding impacts and planning for recovery is often given little attention. Once a fire is out, most IMTs disband and funding is withdrawn before the recovery process can commence.

The repair and recovery of bushfire impacts, especially those resulting from fire operations, should be properly funded within overall fire costs.

5. CONCLUSION

The underlying cause of the biggest bushfire season ever seen in Australia was climate change caused by human activity. It will get worse. The first defence must be to urgently cut net carbon emissions to zero, here and everywhere.

Communities, governments and fire agencies must also prepare for a more dangerous future and improve how bushfires are managed.

Even worse fire impacts than what we have seen can be reduced through a two-pronged approach: boosting community resilience and keeping fires smaller.

The first step is to support communities at the front line of bushfires to learn how to better manage risks to protect their properties.

Fire mitigation programs based on evidence and local conditions can reduce the threat to communities while also protecting ecosystems and important conservation values.

Secondly, every effort needs to be made to put fires out before they get too big. Better systems for rapid detection and then fast and vigorous attack can extinguish most of them.

Fires that get away can be kept smaller and less dangerous by having better fire behaviour predictions, making better risk-based decisions, having confidence to use more nuanced fire suppression strategies and learning from past operations.

Building critical skills and acquiring the right equipment are critical.

A determined and whole-of-community effort is needed to minimise the cost and impact of wildfires, reduce human injuries, deaths and trauma and conserve our precious natural and cultural heritage.

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7. AUTHORS

Denise Allen

BSc Forestry

Denise Allen is a professional forester with over 39 years' experience in land management. Denise spent 15 years working for the Forest Department and the Department of Conservation and Land Management in Western Australia, nine of those years as District Manager Jarrahdale, just 60km south-east of the Perth CBD. There she was responsible for implementing broadscale aerial burns and fire suppression activities within close proximity to a large and vocal populous. Working for the NSW National Parks and Wildlife Service, Denise has had roles managing the fire management program at an Area, Region and Branch level. She assisted in establishing the Enhanced Bushfire Management Program on the north coast of NSW and has been involved in overseeing its implementation. Denise most recently acted as Manager of Booderee National Park, a park jointly managed by the local indigenous community of Wreck Bay and Parks Australia staff.

Ian Brown

OAM, BA Earth Sciences, National Fire Medal

Ian Brown worked in national park management for 20 years and was involved in over 100 bushfires in roles from crew member to Incident Controller. He was the planning leader for the 1994 Bell Range fire emergency in the Grose Valley (Blue Mountains National Park) and Deputy Incident Controller for the emergency declaration phase of the 1994 Gospers Mountain fire (Wollemi National Park). He worked on planning for the Northern Strategic Line in the Blue Mountains. He managed bushfire programs across the Blue Mountains park system and served on two district bushfire management committees. In recent years he has been an independent environmental consultant, maintaining a strong interest in bushfire issues.

Dave Darlington

BA Earth Sciences, DipEd, National Fire Medal

Dave Darlington is a retired NPWS Regional Manager from the Snowy Mountains. Dave helped to develop and refine the incident management system in the 1990s and was a key IMS instructor for NPWS. In the Snowy Mountains fires of 2002-03 he was the Section 44 incident controller continuously from mid-December 02 to March 03 (for which he was awarded Australia Day Citizen of the Year by Snowy River Shire Council). He has also managed numerous smaller incidents. He was the NPWS representative on several Bushfire Management Committees from the mid 90's until his retirement in 2013. Dave is an active member of the Jindabyne RFS Bushfire Brigade and is the Brigade President. He assisted RFS to develop a Community Fire Protection Plan and a Community Fire Unit for some key rural residential estates in his Brigade area.

Stephen Dovey

BSc, National Fire Medal

Stephen Dovey has been actively involved in fire management and suppression over 35 years in the NPWS. For the past 20 years as Area Manager he has been actively involved in cooperative firefighting with other agencies on the Bega Valley District Bushfire Committee. He has applied fire for ecological purposes as well as protection of life and property.

Nicholas Gellie

BSc Forestry, MPhil

Nicholas Gellie is a landscape ecologist and fire scientist with 37 years' experience in fire management, fire research, fire ecology, fire risk planning and vegetation mapping. He has an in-depth knowledge of landscape and bushfire processes in south-east Australia, having reconstructed over 100 major bushfires, including 2003, 2007 and 2009 (Black Saturday) in Victoria, 2003 in Canberra and 2019-2020 in NSW, as well as in Portugal and in California. He has undertaken many consultancies and published many scientific papers. He has worked extensively on fire behaviour analyses and the effectiveness of planned burning programs. He was a pioneer of community fire planning in NSW, has been involved in suppression strategies and aerial ignition for numerous wildfires and has planned and implemented many prescribed burns. From 2009 to 2014 he worked with Victoria's Department of Sustainability of Environment and the Bushfire CRC on analysing the Black Saturday fires. He was a key consultant to the House of Representatives Select Committee's inquiry into the 2003 Australian bushfires, A Nation Charred.

Lyndsay Holme

DipTeaching, TeachingCert, AssocDip (Environmental Control), MAppSc (Environmental Management), National Fire Medal

Lyndsay Holme has worked as a teacher in the Australian education system and for several decades as a ranger, field officer, forest fire fighter, ecologist and educationist with both the National Parks and Wildlife Service and the Rural Fire Service in New South Wales. He is the principal of Blue Labyrinth ECOServices, a private consultancy, where he undertakes ecological survey and bushfire risk assessment and prepares land system fire management plans for both government and the private sector. For 18 months in 2016-17 he worked as an Australian Government volunteer in the Kingdom of Bhutan, assisting with forest fire fighter training and advising Bhutan's Department of Forests and Park Services on strategic fire management and planning. He is also an active member of his neighbourhood CFU which was activated a number of times during the recent fire emergency period.

Wyn Jones

BAgSc

Wyn Jones is a wildlife ecologist and botanist with 50 years' field and research experience across a variety of landscapes. He is regarded as an expert on the ecology and wildlife of the Blue Mountains, where he has undertaken many studies on endangered species of flora and fauna, examined bushfire impacts and mapped vegetation. He has also created numerous community-based education and engagement programs founded in the natural values of the area. He is a photographer and a poet.

Geoff Luscombe

BSc (Hons)

Geoff Luscombe worked for 30 years with the NSW National Parks and Wildlife Service, 23 years as Regional Manager for the Blue Mountains and then Central Coast. He led fire management and fire operations throughout his career, in one of the most complex fire management areas in Australia. He played a key role in developing NPWS fire policies and fire training, developed the state's largest strategic burning program, and numerous fire management plans. He was Incident Controller for many emergency-level fires, some involving significant property loss, coronial enquiry and litigation. Geoff has served on many bushfire management committees.

Tim Shepherd

BSc (Hons), Grad Dip Mediation and Conflict Resolution

Tim Shepherd is a former NPWS Regional Manager on the NSW Far South Coast. His firefighting career began as a seasonal fire fighter in the late 1970s with the then Victorian Forestry Commission. As Regional Manager he held senior IMT roles and worked in coordination roles between agencies and other IMTs during major incidents. He formed the first Aboriginal fire team in NSW NPWS and worked with the Boards of the Aboriginal owned Gulaga and Biamanga National Parks to develop approaches to cultural burning. Under his leadership the NPWS Far South Coast region doubled its hazard reduction output in terms of numbers of burns and hectares treated. In the 2019-2020 fires he served as a volunteer in the Incident Management Team based in Bega.

Bill Shields

Bill Shields is a Bilpin orchardist who as a volunteer with the Rural Fire Service for more than 50 years has been involved at every level of fire fighting since the 1960's. He served as Captain of Bilpin RFS for 30 years and as a Group Officer in the Hawkesbury for 16 years. Over this period, he was involved in every major fire in the Bilpin area, including as Divisional Commander for all the big fires until 2013. He has been a Divisional Commander and Strike Team Leader on numerous fires outside the Hawkesbury in NSW. He has managed the planning and implementation of many backburns and planned burns. He was a pioneer in community fire planning and education long before it became more widely adopted.

Marg Turton

BSc

Marg Turton is a Blue Mountains based ecologist who has been employed in various roles within the NPWS, Blue Mountains City Council and as an environmental consultant for over 25 years. Marg has written several threatened species recovery plans, has studied the fire ecology of numerous endangered plant species, prepared Fire Management Plans, worked on various post-fire monitoring studies and also worked with the NCC Hotspots program. Marg has an extensive knowledge of the Blue Mountains environment, it's varied habitats and its wildlife.

Philip Zylstra

B App Sc (Environmental Science), PhD (Mathematics in bushfire modelling)

Phil Zylstra is an Adjunct Associate Professor at Curtin University (WA) and an Honorary Fellow at the University of Wollongong. Phil worked in fire management across the Snowy Mountains from 2002-2012 and again in 2017, where he was one of NSW's first fire behaviour analysts. He combined management with research starting in 2004, to develop FRaME (Fire Research and Modelling Environment), which is the only peer-reviewed fire behaviour model in Australia for forests other than West Australian jarrah, the only existing model showing species' effects on fire behaviour, and the only model for first-order fire effects on wildlife. Phil now combines these mechanistic approaches with empirical analyses of fire history to understand what drives flammability in Australian forests, and what new thinking is needed to mitigate the increasing fire risk posed by climate change.