Hazard Notes 2013–2021

Summarising eight years of Bushfire and Natural Hazards CRC research

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INTRODUCTION

HAZARD **NOTE**

COLLECTION ISSUE 2013–2021

TOPICS IN THIS EDITION | HAZARD RESEARCH | KNOWLEDGE | AUSTRALIA

Hazard Notes are a series of topic-focused research briefing papers that have been regularly published by the Bushfire and Natural Hazards CRC between 2013 and 2021.

Previously developed at the Bushfire CRC as *Fire Notes*, the intention of *Hazard Notes* was to translate key research findings into a succinct and accessible format using simple language, to enable a better understanding of natural hazard science in Australia that can be shared with partners and the wider community.

Each *Hazard Note* is a simple and concise summary of key research insights and findings based on the latest CRC research, including an outline of how this research can be, or is being, used by the industry. They spell out the broad outline of a research area, and points readers to further resources for a more in-depth understanding of published scientific literature. *Hazard Notes* can also be used as a springboard for further investigation or collaboration.

All *Hazard Notes* are publicly available online and are distributed through an extensive database that includes all state and territory emergency management organisations, government departments, small-to-medium enterprises, rural fire brigades, State Emergency Service units, local governments and interested members of the public. Many take the opportunity to share the *Hazard Notes* with their networks. *Hazard Notes* are also widely shared and engaged with on social media and through agency news and other publications.

As part of the *Hazard Notes* series, the CRC also coordinates and publishes the Australian Seasonal Bushfire Outlooks to provide an assessment of bushfire potential across Australia. These Outlooks are developed in collaboration with state and territory fire and land management agencies, as well as the Bureau of Meteorology and the Australasian Fire and Emergency Service Authorities Council – a significant cooperative effort and valued contribution to year-round fire management across the country. The Outlooks are used by fire and emergency service agencies to work with relevant state and federal governments to prepare for the bushfire season.

Since 2013, the CRC has published almost 100 *Hazard Notes*, including 23 Seasonal Bushfire Outlooks, all of which are included in this book. Here, you can read all the key findings of CRC research across the ten Driving Change themes, which reflect how the research can be best used.

This collection summarises much of the CRC's research and is an invaluable contribution to the better understanding of natural hazard science in our community. It is supported by three other end-of-CRC publications: *Highlights and Achievements 2013–2021, Postgraduate Research* and *Research Posters*. These are all available on the CRC's website.

All *Hazard Notes* are available at www.bnhcrc.com.au/hazardnotes

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ISSUE 89 FEBRUARY 2021

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HOW TO ENHANCE COMMUNITY RECOVERY AFTER DISASTERS

▲ **Above:** THIS RESEARCH SUPPORTS WELLBEING AFTER DISASTERS BY PROVIDING AN EVIDENCE-BASED FRAMEWORK OF RECOVERY CAPITALS FOR INDIVIDUALS AND COMMUNITIES. ILLUSTRATION: OSLO DAVIS.

ABOUT THIS PROJECT

The *Recovery capitals* project began in 2017 and aims to support wellbeing after disasters by providing evidence-based guidance about factors influencing the recovery process for people and communities. This research is a collaboration between the University of Melbourne, Massey University (Aotearoa New Zealand), Australian Red Cross, and other researchers, government and non-government agencies, and emergency management agencies from across Australia and Aotearoa New Zealand.

AUTHORS

Phoebe Quinn and Prof Lisa Gibbs, University of Melbourne; John Richardson, Australian Red Cross; Dr Denise Blake, Prof David Johnston and Emily Campbell, Massey University.

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SUMMARY

Using an adapted version of the Community Capitals Framework, the *Recovery capitals* project promotes a multidimensional and inclusive, systemic approach to disaster recovery. The research emphasises the interactions between natural, cultural, human, social, political, built and financial capital resources (see 'What is a capital?' on page 2) in disaster recovery.

Researchers are developing a set of evidence-based resources to guide recovery workers, having launched the first guidance document in July 2020 to support current Australian recovery from the Black Summer bushfires and the COVID-19 pandemic – now available on the Disaster Mental Health Hub.

This user-oriented project involves authentic collaboration between end-users and academics at every stage, from framework development and evidence mapping to resource design and piloting.

The resulting resources will consider people, geographies and temporality, while interweaving issues of access, equity and diversity.

HAZARD **NOTE**

WHAT IS A CAPITAL?

In the context of this research, capitals are assets or resources that can be used to generate more or new resources for the purpose of supporting wellbeing. For example, social capital refers to the connections and trust among people and groups that can be thought of as a resource at both the individual and community level.

CONTEXT

The complexity of disaster recovery processes is well established – it is multifaceted and dynamic, far from being a linear process with a single outcome. For the past decade, four recovery environments (built, social, economic and natural) have been used to recognise the multiple aspects of recovery. However, often recovery efforts remain siloed, with little attention paid to the interconnected and diverse layers which collectively contribute to the process.

In recent years, 'capitals' approaches have been applied to disaster recovery as part of continuing efforts to develop integrated understandings of the many factors involved, with notable attention given to social capital.

Capitals frameworks can be useful in understanding the dynamic and complex ways in which different environments relate to each other, and which resources can be drawn upon to achieve desired outcomes.

One capitals approach that has been applied in recent years in the disaster resilience field is the Community Capitals Framework (CCF). This framework consists of seven capitals – social, cultural, natural, built, political, financial and human – which are the foundation of the current *Recovery capitals* project.

BUSHFIRE AND NATURAL HAZARDS CRC RESEARCH

This project involves working closely with end-users to improve the way that planning and decision making for disaster recovery is addressed. The research comprises three stages – firstly the establishment of the Recovery Capitals Framework, secondly the mapping of current evidence to inform the framework, and finally the development of specific resources for use by collaborative partners across Australia and Aotearoa New Zealand.

Recovery Capitals Framework

The first stage was to develop a Recovery Capitals Framework to guide the approach to gathering evidence and developing resources. Researchers used the Community Capitals Framework (see Emery and Flora, 2006) as a starting point, in recognition of its usefulness in highlighting complexity and interconnectedness in disaster recovery. The Recovery Capitals Framework comprises natural, social, financial, cultural, political, built and human capital (see Figure 1, below).

In the absence of pre-existing definitions of each of the seven capitals in disaster contexts, researchers developed new disaster-focused definitions in collaboration with end-users. The capitals were defined broadly to allow for fluidity of meanings and relationships between the different capitals, and to represent the richness and diversity of experiences amongst people and communities in Australia and Aotearoa New Zealand. Definitions of the capitals can be seen in the first Recovery Capitals resource (discussed on page 4).

While developing these definitions, researchers identified that traditional capitals approaches tend to frame production and accumulation of capital as inherently valuable, whereas the *Recovery capitals* project assumes that the value of capitals lies primarily in their usefulness to support and sustain *wellbeing* (a complex concept central to disaster recovery, as discussed by Gibbs et al., 2015). Accordingly, the Recovery Capitals project outputs not only include evidence of how each capital may influence other capitals, but also evidence of influences on wellbeing.

▲ **Figure 1:** RECOVERY CAPITALS FRAMEWORK. ALL CAPITALS WORK TOGETHER TO SUSTAIN WELLBEING AFTER A DISASTER.

Social | key considerations

'Social capital' refers to the connections, reciprocity and trust among people and groups. There are three types of social capital: **bonding** (strong ties between similar people e.g. family and friends), **bridging** (looser ties between a broader range of people, often cutting across race, gender and class) and **linking** (ties connecting people with those in power, such as decision-makers)[20]. Social capital can be thought of as a resource at both an individual and community level.

Relocation decisions

What we know

Social networks and connection to a community can influence people's decisions about relocating or living locally after a disaster. Neighbourhoods with high levels of social capital tend to repopulate more quickly after disasters[21,22]. Following Black Saturday, strong sense of community was a reason people chose to stay locally, while for others damaged sense of community arising from disagreements and changes to the local area led to decisions to relocate[15,23]. After Hurricane Katrina, survivors relied on information about the plans of their neighbours, friends and store owners when deciding whether to return to New Orleans or relocate[21,24].

Decisions about relocation may be further complicated for Aboriginal people with connections to Country in the disaster-affected area[2,16]. In addition to the ramifications for social, cultural and political life, these decisions are influenced by the distinctive nature of the formally recognised rights and interests held by Aboriginal people – such as native title, which cannot be bought or sold – as compared to non-Indigenous land ownership[2].

Consider

- **What local groups, spaces, resources and activities help people connect with each other socially? How can these be supported? Be sure these opportunities are culturally sensitive and support marginalised groups.**
- **Facilitate ways for people to connect (e.g. through free local events) even if they are far apart (e.g. community pages on social media).**
- **Are there people who will have less opportunity to decide whether to stay or relocate than others (e.g. those in public housing or in rental homes)? Identify opportunities to help these people to connect and access support.**

Figure 2: A SAMPLE PAGE FROM THE *GUIDE TO POST-DISASTER RECOVERY CAPITALS*, AVAILABLE AT WWW.RECOVERYCAPITALS.ORG.AU. THE GUIDE OUTLINES EACH OF THE RECOVERY CAPITALS (FOR EXAMPLE, SOCIAL CAPITAL), AND PROVIDES KNOWLEDGE AND CONSIDERATIONS FOR EACH.

This process also highlighted the complexity of recovery, and the need to consider people, place and time at multiple levels. Drawing from socioecological models, the Recovery Capitals Framework (and subsequent resources) considers the wide range of types and scales of the disasters and recovery experiences for people, households and communities. It explores the role of various systems and infrastructures at the local, regional and national level. The Framework also recognises that disaster recovery happens over time, and as such the effects of each capital and the interactions between them can change. The phases of the disaster cycle (prevention, preparedness, response and recovery) are deeply intertwined, rather than linear and discrete. For example, preparedness activities can strongly influence how recovery is experienced. Further information about these considerations can be found in the first Recovery Capitals resource (discussed on page 4).

A final important consideration while developing the framework was the collective commitment to interweave issues of access, equity and diversity throughout the project and its outputs. The *Recovery capitals* project recognises that disasters and recovery processes can exacerbate inequities, and that people and communities have complex and interrelated needs which should be understood, respected and addressed. As a collaboration across Australia and Aotearoa New Zealand, the project includes Māori researchers, and with increasing input from Aboriginal researchers and advisors, this project continues to benefit from different perspectives based on cultural, environmental, political and societal contexts.

This has enhanced the relevance, nuance and appropriateness of the resources, particularly with respect to Indigenous peoples, while also deepening connections and understanding within and across the two countries. Through these commitments and dialogues, researchers have aspired to adapt mainstream frameworks to produce culturally relevant and inclusive guidance. For example, the Recovery Capitals resources are evidence-based, yet the available literature systematically overlooks some perspectives and experiences. The research team have developed several strategies in response to this, including highlighting evidence gaps and developing diverse case study material to accompany summaries of peer-reviewed evidence.

Evidence mapping

With the framework established, the next stage of this research was to review the literature and map evidence against this framework. Given the enormous amount of literature relating to disaster recovery, researchers focused on relevant findings from project collaborators. This includes Beyond Bushfires study and related research conducted by the University of Melbourne, Resilient Wellington and related research conducted by Massey University, from the CRC's Australian Disaster Resilience Index and *Optimising post-disaster recovery interventions in Australia* project, and the work of social scientist Prof Daniel Aldrich (Northeastern University). In addition, using the Recovery Capitals Framework to identify key gaps in the literature, researchers specifically sought out evidence relating to important topics such as Indigenous peoples' recovery experiences.

Resource development

The final stage – the development and piloting of guidance resources – has commenced and will continue into 2021. The approach to resource development has been highly collaborative. In a *Recovery capitals* workshop in August 2019, end-users discussed the content and format of useful resources from the perspective of recovery workers. Discussions from this workshop informed a plan for a series of complementary tangible and online resources to share evidence-based findings.

End-users stated they are most likely to use resources that start with simple core messages, backed up by additional evidence and then more detailed guidance.

In keeping with the Recovery Capitals Framework, it was agreed that resources would be designed to accommodate diverse groups, community contexts and multiple hazards. End-user support and commitments of in-kind contributions to Recovery Capitals resource piloting and development have since supported additional funding for resources beyond the scope of the original project agreement. Draft versions of the pilot resource have been presented to end-users in recent months, leading to further iterations.

RESEARCH FINDINGS

In order to support end-users in recovery efforts from both the Black Summer bushfires and the COVID-19 pandemic, the first of the Recovery Capitals resources was released earlier than originally planned, in July 2020. The Australian pilot edition of the *Guide to Post-Disaster Recovery Capitals* is now available via the Disaster Mental Health Hub. Limited numbers are also available in hard copy on request. The Guide provides visually engaging overviews, based on the evidence, of the role of each of the recovery capitals, highlighting the complex interplay between them all. It also includes prompts for those involved in disaster recovery to consider when planning practical recovery options. See an example of the Guide's pages in Figure 2, page 3.

The final project output will be a set of disaster recovery resources in different forms, enabling users to engage with the material in a variety of ways. This will include online and hard copy formats, high level key messages, evidence summaries, cases studies and podcasts. To ensure the appropriateness of the resources in both Australia and Aotearoa New Zealand, particularly relating to the Indigenous peoples of each country, resources are being adapted to the two countries separately, as necessary.

HOW COULD THIS RESEARCH BE USED?

Integral to this research is a new set of evidence-based resources being developed through collaboration between academics, end-users and creatives across Australia and Aotearoa New Zealand, which will continue to be released throughout 2021. The Recovery Capitals resources are designed to encourage practitioners and policy makers to consider all the recovery capitals in the context of their own work, emphasising interconnectedness in order to support a shift towards more holistic approaches to recovery.

FUTURE DIRECTIONS

The *Recovery Capitals* project is still in progress. The first resource was released in July 2020, and is being distributed to end-users who are piloting it and providing feedback about feasibility, appropriateness and usefulness. In the meantime, development of the complete set of resources and adaptation into Aotearoa New Zealand editions continues.

END-USER STATEMENT

"Recovery planning has long been based on intuitive decisions. Research undertaken over the past decade has improved our decision making, as it is now more evidence informed. Despite best efforts of recovery managers around the country, often key recovery decisions, i.e. about rebuilding or infrastructure are taken without consideration of the psychosocial or cultural dimensions. This research and the supporting resources enable us, as decision makers, programmers, and practitioners, to make decisions understanding the complexity of recovery, and to reduce the potential for downstream unintended consequences from decisions taken without the full picture."

John Richardson, National Resilience Adviser, Australian Red Cross

FURTHER READING

Emery M & Flora C (2006) Spiraling-up: mapping community transformation with community capitals framework, Journal of the Community Development Society, 37(1): pp.19–35, available at https://www.uvm.edu/rsenr/rm230/costarica/Emery-Flora-2006.pdf.

Gibbs L, Harms L, Howell-Meurs S, Block K, Lusher D, Richardson J, MacDougall C, Waters E (2015) Community wellbeing: applications for a disaster context, *Australian Journal of Emergency Management*; 30(3): pp.20–24, available at https://knowledge.aidr.org.au/media/1473/ajem-30-03-06.pdf.

Gibbs L, Johnston D, Quinn P, Richardson J, Blake D, Campbell E (2020) Recovery Capitals (ReCap): applying a community capitals framework to disaster recovery, Bushfire and Natural Hazards CRC, available at https://www.bnhcrc.com.au/publications/biblio/bnh-7197.

Quinn P, Gibbs L, Blake D, Campbell E, Johnston D, Ireton G (2020) Guide to post-disaster recovery capitals (ReCap), Bushfire and Natural Hazards CRC, available at http://www.redcross.org.au/recap.

The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

HAZARD **NOTE**

bushfire&natural HAZARDSCRC

ISSUE 39 SEPTEMBER 2017
TOPICS IN THIS EDITION | COMMUNITIES | POLICY | RESILIENCE

ASSESSING AUSTRALIA'S RESILIENCE TO NATURAL HAZARDS

ABOUT THIS PROJECT

This research was conducted as part of the *Australian Natural Disaster Resilience Index* project.

AUTHORS

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SUMMARY

This research has developed an index of disaster resilience that is designed to help meet the challenges of Australia's natural hazards. For the first time, this index will assess and report the state of disaster resilience on a large scale across Australia. The index will use a nationally standardised measure that will make it easy for end-users to identify areas of strength and areas needing improvement, to plan future actions, policies and programs, and provide a baseline from which to measure progress in disaster resilience.

▲ **Above:** EMERGENCY SERVICE VOLUNTEERS ARE CRUCIAL TO ENSURING THEIR LOCAL AREA CAN BOUNCE BACK AFTER AN EMERGENCY. PHOTO: SOUTH AUSTRALIA SES.

CONTEXT

Extreme natural disasters usually cannot be prevented, but their risks can often be minimised, and impacts on people and property reduced. For Australian communities, 'disaster resilience' broadly means the capacity to cope with, adapt to, learn from and transform behaviour and social structures in response to a natural hazard and its aftermath.

The focus in managing natural disasters in Australia and internationally has in recent years moved from risk and vulnerability towards resilience, including an emphasis on shared responsibility. This shift towards disaster resilience recognises the uncertainties inherent in natural hazards.

These uncertainties range from the unpredictability of their location and impact, to the changing patterns resulting from changing climate and demographics.

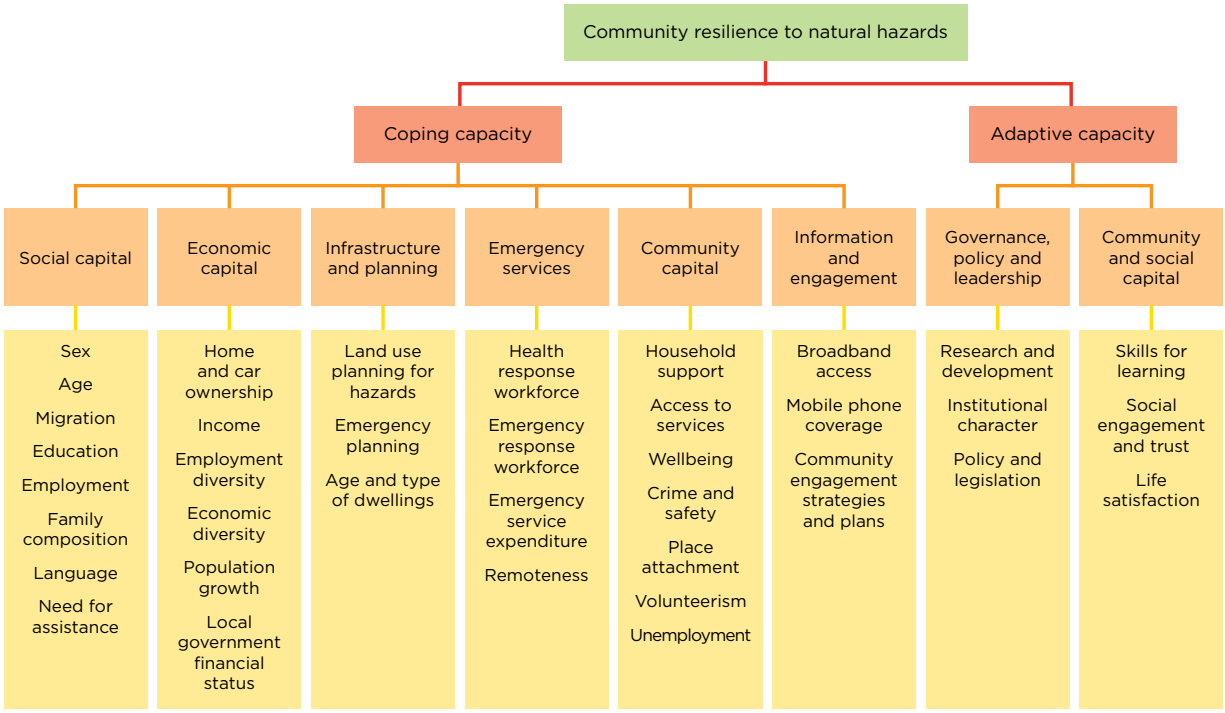
Understanding how to improve disaster resilience will help communities, governments and organisations to develop the capacities needed for living with natural hazards.

BACKGROUND

Although resilience is increasingly the focus of natural hazard policy and program directions, there is no nationally standardised assessment of disaster resilience. An evidence-based assessment is crucial for identifying areas of strength and areas needing improvement, for planning future actions, policies and programs, and to provide a baseline for measuring progress in disaster resilience at scales relevant to state and national policy and programs.

To address this critical gap in disaster management, this project has developed an index of disaster resilience applicable across Australia. The Australian Natural Disaster Resilience Index, developed in partnership with emergency service agencies across the country, will produce a consistent, spatially represented assessment of Australia's current state of disaster resilience and deliver its results as a State of Disaster Resilience report.

FIGURE 1: THE STRUCTURE OF THE AUSTRALIAN NATURAL DISASTER RESILIENCE INDEX*



* For brevity, indicators are listed as general areas.

BUSHFIRE AND NATURAL HAZARDS CRC RESEARCH

Design of the Australian Natural Disaster Resilience Index

Academic research on disaster resilience is diverse and active, and resilience is increasingly the foundation of public policies and programs in natural hazard and disaster management. There are many definitions of disaster resilience but they are consistent in three aspects.

These are the capacities to:

- absorb or accommodate the effects of an external disturbance or stressor event
- recover and return to a functioning state or to persist following an event
- learn, adapt or transform.

For the Australian Natural Disaster Resilience Index, disaster resilience is defined as the capacities of communities to prepare for, absorb and recover from natural hazards; and to learn, adapt and transform towards resilience.

Importantly, this definition does not highlight the actual realisation of resilience, but the capacities for resilience.

The design of the Australian Natural Disaster Resilience Index is based on two sets of capacities for resilience: coping capacities and adaptive capacities.

END-USER STATEMENT

At their best, resilient communities are prepared, adaptable to changing situations, connected to each other and self-reliant.

Recent reports into disasters have identified that both governments and communities share responsibility for preparing for emergencies. And it is clear that governments bear a responsibility to support the community to build the knowledge, skills and protective behaviours that are essential to disaster resilience.

The Australian Natural Disaster Resilience Index will support national, state and local governments and, most importantly, communities. The ability to identify hot spots of high or low disaster resilience in Australia will potentially embed disaster resilience into policy and legislation, and increase shared responsibility and resilience across Australia.

– Suellen Flint, Director Community Engagement, Department of Fire and Emergency Services, Western Australia

Coping capacity enables people and organisations to use their available resources and abilities to face adverse consequences. These factors influence the capacity of a community to prepare for, absorb and recover from a natural hazard.

Adaptive capacity enables a system to modify or change its characteristics and behaviours to cope with actual or anticipated stresses. It involves deliberate, incremental and transformational change across social, government and economic systems. These factors enable responses and behaviours to adjust through learning, adaptation and transformation.

Index structure and indicators

The Australian Natural Disaster Resilience Index has a hierarchical design (Figure 1, above). The first level of the hierarchy comprises the coping and adaptive capacity dimensions. Within these are eight themes expressing the main elements of coping and adaptive capacity. The lowest level has the indicator sets that measure the status of a theme.

Coping capacity consists of six themes that express the availability of resources and abilities to prepare for, absorb and recover from a natural hazard: social character; economic capital; infrastructure

TABLE 1: DEFINITION AND DESCRIPTION OF COPING AND ADAPTIVE THEMES

THEME	DEFINITION	DESCRIPTION OF THEME
Coping capacity		
Social character	The social characteristics of the community.	Represents the social and demographic factors that influence the ability to prepare for and recover from a natural hazard event.
Economic capital	The economic characteristics of the community.	Represents the economic factors that influence the ability to prepare for and recover from a natural hazard event.
Infrastructure and planning	The presence of legislation, plans, structures or codes to protect infrastructure.	Represents preparation for natural hazard events using strategies of mitigation or planning or risk management.
Emergency services	The presence of emergency services and disaster response plans.	Represents the potential to respond to a natural hazard event.
Community capital	The cohesion and connectedness of the community.	Represents the features of a community that facilitate coordination and cooperation for mutual benefit.
Information and engagement	Availability and accessibility of natural hazard information and community engagement to encourage risk awareness.	Represents the relationship between communities and information, the uptake of information about risks and the knowledge required for preparation and self-reliance.
Adaptive capacity		
Governance, policy and leadership	The capacity within government agencies to learn, adapt and transform.	Represents the flexibility within organisations to adaptively learn, review and adjust policies and procedures, or to transform organisational practices.
Social and community engagement	The capacity within communities to learn, adapt and transform.	Represents the social enablers within communities for engagement, learning, adaptation and transformation.

and planning; emergency services; community capital; and information and engagement (Table 1, above).

Adaptive capacity consists of two themes that express the processes that enable adjustment through learning, adaptation and transformation: governance, policy and leadership; and social and community engagement (Table 1).

The social, economic, government, infrastructure and community measures used in the Australian Natural Disaster Resilience Index are consistent with those used internationally in previous assessments of disaster resilience. The Australian index extends these themes by including important elements of emergency management in Australia such as emergency services, emergency planning, land-use planning and community engagement. The Australian index also advances the field of disaster resilience assessment by incorporating adaptive capacities related to learning, adaptation and transformation.

Indicators are the variables that determine the status of a theme: the raw data used to compute the index.

The indicators were chosen using three key criteria. First, data had to cover the whole of Australia. This includes data from the Australian Census (or its derivatives), as well as state or local government level data with compatible data in each jurisdiction (for example, crime rate, local disaster-management plans, land-use plans).

Second, the indicators had to be measurable and interpretable in the context of disaster resilience.

Third, the relationship between the indicator and natural hazard resilience was considered using available literature, particularly that pertaining to Australian circumstances. For example, areas with a stable population have increased familiarity with the hazards prevalent in the area, while areas with high levels of income will have greater capacity to prepare for and respond to natural hazards.

Figure 1 (page 2) summarises the indicators that will be collected under each theme.

Computing the index

The index is calculated using numerical data related to the indicators in each theme. For example, it might be using the percentage of people over 65 in a town, or the percentage of people that are involved in formal volunteering activities. This involves using various statistical methods for composite index construction. Each theme will be reported separately and will be spatially represented on maps using colour coding along a continuum of high to low resilience. For any location in Australia, users of the index will be able to access a corresponding set of information about natural hazard resilience.

The index will provide a snapshot of the current state of disaster resilience at a national scale and results will be released as a State of Disaster Resilience report by the CRC when complete.

RESEARCH OUTCOMES

The project began in 2014 and has three distinct stages: conceptual development and index design; data collection and analysis; and reporting. As of September 2017, the team was conducting data collection and analysis (stage two). Collection of data regarding most of the project's indicators has been completed, which will total more than 70. While collecting the indicators, the team discovered that some states and regions have excellent data that could not be used because the project requires national coverage. It was also found that a complete data set was needed, covering all eight themes, to conduct the intensive statistical analysis.

The next stage, statistical analysis, is expected to take several months. It

▲ **Above:** THIS PROJECT IS DEVELOPING A NATIONALLY STANDARDISED MEASUREMENT FOR RESILIENCE ACROSS AUSTRALIA. PHOTO: MARK THOMASSON, COUNTRY FIRE SERVICE.

will involve standardising the indicators, removing any correlated indicators and aggregating the indicators into an index.

Once the index results are complete, design and framing of the State of Disaster Resilience report will begin. The principles underlying the reporting of disaster resilience will include a strengths-based interpretation of the index results, which will highlight areas of strength, emerging strengths and opportunities for improvement. The index will also be transparent in its design, methods and limitations. Where possible, it will link to previous research and provide a baseline against which changes in disaster resilience can be examined over time.

HOW COULD THE RESEARCH BE USED?

The Australian Natural Disaster Resilience Index is expected to deliver many benefits to a very broad range of end-users and its findings will be available in the State of Disaster Resilience report. The index's map-based outputs will allow community members to see the broad influences of disaster resilience in their area. For example, are there strengths in some themes but opportunities for improvement in others?

Emergency service organisations will be able to use the Australian Natural Disaster Resilience Index results in community engagement activities and initiatives. The index results will also inform evidence-based policy-making at state and national levels. They will be a call to action by supporting business cases for resilience-oriented policy and programs in Australian emergency management.

The project team is working with its end-users, which includes: Emergency Management Victoria; Victoria's Metropolitan Fire Brigade; Victoria's Country Fire Authority; Victorian Department of Environment, Land, Water and Planning; New South Wales State Emergency Service; New South Wales Rural Fire Service; Western Australia Department of Fire and Emergency Services; South Australia Metropolitan Fire Service; Tasmania Fire Service and AFAC. This collaborative process will align the results and outputs from the Australian Natural Disaster Resilience Index with agency policy and programs. The researchers will work with agencies to develop fact sheets that agencies can use in community profiling and community engagement tools. The index results can also be included in risk assessments. The maps provide quantitative spatial information about resilience for community planning and community engagement activities.

FUTURE DIRECTIONS

The data collection, analysis and reporting phases of the project will continue until June 2018, after which another stage of agency implementation and utilisation will continue through to June 2020.

FURTHER READING

Parsons M, Glavac S, Hastings P, Marshall G, McGregor J, McNeill J, Morley P, Reeve I and Stayner R (2016), Top-down assessment of disaster resilience: a conceptual framework using coping and adaptive capacities, *International Journal of Disaster Risk Reduction*, **19**, pp.1-11.

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HAZARD **NOTE**

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ISSUE 17 JUNE 2016

TOPICS IN THIS EDITION | RESILIENCE | COMMUNITIES | INDIGENOUS COMMUNITIES

WHAT IS DISASTER RESILIENCE AND HOW CAN IT BE MEASURED?

ABOUT THESE PROJECTS

This is an overview of the *Understanding and measuring social resilience* cluster of Bushfire and Natural Hazards CRC research projects. This cluster has three linked studies:

1. **The Australian Natural Disaster Resilience Index** – Dr Phil Morley, Dr Melissa Parsons, A/Prof Graham Marshall, Dr Sonya Glavac, Dr Richard Stayner, Dr Judith McNeill, James McGregor, Dr Ian Reeve, University of New England; Dr Peter Hastings, Queensland University of Technology. Contact pmorley@une.edu.au
2. **Scoping north Australian community resilience** – Adj Prof Jeremy Russell-Smith, Dr Kamaljit Sangha, Prof Andrew Campbell, Charles Darwin University; Dr Bevlyne Sithole, ARPNet; Glenn James, Peter Yu, Melissa George, North Australian Indigenous Land and Sea Management Alliance; Prof Bob Costanza, Dr Ida Kubizewski, Australian National University. Contact jeremy.russell-smith@cdu.edu.au
3. **North Australian bushfire and natural hazard training** – Stephen Sutton, Dr Petra Buergelt, Dr Peter Jacklyn, Dr Natalie Rossitor-Rachor, James Smith, Charles Darwin University; Ken Baulth, Bushfires NT; Ed Hatherly, Department of Parks and Wildlife WA; Clifton Bieundurry, Department of Fire and Emergency Services WA; Bruno Griemel, Queensland Fire and Emergency Services; Otto Champion-Bulmaniya, Guruwilling Rangers; Dr Bevlyne Sithole, ARPNet. Contact stephen.sutton@cdu.edu.au

▲ **Above:** BRIGADE PERSONNEL INSTRUCT RESIDENTS HOW TO PREPARE FOR A BUSHFIRE. PHOTO: DAMIEN FORD, NSW RURAL FIRE SERVICE.

CONTEXT

While extreme natural disasters usually cannot be prevented, their risks can often be minimised and impacts on people and property reduced. For Australian communities, 'disaster resilience' broadly means the capacity to cope with, adapt to, learn from and transform behaviour and social structures in response to a natural hazard and its aftermath.

The shift from a risk-based approach to managing natural hazards toward ideas of disaster resilience reflects the uncertainties inherent in natural disasters. These uncertainties range from predicting their location and impact, to the changing patterns of natural hazard risks resulting from changing climate and demographics. Understanding how to enhance disaster resilience will help communities, governments and organisations to develop the capacities needed for living with natural hazards.

HAZARD **NOTE**

THE AUSTRALIAN NATURAL DISASTER RESILIENCE INDEX

BACKGROUND

Natural hazard management policy and program directions in Australia and internationally are increasingly being aligned to ideas of resilience. However, there is little consensus about how to measure or operationalise resilience in practice. Part of operationalising this in Australia involves assessing the current state of disaster resilience. The Australian Natural Disaster Resilience Index is designed to assess resilience to natural hazards nationwide with various inputs from macro-level policy, strategic planning, community planning and community engagement at national, state and local levels.

The Index will provide a tool for assessing the resilience of communities to natural hazards by first providing a snapshot of the current state of natural hazard resilience at a national scale. Secondly, it will be a layer of information for use in strategic policy development and planning. Its third function is to be a benchmark against which to assess future changes in resilience to natural hazards. The Index will also provide content for use in agency profiling, community engagement and information initiatives.

RESEARCH ACTIVITY

The project has published a conceptual framework that outlines the philosophy and structure of the Index. The framework defines the boundaries – the why, what and how – around the evidence that will be used to assess disaster resilience.

The Index assessment has a hierarchical structure. The first level comprises the coping and adaptive capacity dimensions of disaster resilience. Below this are themes that express elements of coping or adaptive capacity (see figure below). Coping capacity has six themes that express the availability of resources and abilities to prepare for, absorb and recover from a natural hazard. The themes are:

- social character
- economic capital
- infrastructure and planning
- emergency services
- community capital
- information and engagement.

Adaptive capacity has two themes that express the processes that enable adjustment through learning, adaptation and transformation. They are:

- governance, policy and leadership
- community and social capital.

Each theme contains indicators that relate and combine to provide an indication of the resilience of an area for that theme. The Index is a top-down assessment of disaster resilience and uses existing data to evaluate the capacities for disaster resilience in Australia. Data sources include the Australian Bureau of Statistics. It is not a scorecard approach that uses local surveys, but a macro-level, standardised reading of the state of disaster resilience in Australia based on coping and adaptive capacities.

RESEARCH OUTCOMES

Scheduled for release in 2018, the results will be freely available to download in the form of maps and reports that will span Australia. For any location, users will be able to drill down at different spatial scales and determine various aspects of resilience for that specific area. This will allow the prioritisation of issues and areas. The Index and indicators will also be the basis of a state of disaster resilience report that will interpret the strengths and opportunities in disaster resilience

END USER STATEMENT

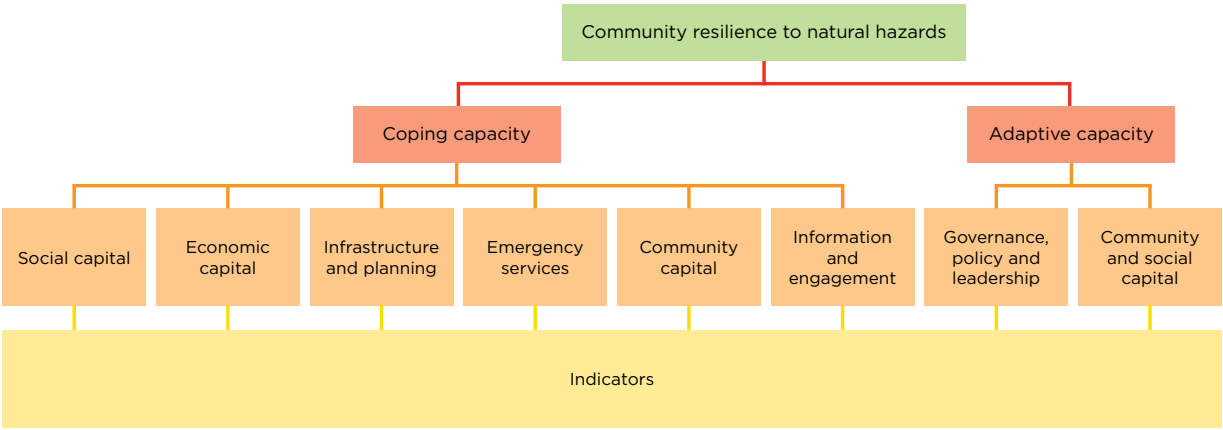
Recent reports into disasters have identified that governments and communities share responsibility for preparing for emergencies. Developing disaster resilience is a vital aspect of this preparation.

Emergency services support communities by helping to build the knowledge, skills and importantly, protective behaviours that foster natural hazard resilience in communities. This involves highly complex forms of engagement based on extensive, community development-based research that includes psychology, physiology, knowledge exchange and information adoption.

This cluster of research will be advantageous in many ways and support federal, state and local governments and lead to an increase in shared responsibility and resilience across Australia. These projects particularly address the urgent need for culturally appropriate communication and engagement strategies, and training programs that suit the complex resilience challenges facing northern Australia.

– Suellen Flint, Director Community Engagement, Department of Fire and Emergency Services, WA

THE HIERARCHICAL STRUCTURE OF THE AUSTRALIAN NATURAL DISASTER RESILIENCE INDEX



SCOPING NORTH AUSTRALIAN COMMUNITY RESILIENCE

BACKGROUND

Community resilience among Indigenous communities in remote areas is a complex and challenging concept. Nearly 45% of northern Australians in remote areas are Indigenous, with most of these residents living in communities that are susceptible to cyclones, floods and bushfires. Despite this, it has proven difficult to provide the communities with effective emergency services. Poor infrastructure, restricted communication services and economic opportunities, and at times problematic governance models have heightened residents' vulnerability to natural hazards. Many current government services struggle to deal effectively with natural hazards, now or in the foreseeable future. A key question for this project is: What service models can improve resilience in Australia's remote Indigenous north?

RESEARCH ACTIVITY

Two major desktop studies have been completed; a literature review on the current understanding of community resilience in northern Australia; and an asset mapping exercise in the Northern Territory communities of Gunbalanya and Ngukurr.

Participatory action research has also been undertaken in both communities through the Aboriginal Research Practitioners Network, which involves trained Indigenous researchers conducting interviews with local people, in the local language and with due attention given to local cultural sensitivities. Twenty-two researchers spread across two teams conducted field research for a total of 10 days. Researchers are currently analysing data from interviews with 194 residents.

Economic resilience is being assessed through developing culturally appropriate land and sea management economic opportunities, which in turn will build local community resilience. An initial assessment of payment for environmental service enterprise opportunities available at Gunbalanya, Ngukurr and surrounding outstations has been undertaken, and an initial assessment of the monetary value of tangible and intangible ecosystem services from the Indigenously-held Fish River Station in the NT. A detailed literature review on current uses of savanna lands and related economic returns has also been conducted. It is hoped the Fish River Station research will highlight the monetary value of ecosystem benefits to local Indigenous communities and provide an early template for similar studies.

▲ **Above:** DR BEVLYNE SITHOLE BRIEFS THE ARPNET RESEARCH TEAM IN NGUKURR. PHOTO: HMALAN HUNTER-XENIE, ARPNET

RESEARCH OUTCOMES

The asset mapping study recorded 'hard' infrastructure, such as a community's essential physical assets, including transport/mobility, communication, energy, water management and housing. It also mapped 'soft' infrastructure – all the institutions required to maintain the economic, health, and cultural and social standards of a community (including emergency services, social, economic and natural heritage). This mapping also accounts for resilience enablers (which strengthen community resilience) and potential threats.

The literature review identified information gaps relating to Indigenous perspectives on risk and hazards, as well as an understanding of the existing capacity of communities to respond to these hazards. It identified key enablers of community disaster resilience, including local/cultural knowledge and economic diversification, and highlighted land management activities in enabling resilience and considered the relationship between emergency management service providers and Indigenous communities. There also appears to be a gap in translating strategies and policies for building community resilience into practical emergency response and recovery approaches and actions.

The participatory action research found that participants' stories about disasters related to local land features, such as rivers, and their vulnerability. Safety stories were connected to views about housing quality and infrastructure and, most of all, to the absence of people on country. Participants advocated strongly for returning people to country to strengthen connections and coping capabilities within families. Among the survey findings were that disasters further worsen the physical, spiritual and economic conditions of most Aboriginal households, and that only 46% of those surveyed knew that there was an emergency plan for their community, while only 15% had actually seen the emergency plan. A report detailing the key findings, and a preliminary set of recommendations and protocols for how remote Indigenous communities can be more effectively engaged in emergency management, will be available soon.

Both the participatory action research and the desktop studies highlight the significant gap between the roles and responsibilities of emergency service agencies on the one hand, with the expectations of community members on the other. A critical challenge for government authorities is to effectively engage with Indigenous community governance structures in order to develop mutually respectful partnerships.

HAZARD **NOTE**

The economic resilience research suggests that fire management projects will contribute to improving natural and social capital, build capacity for dealing with natural hazards, and thus contribute to enhancing community resilience. This is based, in part, on having Indigenous managers conduct better planned burning regimes that reduce greenhouse gas emissions, thereby generating income through the Federal Government's Emissions Reduction Fund. There are many potential benefits from developing Indigenous land management enterprise opportunities, focused, for example, on fire, weed, and pest management, while enabling ongoing cultural practices. These benefits include protecting biodiversity and enhancing cultural identity. At Fish River Station, Indigenous management and engagement activities have been valued at between $93 million to $355 million annually, depending upon the valuation method. This research is currently being extended to examine the value of ecosystem services and potential economic returns to remote Indigenous communities derived from land sector ecosystem services across the savannas.

NORTH AUSTRALIAN BUSHFIRE AND NATURAL HAZARDS TRAINING

Left: RESEARCH IS DEVELOPING BETTER TRAINING COURSES TO SUIT THE NEEDS OF REMOTE COMMUNITIES.

PHOTO: BILL MCLEOD, BUSHFIRES NT.

FURTHER READING

Parsons M, Morley P, Marshall G, Hastings P, Glavac S, Stayner R, McNeill J, McGregor J & Reeve I (2016), The Australian Natural Disaster Resilience Index: conceptual framework and indicator approach, Bushfire and Natural Hazards CRC.

Russell-Smith J, Scoping remote north Australian community resilience and developing governance models through action research (2015), Bushfire and Natural Hazards CRC.

Sangha KK, Russell-Smith J, Yates C, Gould J, Michael C & James G (2015). Developing enterprise opportunities and resilience in remote north Australian communities, proceedings from the Bushfire and Natural Hazards CRC and AFAC Conference, Adelaide, 2015.

BACKGROUND

This project aims to provide a training program that builds on the current assets in the north, such as ranger programs, and increases competence and confidence in dealing with natural disasters and, in turn, resilience. The project responds to north Australian stakeholder concerns that existing training does not meet their needs because it is based on models suitable for southern Australia. The factors differentiating between northern and southern training needs are significant, ranging from geographical (the scale of northern natural disasters and distances), to social and cultural, as in the impacts of natural disasters on remote Indigenous communities. Indigenous researchers, through the Aboriginal Researchers Practitioners Network, are evaluating the delivery of pilot training in remote communities.

RESEARCH ACTIVITY

The project has reviewed 21 training courses offered through Charles Darwin University and its Registered Training Organisations.

Five new training units have been completed. The team is developing additional units and adapting existing units to suit the needs of northern Australia.

These adapted and new units will provide a comprehensive training package that is sensitive to Indigenous cultural and language variations and reflects local knowledge and contexts. This will allow qualified trainers to deliver training in ways that can be tailored to suit remote locations. The project has also developed a Course Delivery Handbook based on the training materials.

RESEARCH OUTCOMES

The course and education review identified three areas that the current project addresses. It found current courses are high quality and need to be supplemented, rather than replaced. Key areas that are being addressed are adding a northern focus, as well as incorporating Indigenous knowledge and practices. The various courses are also distributed in different faculties, streams and settings; the new training units are designed to be integrated into current streams, making the training more easily accessible.

The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

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Economics, Mitigation and Value

HAZARD **NOTE**

bushfire&natural HAZARDS CRC

ISSUE 86 DECEMBER 2020

TOPICS IN THIS EDITION | EXPOSURE | FLOOD | MITIGATION

IMPROVING RISK MITIGATION THROUGH BETTER SCENARIO MODELLING: A COASTAL INUNDATION CASE STUDY

ABOUT THIS PROJECT

This research was conducted as part of the Bushfire and Natural Hazards CRC's *Improved decision support for natural hazard risk reduction* project, part of the economics and strategic decisions cluster.

AUTHORS

David Parsons, Charles Sturt University; Dr Graeme Riddell and Prof Holger Maier, University of Adelaide.
Contact holger.maier@adelaide.edu.au

SUMMARY

This project trialled the application of decision support software developed by the research team, called UNHaRMED – Unified Natural Hazard Risk Mitigation Exploratory Decision system – in a mitigation and planning exercise. The exercise, conducted in August and September 2019, brought together a diverse multi-agency team to explore future coastal inundation risk at the City of Port Adelaide Enfield in South Australia. The trial explored the ways in which the likelihood and consequence of coastal inundation risk at the port could change in future decades. UNHaRMED was crucial in focusing attention on the key policy issues to be addressed and resolved to mitigate future risk.

Above: THIS RESEARCH EXPLORED WAYS IN WHICH THE LIKELIHOOD AND CONSEQUENCE OF COASTAL INUNDATION RISK WILL CHANGE IN FUTURE DECADES AND WHAT CAN BE DONE TO MITIGATE THE CHANGING RISK. PHOTO: ANTHONY VIRAG, COASTAL MANAGEMENT BRANCH, SOUTH AUSTRALIAN DEPARTMENT OF ENVIRONMENT AND WATER

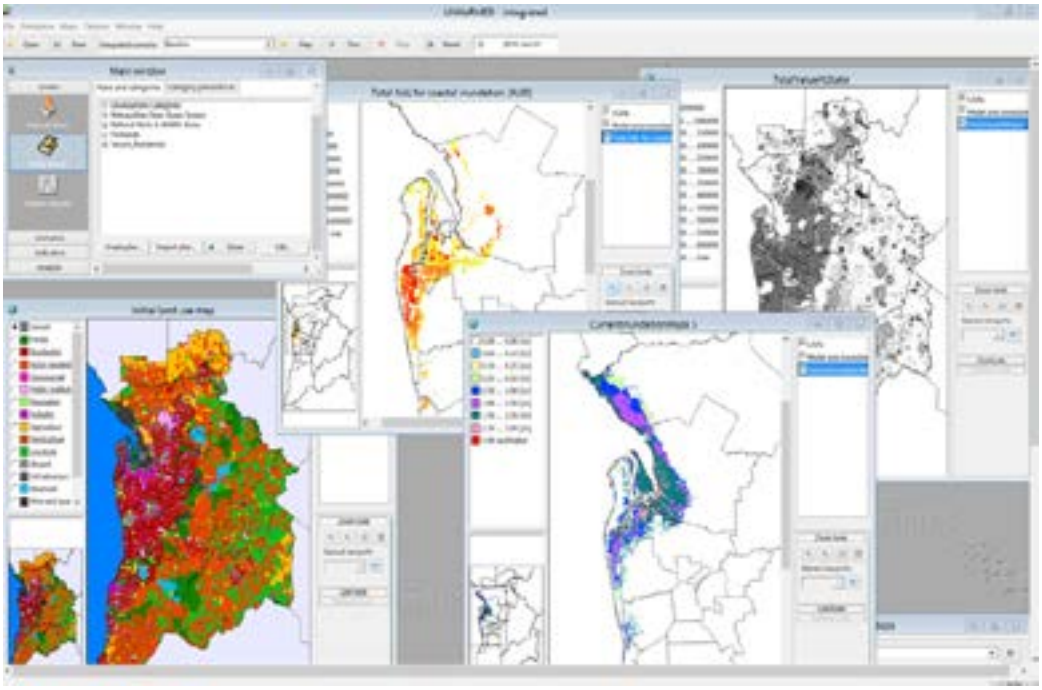
CONTEXT

Community risks are constantly evolving, driven by a range of factors, including demographic change, land use developments and climate change. This means it is essential that decision making about ways to treat risk is based on a sound understanding of costs and benefits.

Understanding plausible future risks using different 'what if' scenarios, and identifying the most appropriate strategies for reducing these risks, requires the contribution of many organisations across all tiers of government, as well as the local community and the private sector. The development of different mitigation options must consider current risk, an understanding of how risks evolve over time, and an analysis of the trade-offs across investment options. An understanding of current and projected risk requires context setting exercises and a platform for open discussions.

BACKGROUND

The City of Port Adelaide Enfield in South Australia has an existing risk from coastal inundation flooding. The 2016 Port Adelaide Enfield coastal flood inundation event affected dozens of homes. Without the implementation of risk mitigation measures, the number of



▲ **Above:** UNHARMED SOFTWARE WAS USED TO ASSESS THE COASTAL INUNDATION RISK AT PORT ADELAIDE ENFIELD, SOUTH AUSTRALIA. SOURCE: UNIVERSITY OF ADELAIDE.

properties affected by coastal flood inundation will grow steadily from dozens to many thousands by 2100, due to land subsidence and climate-change-related sea level rise.

Risk mitigation will most likely require the application of a combination of options, including:

- changes in floor levels in buildings (raising them above the inundation) and other practices to reduce building vulnerability
- structural defences (sea walls etc.)
- land use planning – development of exclusion overlay and coastal retreat.

Effective implementation of risk reduction options depends on the identification of the key policy issues to be addressed and the critical stakeholders to be engaged. The treatment of the risk of coastal inundation flooding will require integrated action by a range of organisations.

BUSHFIRE AND NATURAL HAZARDS CRC RESEARCH

UNHaRMED is an integrated decision support system that was developed by the CRC in partnership with the University of Adelaide and the Research Institute for Knowledge Systems.

It is a tool that measures mitigation benefits over extended periods, enabling future changes to land use, building stock, demographics, climate and mitigation options to be explored (or quantified) using dynamic spatial modelling, developing projections of consequences arising from different hazards, and how these impacts affect risk – an essential element of planning for disaster risk reduction.

Close consultation with stakeholders ensures that the system can provide the analysis required by policy and planning professionals in emergency and disaster risk management fields. It is a decision support tool – and provides an important input into risk reduction planning. By producing estimates on future exposures, and using damage curves and a variety of other policy metrics in a spatial and temporal format, UNHaRMED can assess the effectiveness of a range of risk mitigation options and enable a cost benefit analysis for each of the different risk mitigation options.

For this project, UNHaRMED was used to:

- develop projections of consequences arising from coastal inundation (for example, emergency evacuation requirements, home contents damage, waste disposal, disruption to Flinders Port, impacts on vulnerable people)
- identify future damage losses arising from projected sea level rise
- identify the effectiveness of a range of risk mitigation options
- perform cost benefit analysis of a range of risk mitigation options.

Using UNHaRMED, three scenarios were modelled for analysis:

1. Future losses under current conditions: based on the 2016 coastal flooding storm event, current land elevation, current sea levels and current land use.
2. Future losses under projected conditions: based on future losses under the 2016 coastal flooding storm event, projected land subsidence, projected sea level rise expected by 2050 and land use based on population and economic projections (see Figures 1 and 2 on page 4 for examples of projected inundation and economic damage).
3. Future losses under accelerated conditions: based on future losses under the 2016 coastal flooding storm event, projected land subsidence, accelerated sea level rise by 2050 based on 2100 projections (from the United Nations' Intergovernmental Panel on Climate Change) and modelled land use based on population and economic projections.

RESEARCH FINDINGS

UNHaRMED was used as a key component of a mitigation and planning exercise in August and September 2019 to explore coastal inundation risk in future decades at the City of Port Adelaide Enfield in South Australia. Participating organisations included local councils, South Australian and

HAZARD **NOTE**

END-USER STATEMENTS

"This collaboration facilitated complex discussions that highlighted the need for interconnected planning across agencies and sectors to achieve effective mitigation that also take into account the social acceptability of proposed solutions. Participants agreed that the flexibility of the UNHaRMED tool allows it to be easily applied to different hazards and geographic areas, limited only by the availability of access to appropriate data."
Brenton Keen, Director Emergency Management, South Australia Fire and Emergency Services Commission

"UNHaRMED is a useful product that helps provide visual representations of interacting data sets that may not otherwise be intuitively evident to key decision makers. The ability to run multiple scenarios and produce outputs on both numeric and visual bases provides users of UNHaRMED the tools required to influence both left-brain and right-brain decision makers easily and effectively."
Matthew Kildea, Project Manager, City of Charles Sturt council

"The UNHaRMED tool and this exercise were great tools to bring together all relevant stakeholders and facilitate a coordinated and informed approach to dealing with a flood risk. The Department of Environment and Water is currently also involved in utilising the UNHaRMED tool to work through flood mitigation options for the Gawler River. Key strengths of the tool are the ability to work through a number of scenarios and test different management options and compare these in terms of damages and costs. It allows for a much more informed debate about flood management options.

Good flood study information and information about damages is key to providing quality outputs. Utilising the tool to engage with communities to explore levels of acceptable risk and mitigation options could be a useful next application in the flood space. Opportunities to have a more dynamic approach to flood study information where projected changes in land use also feedback to changes in flood risk would be valuable."
Ingrid Franssen, Manager Flood Management, Department of Environment and Water South Australia

interstate emergency service agencies, South Australian government departments, the Bureau of Meteorology, port management, power companies and the research team.

For the exercise, UNHaRMED produced projections of future disaster losses from water inundation, and the effectiveness of different mitigation strategies, allowing participants to:

- better understand the extent of current and future risks
- assess the effectiveness and net benefit that could be achieved with risk mitigation options
- assist in prioritising expenditure on risk mitigation options
- develop a localised multi-decade risk mitigation implementation roadmap.

Risk information generated using UNHaRMED provided insight into changes in land use and hazard exposure, linked to the consequences and associated costs and savings that could be achieved from selected risk reduction options under different scenarios of climate change and sea level rise.

Participants identified a range of strategic response and recovery issues that required attention, including the need for effective strategies for:

- warning and communications
- evacuation, including vulnerable persons
- long-term accommodation for residents whose homes are uninhabitable
- building sustainable surge capacity for emergency services
- recovery from disasters
- property owners, associated with lost property values, lack of insurance options and liveability issues
- UNHaRMED was also crucial in highlighting that the capacity of emergency services will become increasingly stretched as the flood depth increases and the occurrence of simultaneous coastal inundation across multiple locations becomes more likely.

HOW IS THIS RESEARCH BEING USED?

The exercise, accompanied by the high-quality projections provided by UNHaRMED, was very useful for end-user participants to:

- build a common understanding of the type and scale of existing and potential risks
- explore the magnitude of benefits and issues associated with a range of risk mitigation measures
- identify the policy issues that need to be resolved to achieve implementation of risk mitigation initiatives
- identify the breadth of stakeholders that need to be engaged in this discussion and planning
- develop a risk mitigation implementation roadmap.

The range of community resilience-building initiatives identified by participants included:

- creating a risk informed community
- creating a prepared community
- enhancing the community's understanding of warnings
- developing more robust evacuation plans
- developing shelter in place plans
- conducting relevant exercises with emergency services
- enhancing business continuity planning by the business sector
- developing forward-looking recovery plans.

Participating organisations included:

- Bureau of Meteorology
- Bushfire and Natural Hazards CRC
- City of Charles Sturt
- City of Port Adelaide Enfield
- Department for Environment and Water, SA
- Department of Human Services, SA
- Department of Planning, Transport and Infrastructure, SA
- ElectraNet
- Emergency Management Victoria
- Flinders Ports
- Queensland Fire and Emergency Services
- Department of the Premier and Cabinet, SA
- SAFECOM
- South Australia Health
- South Australia Housing
- South Australia Local Government Association
- South Australia Power Networks
- South Australia Police
- South Australia State Emergency Service
- University of Adelaide
- University of Melbourne

HAZARD **NOTE**

The research informed robust discussions and comparisons of risk mitigation options, with the ability to estimate costs and benefits with UNHaRMED critical. The information produced by UNHaRMED quickly focused participants' attention on the key policy issues to be resolved.

FUTURE DIRECTIONS

Participants identified many other hazards that would benefit from the application of UNHaRMED in multi-agency exercises. These hazards included flooding, bushfires and earthquakes.

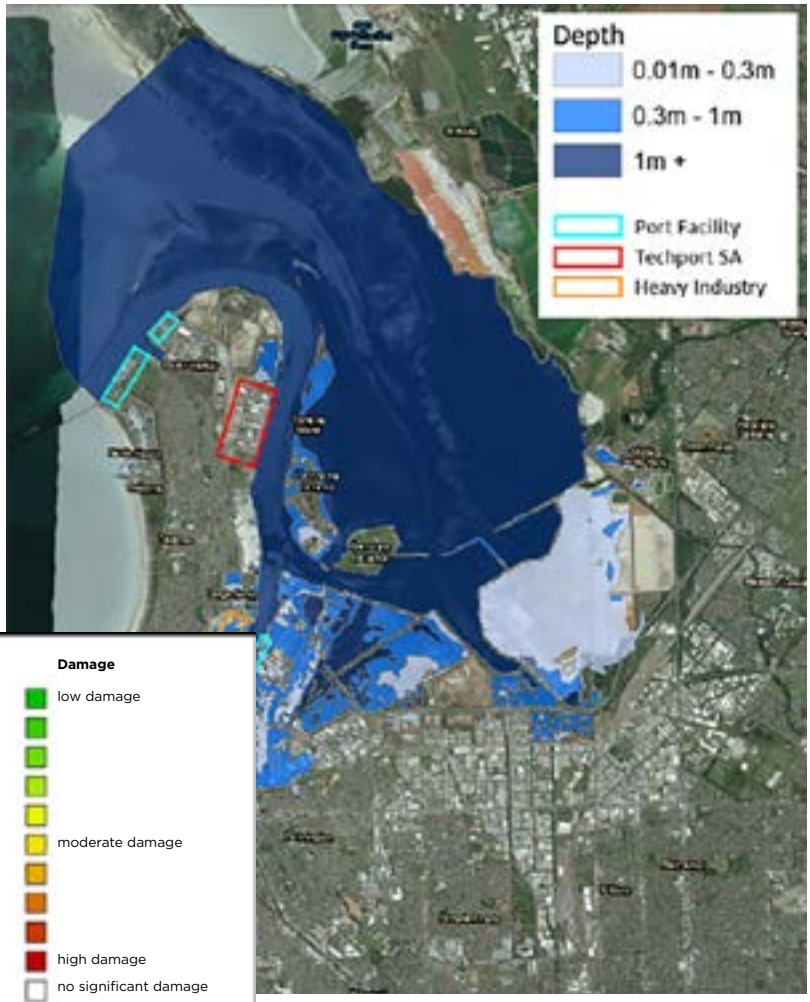


Figure 1: 1-IN-100-YEAR FLOOD INUNDATION OF FLINDERS PORT AREA IN THE YEAR 2050, INCLUDING THE PROJECTED 300MM OF SEA LEVEL RISE (SCENARIO 2). SOURCE: UNIVERSITY OF ADELAIDE.

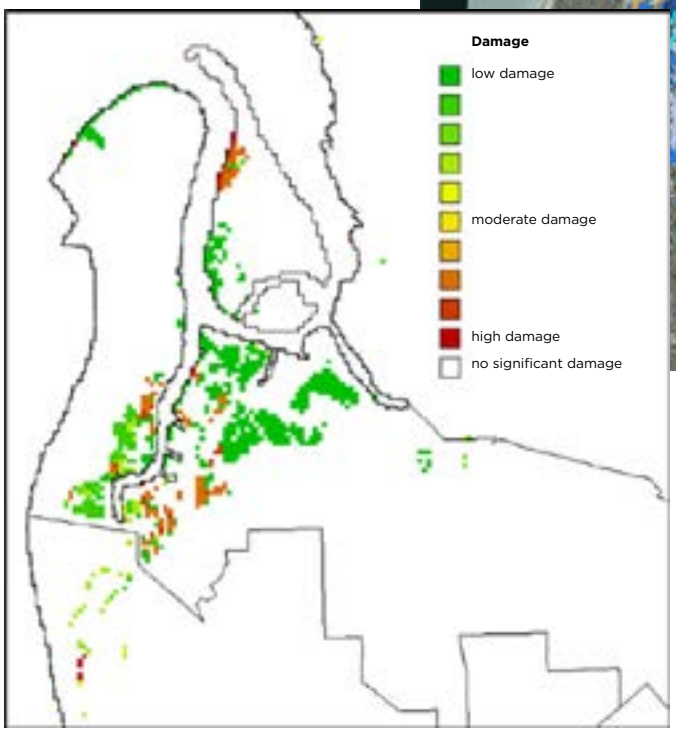


Figure 2: CALCULATED DAMAGE TO CAPITAL STOCK IN FLINDERS PORT AS A RESULT OF A 1-IN-100 YEAR FLOOD INUNDATION IN THE YEAR 2050 (SCENARIO 2). DAMAGE IS REPRESENTED FROM LOW TO HIGH, MEASURED IN COST, WITH RED SHOWING THE MOST DAMAGED AREAS OF THE PORT. SOURCE: UNIVERSITY OF ADELAIDE.

FURTHER READING

Riddell GA, van Delden H, Dandy GC, Maier HR, Zecchin AC, Newman JP & Newland C (2015) *Futures Greater Adelaide 2050: an exploration of disaster risk and the future*, Bushfire and Natural Hazards CRC, Melbourne.

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HAZARD **NOTE**

bushfire&natural HAZARDSCRC

ISSUE 42 NOVEMBER 2017

TOPICS IN THIS EDITION | ECONOMICS | POLICY | PRESCRIBED BURNING

INVESTING IN PRESCRIBED BURNING: HOW MUCH SHOULD WE SPEND?

ABOUT THIS PROJECT

This research was part of a PhD study, *Economic analysis of prescribed burning in the south west of Western Australia*, which was part of the Bushfire and Natural Hazards CRC project *Economics of natural hazards*.

AUTHOR

Dr Veronique Florec, University of Western Australia. Dr Florec completed her CRC PhD in 2016.
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SUMMARY

This study explored the impacts of changing the level of investment in prescribed burning in the south west of Western Australia. To achieve this, an economic model was developed that was used in conjunction with the AUSTRALIS bushfire simulator to evaluate the impacts of increasing and decreasing the area subjected to prescribed burning annually. This new model builds on the existing Cost Plus Net Value Change model, and introduces new explanatory variables, among other improvements. By combining the new model with the bushfire simulator, this research has identified the threshold point for maximising the benefits of prescribed burning. Broadly, the study found that in the long-term, not conducting any prescribed burning for several years can be very costly, leading to large increases in damages and suppression expenditures. Specifically, the results identify a threshold point – 10% of land managed by the Department of Biodiversity, Conservation and Attractions (DBCA) – up to which substantial benefits may be gained from increasing the area subjected to prescribed burning annually. But beyond this threshold, prescribed burning generates little additional economic benefits.

▲ **Above:** THIS RESEARCH INVESTIGATED THE OPTIMAL AMOUNT OF MONEY TO SPEND ON PRESCRIBED BURNING TO ACHIEVE THE BEST POSSIBLE MITIGATION OF BUSHFIRE RISK. PHOTO: VERONIQUE FLOREC.

CONTEXT

The increased frequency and severity of large bushfires in recent years has led to substantially higher expenditures on suppression, with this trend expected to continue. However, increasing suppression capacity alone will not solve the bushfire problem, and there is a risk that Australia will continue to increase its firefighting capacity and expenditures without improving its bushfire management.

Over the past two decades, the use of prescribed burning to manage bushfire risk has been debated in the scientific community. Much of this debate revolves around its efficacy in reducing bushfire extent and severity, rather than the economic impacts of prescribed burning programs and trade offs in the allocation of resources between different fire management activities. This PhD research aimed to fill these research gaps and provide a framework for identifying and evaluating the trade-offs between prescribed burning, bushfire suppression and bushfire damages.

BACKGROUND

National inquiries and government reports that recommend changes in prescribed burning levels (such as the Royal Commission on the 2009 bushfires in Victoria) do not analyse their potential economic impacts. In the scientific literature, research into whole fire management programs or the trade-offs between different management activities is still scarce.

BUSHFIRE AND NATURAL HAZARDS CRC RESEARCH

Using a combination of economic techniques and the AUSTRALIS bushfire simulator, this research evaluated the economic impacts of changing the prescribed burning strategy in the south west of WA under different scenarios and timeframes. The study developed a new economic model that estimates the amount of area subjected to prescribed burning which minimises the sum of prescribed burning costs, suppression costs and bushfire damages, for

a given arrangement of the treatments in the landscape (in terms of proximity to towns and size of the treatments). In other words, it estimates the amount of area that maximises the economic benefits for a particular burn arrangement.

The new model developed is a key contribution because it integrates factors that have not been incorporated in previous integrated economic assessments of prescribed burning. These include the variation in value between different types of assets in the landscape and the change in prescribed burning costs with the location and size of the treatments. This model takes into account previous researcher findings that: (1) prescribed burning costs change with the size and location of treatments; (2) varying the size and the location of the treatments can strongly affect their efficiency; and (3) the assets protected differ in nature and value.

▲ **Above:** SOUTH WEST WESTERN AUSTRALIA IS AN EXTREMELY FIRE PRONE AREA. PHOTO: NATHAN MADDOCK, BUSHFIRE AND NATURAL HAZARDS CRC.

END-USER STATEMENT

Building a body of scientific and economic research is essential to guide government policy decisions and resource allocation. It is not just a matter of doing more with less, but better with less. For Western Australia, this research will be a component of the foundation of knowledge underpinning the bushfire reform underway.

– Tim McNaught, Executive Manager, Office of Bushfire Risk Management, WA

FURTHER READING

Florec, V (2016), *Economic analysis of prescribed burning in the south-west of Western Australia*, PhD thesis, University of Western Australia

RESEARCH FINDINGS

If investments in prescribed burning are evaluated in the short-term (that is, on an annual basis), there is no significant difference in the economic results when the level of prescribed burning is varied over a wide range of values. However, a long-term analysis reveals that not conducting any prescribed burning for several years (that is, 15+ years) can be very costly for the south west forest region, resulting in large increases in damages and in suppression expenditures. This indicates that decisions about the strategic optimal rate of prescribed burning for the region or the funds required in any given year for the application of the treatment must be derived from a long term analysis. The bushfire management problem should not be approached from an annual budgeting perspective nor influenced by state electoral cycles.

The improved economic model has shown that substantial benefits may be gained from increasing the area subjected annually to prescribed burns in DBCA-managed land. The model suggests that in the case study area, a rate of 10% of DBCA-managed land treated per year would optimise savings on prescribed burning costs, suppression costs and damages. Beyond 10%, the additional benefits for every dollar invested would be minimal.

In addition, the long-term simulation model shows that prescribed burning reduces the probability of large areas being burned by bushfires in the region and the recurrence times of catastrophic and major fire seasons. Minimising prescribed burning considerably increases the likelihood of exceedingly costly fire seasons. In contrast, at high levels of prescribed burning, catastrophic fire seasons are much less likely. Thus, there are important trade-offs to be considered between the amount of area treated with prescribed burning (and the possible resulting costs) and the expected recurrence of different levels of damage.

HOW THIS RESEARCH COULD BE USED?

This analysis clarifies the implications of changing the level of investment in prescribed burning in the south west of WA and can assist fire and land managers in making decisions about resource allocation.

It can also help fire agencies communicate to the community the impacts of different levels of investments in prescribed burning. The research quantified the extent to which more investment in prescribed burning can reduce the chances of economically catastrophic fire seasons occurring in WA's south west.

FUTURE DIRECTIONS

This study has contributed significantly towards developing models that can inform fire and land managers about how to optimise their returns on investment when deciding where to deploy resources and which management options to use. More research is needed to help identify the trade-offs between asset protection (such as protecting environmental assets versus houses) and fire management investment, which could range from education campaigns to firefighting capacity. Currently, the researcher is working on estimating the differences in costs and benefits from changing the spatial arrangement of the prescribed burning treatments in the long-term and improving the model by including the value of other assets in the analysis.

The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

HAZARD **NOTE**

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ISSUE 30 MAY 2017

TOPICS IN THIS EDITION | DECISION-MAKING | ECONOMICS | MITIGATION | RISK ANALYSIS

PLANNING FOR THE FUTURE: PRIORITISING MITIGATION OPTIONS AND IMPROVING RISK REDUCTION

ABOUT THIS PROJECT

This research was conducted as part of the *Improved decision support for natural hazard risk reduction* project.

AUTHORS

Prof Holger Maier, Dr Aaron Zecchin, Emeritus Prof Graeme Dandy, Jeffery Newman, Graeme Riddell, University of Adelaide; A/Prof Hedwig van Delden, Roel Vanhout, Research Institute for Knowledge Systems, The Netherlands. Contact holger.maier@adelaide.edu.au

SUMMARY

This project is developing tools to help emergency managers and planners better understand how risks from multiple natural hazards change into the future, and how to best manage and minimise these risks. A decision support system has been developed that models future risks from coastal inundation, river flooding, bushfires and earthquakes, and how they may vary based on climate, economic and population changes. This system, coupled with processes to consider how a region may develop into the future, allows emergency managers and planners to consider how to best mitigate risks, while taking into account the resources available to undertake mitigation activities.

Above: RESEARCH HAS DEVELOPED WAYS TO MODEL FUTURE RISK, BASED ON CHANGES TO CLIMATE, POPULATION AND MITIGATION MEASURES. PHOTO: SOUTH AUSTRALIA STATE EMERGENCY SERVICE.

CONTEXT

Future risk is a function of decisions made today. It is important to consider risk as dynamic rather than static; as is currently done. To explore how to manage risk into the future, an integrated and dynamic approach is needed that considers different drivers and options impacting on future risk.

BACKGROUND

Significant discrepancies exist between the level of relief and recovery spending in Australia versus the investment in prevention and preparedness. This is despite the wealth of analysis showing positive benefit cost analysis of anywhere between 1.4 and 70 to 1 (i.e. spending $1 on mitigation will save anywhere between $1.40 and $70 in response and recovery costs). Although it seems obvious that it is better, 'to build a fence at the top of a cliff, than park an ambulance at the bottom', there are challenges in determining where and when to build it, and how tall it should be. This project therefore looks to integrate the best understanding of risk from various emergency and land management agencies and researchers to allow decision makers and planners to better plan how to build the figurative fence at the top of the cliff.

BUSHFIRE AND NATURAL HAZARDS CRC RESEARCH

The project has and is developing decision support systems for long term risk reduction planning. A case study for Adelaide and surrounding regions is now complete, while case studies for Melbourne and surrounding regions, along with Tasmania, are well developed. These software systems integrate modelling and knowledge from government departments and agencies across the three locations to ensure the system best fits the use required by different organisations.

A participatory, design focused approach was taken to the software development. This has seen prototypes developed and implemented within organisations via training courses and workshops. These prototypes can then be revised as organisations use the system more and gain a greater appreciation for its capabilities.

RESEARCH FINDINGS

To date, modelling approaches for dynamic risk assessments and long-term planning/policy impact assessment have been developed. This has also been supplemented with scenario exercises which have explored what the future of risk and resilience could look like in Adelaide and surrounds (see Riddell *et al.*, 2017). Similar outputs will soon be available for the greater Melbourne case study, which extended the range of mitigation options to include elements of social programs such as community engagement and education. Work for Tasmania also considers different scenarios for future development based on economic and population growth, as well as considering optimising the spending of mitigation budgets across different scenarios.

The results of scenario modelling for greater Adelaide highlighted the variability in regional risk based on variability of the drivers into the future. They also showed the importance of effective planning of new regional developments to ensure a safer future. It is hoped that more integration of this scenario work can build strategic capacity across agencies in the understanding of future risk.

HOW IS THIS RESEARCH BEING USED?

Multiple workshops have been held to inform the development of the system. Discussion has centred around:

- available risk reduction options and their benefits
- costs – positive and negative – across multiple criteria
- drivers for regional change and uncertainties
- current and desired decision/policy making processes.

These discussions have been incorporated within the design of the software, and insights can also be used to inform various other policy processes and risk assessments.

The software is now available for Adelaide and surrounding areas. End-users from SA's Department of Environment, Water and Natural Resources are being trained in its use, along with other agencies. It is hoped with further integration into South Australian emergency management agencies and land management departments, improvements can be made to better inform risk reduction planning into the future in the state.

More broadly, it is expected the software will be used within agencies and departments for their own planning and resourcing requirements. It will give users a better understanding of the future risks, both from natural hazards and organisational perspectives. The software and scenario processes can also be used as effective communication tools between different agencies to have a common tool for discussion and exploring combined strengths and weakness and between agencies and the community.

END-USER STATEMENT

All emergency management practitioners and land managers across Australia make choices in an effort to minimise losses from natural disasters.

They ask questions like 'what are the benefits and costs of mitigation options?', 'how do we quantify many of the intangibles?' and 'who owns the risk?' In a multi-stakeholder environment this is complicated, and it is hoped tools such those developed through this research will help agencies answer these important questions, leading to better decisions in mitigating future natural hazards.

– Ed Pikusa, Manager Policy and Reporting – Fire & Flood Management Unit, Department of Environment, Water and Natural Resources South Australia.

FURTHER READING

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FUTURE DIRECTIONS

The case studies for greater Melbourne and Tasmania are well developed, with the scenario software expected to be available late 2017 for end-users in these areas. Future efforts will focus on improving several components of the study, including aligning indicators - improved economic assessment of policies and broader consideration of values at risk, and improving the consideration and modelling of demographics and associated vulnerabilities - with agency/department needs.

There will also be a significant emphasis on how to best integrate the system within end-user organisations, and what capacities need to be developed to improve organisations' abilities to engage with future risk and strategic planning.

The team is always interested in applying the process to new regions, bringing in new knowledge to improve the system, making it more effective and robust.

The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

HAZARD **NOTE**

bushfire&natural HAZARDSCRC

ISSUE 25 DECEMBER 2016

TOPICS IN THIS EDITION | DECISION MAKING | ECONOMICS | MULTI-HAZARD | POLICY

WHAT CAN ECONOMICS OFFER EMERGENCY SERVICES?

ABOUT THESE PROJECTS

This is an overview of the *Economics and strategic decisions* cluster of Bushfire and Natural Hazards CRC research projects. This cluster has four linked studies:

1. **Decision support system for assessment of policy and planning investment options –** Prof Holger Maier, Dr Aaron Zecchin, Emeritus Prof Graeme Dandy, Jeffery Newman, Graeme Riddell, Charles Newland, University of Adelaide; A/Prof Hedwig van Delden, Research Institute for Knowledge Systems, The Netherlands. Contact holger.maier@adelaide.edu.au
2. **Economics of natural hazards –** Prof David Pannell, A/Prof Atakelty Hailu, A/Prof Michael Burton, Dr Fiona Gibson, Dr Veronique Florec, Dr Abbie Rogers, University of Western Australia. Contact david.pannell@uwa.edu.au
3. **Mapping and understanding bushfire and natural hazard vulnerability and risks at the institutional scale –** Prof Roger Jones, Celeste Young, Dr John Symons, Prof Peter Sheehan, Prof Bruce Rasmussen, Victoria University. Contact roger.jones@vu.edu.au
4. **Pre-disaster multi-hazard damage and economic loss estimation model –** Prof Mehmet Ulubasoglu, Dr Prasad Bhattacharya, Dr Habibur Rahman, Deakin University; Prof Abbas Rajabifard, A/Prof Nelson Lam, Dr Mohsen Kalantari, Dr Benny Chen, Dr Katie Potts, Anggraini Dewi, University of Melbourne; Dr Peeranan Towashiraporn, Asia Disaster Preparedness Centre. Contact mehmet.ulubasoglu@deakin.edu.au

CONTEXT

A better understanding of the economic costs of disasters and their risks, and the risk-reducing benefits of mitigation, can build a more compelling case that improves the likelihood of mitigation options being resourced and implemented. This cluster of research projects focuses on developing the tools required to undertake sound analysis of the costs and benefits of different disaster risk reduction strategies.

DECISION SUPPORT SYSTEM FOR ASSESSMENT OF POLICY AND PLANNING INVESTMENT OPTIONS

BACKGROUND

To allow policy and decision-makers to make better long-term decisions with regard to mitigation and risk reduction strategies, an evidence base is required that enables decisions to be justified on a rational basis with the best available information. Currently, there are no tools that allow for a comparison of different hazards and their mitigation options, while also taking into account long-term planning. This study is developing decision support systems in the form of software tools that contain integrated models for the assessment of natural hazard mitigation options. The decision support systems can take into account future changes in demographics, land use, economics and climate, allowing policy makers to better understand the drivers of risk and the impact of their policies on the risk profile now and into the future.

▲ **Above:** RESEARCHER GRAEME RIDDELL SHOWS SOUTH AUSTRALIAN END USERS ASPECTS OF THE DECISION SUPPORT SYSTEM. PHOTO: TIM ALLAN

HAZARD **NOTE**

RESEARCH ACTIVITY

The team has been developing a generic approach to assessing the long-term impacts of mitigation options on multiple hazards. This approach is then applied to a series of case studies to investigate the effectiveness of policy and planning investment options for optimal mitigation of natural hazards. The case studies comprise three separate locations – Adelaide, Melbourne and Tasmania – with each location looking at a range of hazards and their mitigation options over time, allowing emergency managers and planners to assess the dollar costs of the impacts of mitigation decisions.

For each case study, the tool will be able to analyse areas of risk both now and into the future, test different types of risk reduction options, identify mitigation portfolios that provide the best outcomes for a given budget, and consider single or multiple types of risk reduction options.

RESEARCH OUTCOMES

The decision support system case study for Adelaide is nearing completion. In consultation with end users, the system incorporates hazard modelling of flooding, coastal inundation, earthquake, bushfire and heatwave. Expected impacts of these hazards have been modelled from 2015 to 2050 with an annual time step, showing the change in risks. Data from 2015 were used as a baseline to allow comparison with future impacts. Next steps will allow for the ability to test the impact of different mitigation and risk reduction measures across the different hazards under different long-term socio-economic and climate drivers.

Work on the Melbourne and Tasmanian case studies is ongoing, with end users advising on data collection and methodologies.

ECONOMICS OF NATURAL HAZARDS

BACKGROUND

This study tackles from an economics perspective issues relating to non-financial benefit estimation, risk analysis and development of decision-making frameworks that would help deliver value for money from public investments in natural hazard management. It has a broad scope in terms of natural hazards, including fires, earthquakes, floods, cyclones and tsunamis.

RESEARCH ACTIVITY

The project has two main components:

- Estimate the non-financial benefits – an innovative tool is being developed for efficiently generating estimates of dollar values for non-financial benefits. The aim is to develop a tool that people with only a moderate knowledge of economics are able to use, and that people with no economics knowledge can learn from.
- Integrated economic analysis of management and policy – this involves the integration of technical, social, biophysical and policy information within an economics framework. Two case studies are being undertaken: with the first investigating flood management options in Adelaide, accounting for tangible and intangible impacts from floods and management, and the second is investigating prescribed burning options in private land in the Mount Lofty Ranges, South Australia.

Additionally, the project will develop guidelines for sound economic analysis, which includes an accessible and understandable guide to undertaking economic analysis of natural hazard management and policy.

▲ **Above:** A CASE STUDY IS INVESTIGATING MITIGATION OPTIONS FOR FLOOD MANAGEMENT IN ADELAIDE. PHOTO: SOUTH AUSTRALIA SES

RESEARCH OUTCOMES

A case study on mitigation options for flood management for the Brown Hill and Keswick catchments in Adelaide has been completed, focusing on a set of flood mitigation options that are currently under consideration following a public consultation. Previous analysis by a third party had suggested that the benefit-cost ratios appear unfavourable. However, this previous analysis did not include intangible values (i.e. perceived values of public amenity, environmental benefit, health). The case study provides estimates that show how the understanding of the costs and benefits of mitigation options (investments in creek capacity upgrades, river diversions and detention dams) would change with the inclusion of intangible values to account for the health, environmental and social impacts of floods. These mitigation works would substantially reduce flood damage resulting from a flood with a one-in-a-hundred-year average return interval.

The second case study is currently being undertaken exploring the costs and benefits of prescribed burning in private land in the Mount Lofty Ranges. At present, there is a coordinated approach to prescribed burning in public land in the region, but there is no policy or mandate for private landowners to prescribe burn on their properties. Private land constitutes a large proportion of the Mount Lofty Ranges, and fuel levels in private properties may significantly influence overall fire risk levels for the region. However, little is known about the costs and the benefits of prescribed burning in private land and land management agencies need this information to assess whether extending the prescribed burning mandate to private land would generate benefits in excess of the costs.

A literature review has also been completed on non-market valuation of natural hazards. The review found that there is scope to use willingness-to-pay estimates from existing studies, through benefit transfer, for some of the values affected by natural disasters. For some types of impacts, existing evidence is likely to be sufficient to support benefit transfer, while for others, additional studies are needed to fill information gaps.

HAZARD **NOTE**

MAPPING AND UNDERSTANDING BUSHFIRE AND NATURAL HAZARD VULNERABILITY AND RISKS AT THE INSTITUTIONAL SCALE

▲ **Above:** RESEARCH HAS FOUND THAT RURAL AREAS IN VICTORIA ARE AFFECTED MORE ECONOMICALLY BY FLOODS AND BUSHFIRES THAN METROPOLITAN AREAS. PHOTO: COUNTRY FIRE AUTHORITY

END USER STATEMENT

The outcomes from these projects can help end users in a variety of ways, whether they be single hazard response agencies wanting to quantify and understand risks across their one hazard, central planning agencies who need to understand these same risks for multiple hazards across their entire jurisdiction, or local councils or other authorities who want to understand the nature and prioritise mitigation for a certain town or locality.

It is hoped that this research can help answer questions that can be very complicated in a multi-stakeholder environment, questions such as 'who is responsible for risks and mitigation?', 'who is accountable for delivery of mitigation?' and 'who pays for mitigation?'

– Ed Pikusa, Principal Flood Management Officer, Department of Environment, Water and Natural Resources, South Australia

BACKGROUND

Current federal government spending on natural disaster response is more than 20 times the spending on preparedness. While the spending mismatch between response and preparedness is well understood, potential deficits in important social and environmental values are also faced. This study maps a broad range of economic, social and environmental values, and relating them to natural hazards within Victoria and explores them through the lens of risk ownership and vulnerability.

RESEARCH ACTIVITY

A mapping platform and spatial maps of values at risk were produced for a Victorian case study, though the concept has national relevance. A desktop review was undertaken on how risk ownership is currently being allocated, followed by workshops with end users in Victoria, New South Wales, South Australia and Tasmania. The workshops explored, through a series of structured scenario exercises, how values and risk ownership are currently understood in relation to decision making. They also explored the best use of the mapping platform.

Risk ownership was investigated through who 'owns' these values, how they own them and what happens to those values and their associated ownership across different temporal and geographical scales. Risk owners were identified though ownership of assets (values at risk) and responsibility for activities that manage risk. A process-based framework to support better application of risk ownership based upon this work is currently being finalised in collaboration with end users.

RESEARCH OUTCOMES

Institutional maps of risk ownership were constructed following the desktop review and workshops to provide an insight into the current balance of ownership delegations. These conceptual maps examining risk ownership related to strategic management of natural hazard risk prior to and following events.

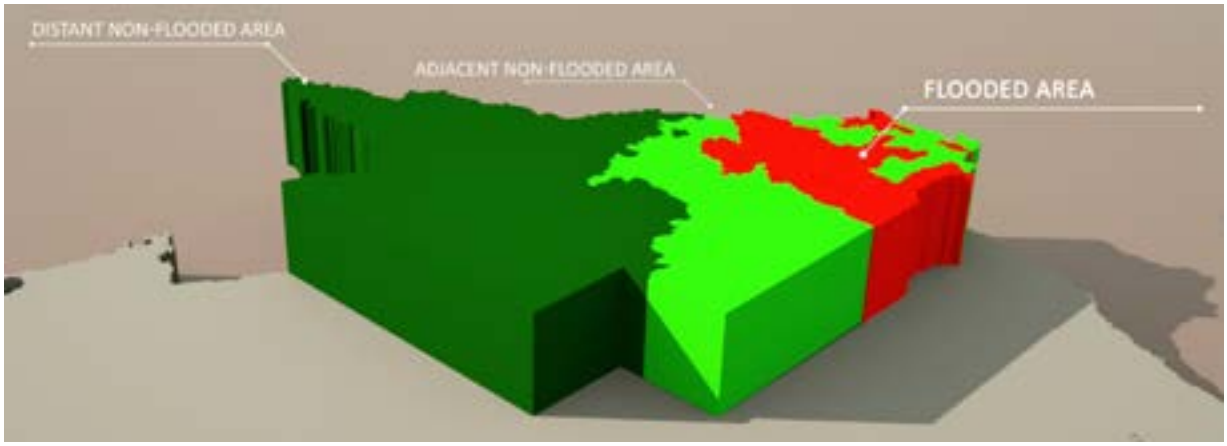
Both the workshops and maps suggest that risk ownership distribution is uneven across the three areas assessed for the different major institutions: local, state and federal government; the community, industry and business; and boundary organisations. State government and local government had the largest allocation of ownership of risk and consequences, and risk actions; whereas ownership of values at risk, covering tangible assets such as built infrastructure, and intangible assets such as connectivity, was more evenly spread between institutions (Young *et al.*, 2016).

Development of the platform and spatial maps has been completed. Consultation with end users about its potential future use settled on its application as a research tool to formulate and test questions. End users also identified sense-making of data – to better understand and use their existing data and mapping tools in support of strategic decision making – as a key need.

A report based on the values-at-risk maps, describes the economic geography of vulnerability to bushfire and flood in Victoria. Industries and localities with the highest vulnerability and lowest economic diversity were identified, based on the exposure of 2011 output data to historical hazards. Vulnerability is high in some sectors (e.g., agriculture) and some regions, mainly rural areas, where up to 50% of annual output can be vulnerable. Metropolitan areas are largely insensitive to these risks and peri-urban areas contain some vulnerable areas.

HAZARD **NOTE**

PRE-DISASTER MULTI-HAZARD DAMAGE AND ECONOMIC LOSS ESTIMATION MODEL



▲ **Above:** AREAS OF QUEENSLAND THAT WERE IMPACTED BY THE 2010-2011 FLOODS.

BACKGROUND

This project is investigating the economic impact of natural disasters on the Australian economy, across sectors such as agriculture, forestry and fishing, mining, manufacturing, utilities, construction, retail trade, transport and health care. Economic impacts can often be overlooked in management planning as the effects are not always immediate. A substantial problem is the inability to estimate the full economic impact of natural hazards, considering all the affected sections of the economy. This effort should take into account not only the primary impacts of natural disasters, but also secondary impact due to economic loss.

The overall objective of this project is to build a scenario-based pre-disaster multi-hazard damage and economic loss estimation model to support decision makers in reducing disaster risks at the sectoral level.

RESEARCH ACTIVITY

The study is using selected emergency events (2010-2011 Queensland floods, 2009 Black Saturday bushfires) to present the impact of these natural disasters on different sectors of the economy. This will include how the event impacted over time, illustrating how events can ripple through the broader economy.

A case study has been undertaken on the Queensland floods, investigating the impact of the event on the different sectors of the economy. The goal is to estimate the effect of the floods on an individuals' income by the sector they are employed in, to identify the sectors that are vulnerable to natural disasters, the sectors that are beneficiaries of natural disasters, and the sectors that are unlikely to be affected by natural disasters. The outcome of this research will be a ranked list of economic sectors according to the impact of the disaster on the sectors. This will provide policy makers with the evidence they desire to minimise the potential negative effects of natural disasters at the sectoral level.

RESEARCH OUTCOMES

Using data from the Australian Bureau of Statistics, the team has compared income variation from 2006 to 2011 of the flood-affected individuals in Queensland with unaffected individuals to detect any differences in income by employment type as a result of the flood. Preliminary results indicate a range of outcomes – some sectors experienced no income difference as a result of the floods, while three sectors were impacted negatively (retail trade, business support services, and accommodation and food services), and two were impacted positively (education and training, and health care).

FURTHER READING

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The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

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Education and Communications

HAZARD **NOTE**

bushfire&natural HAZARDSCRC

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TOPICS IN THIS EDITION | COMMUNICATION | COMMUNITIES | WARNINGS

LESSONS FROM BLACK SUMMER: HOW PEOPLE EXPERIENCED THE 2019/20 NSW FIRE SEASON

ABOUT THIS PROJECT

The New South Wales Rural Fire Service (NSW RFS) commissioned the Bushfire and Natural Hazards CRC to undertake research into community attitudes and experiences of the 2019/20 NSW bushfire season.

AUTHORS

Dr Josh Whittaker, Dr Katharine Haynes, Carrie Wilkinson, Stephanie Samson, University of Wollongong; Dr Matalena Tofa, Dr Tasmin Dilworth, Jessica Collins, Lillian Tait, Macquarie University. Contact josh.whittaker@rfs.nsw.gov.au

▲ **Above:** BUSHFIRE RAGING AT THE NORTH BLACK RANGE IN NSW, DECEMBER 2019. PHOTO: NED DAWSON/NSW RURAL FIRE SERVICE.

SUMMARY

The 2019/20 bushfire season was unprecedented in NSW, with destructive bushfires occurring across the state between August 2019 and February 2020. Tens of thousands of people were displaced by the fires, including residents, tourists and visitors to affected areas, with many fires occurring during the Christmas and New Year holiday period. Tragically, 25 people lost their lives in the fires. Many more people were affected by smoke in both metropolitan and regional areas. By season's end, bushfires had burned a record 5.5 million hectares of NSW and destroyed 2,448 homes (NSW RFS 2020). The fires adversely affected many industries, including agriculture, forestry and tourism.

This research investigated how people across NSW were affected by the bushfires and what actions they took. A total of 202 in-depth interviews were conducted with people affected by the fires to identify key themes and experiences. A further 1,004 others completed an online survey to provide quantitative insights. Themes covered in this research include risk communication, preparedness and how this changed due to the length of the fire season, and the experiences of tourists and visitors, especially during the Christmas and New Year period.

The research found that previous experience of bushfire motivated many people to plan and prepare. The extent of the 2019/20 fires and the sheer number of people affected presents opportunities to reach new audiences with bushfire safety information and promote planning and preparation. However, the research shows the challenges around community expectations of warnings, with many people expecting to receive highly detailed and localised information in near real-time. New initiatives, including fire spread prediction maps and Tourist Leave Zone messages, were found to be effective in communicating risk and motivating people to take protective action during the worst of the conditions.

The NSW RFS uses research such as this to evaluate and measure the effectiveness of its work during emergency events, and to enhance warnings and engagement approaches for future events.

CONTEXT

The study addressed key questions relating to risk communication; effects of prolonged and repeated exposure to fire, as well as previous experience, on planning, preparation and responses; sheltering practices; experiences of tourists and visitors; awareness and attitudes toward bushfire risk reduction; building standards; and community recovery and resilience.

The research builds on previous NSW RFS contracted research relating to major bushfires in the Blue Mountains, Coonabarabran, Southern Highlands and south coast areas, and research in other states such as Victoria, Tasmania, South Australia and Western Australia.

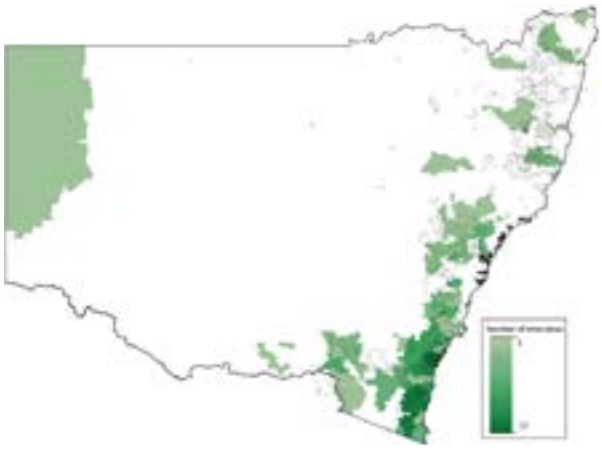
BACKGROUND

The 2019/20 bushfire season saw unprecedented fire conditions and fire impact across NSW. Fires early in the season in the state's north impacted on communities and, as conditions continued to deteriorate across the season, the impacts were felt from the Queensland border to the Victorian border.

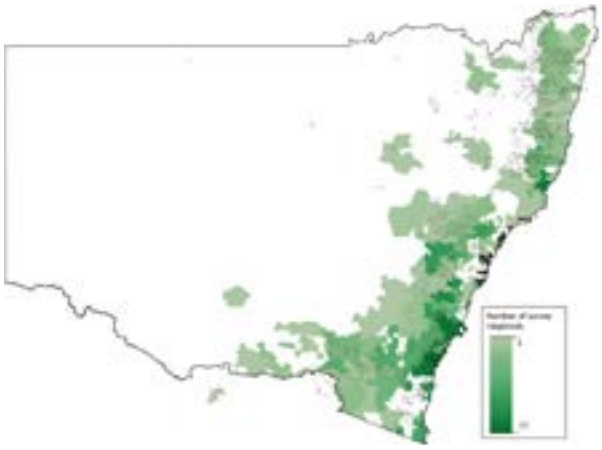
The state experienced six days of Catastrophic fire danger, with three State of Emergency declarations. There were 59 days of total fire ban, including 11 statewide total fire bans.

Tens of thousands of people were displaced by the fires, including residents, tourists and visitors to affected areas.

Tragically, 25 people lost their lives in the fires, including four NSW RFS volunteers



▲ **Figure 1:** GEOGRAPHICAL SPREAD OF INTERVIEWS BY POSTCODE (N=202).



▲ **Figure 2:** GEOGRAPHICAL SPREAD OF SURVEY RESPONSES BY POSTCODE (N=1,004).

and three aerial firefighters from the United States. Many more people were affected by smoke, including in regional areas and major population centres such as Sydney, Canberra, Newcastle and Wollongong.

By season's end, when February rain reduced the fire threat, fires had burned a record 5.5 million hectares of NSW and destroyed 2,448 homes (NSW RFS 2020). Community and commercial buildings and infrastructure were also significantly impacted. The fires adversely affected many industries, including agriculture, forestry and tourism.

BUSHFIRE AND NATURAL HAZARDS CRC RESEARCH

The research involved 202 semi-structured, in-depth interviews, conducted with 215 people threatened or affected by bushfires across NSW (see Figure 1, above left). Gender breakdown was 59% female, 41% male. Of the 202 interviews, 166 were with people who were threatened at their primary place of residence, while 36 were with people who were tourists, visitors or holiday home owners in affected areas. Interviews were conducted via web conferencing and telephone (due to COVID-19 restrictions), were audio recorded, transcribed, and then qualitatively analysed using data analysis software *NVivo 11*.

In addition, an online survey received a total of 1,004 completed responses from people who were threatened or affected by bushfire at their primary place of residence (n=773) or at a secondary residence (e.g. holiday home) or as a tourist or visitor to a fire threatened or affected area (n=231) (see Figure 2, above right).

This *Hazard Note* reports on findings from both the community interviews and the survey. Statistics reported throughout are for survey respondents who were threatened or affected by bushfire at their primary place of residence ('residents') unless otherwise stated.

This *Hazard Note* covers findings relating to prolonged and/or repeated exposure to fire, Fires Near Me NSW, fire spread prediction maps, Tourist Leave Zones, and the experiences of tourists and visitors generally. Full details of the research are available in the report *Black Summer – how the NSW community responded to the 2019-20 bushfire season* (Whittaker et al., 2021).

RESEARCH FINDINGS

PROLONGED AND/OR REPEATED EXPOSURE TO FIRE

The length of the fire season and the repeated threat of bushfire was a significant factor that influenced people's planning, preparation and responses. The extended fire season required many people to adapt to fire as an everyday part of their life, juggling work, schooling and family celebrations with ongoing monitoring, preparation and responses to fire.

Many people were exhausted by the ongoing nature of the threat and the continual need to monitor and prepare. Some discussed living with the continual 'anticipation of threat' and voiced times where they had wished the fires would arrive so that the experience would be over.

The length of the fire season allowed many people to engage in considerable planning and preparation. Residents who had not previously considered the risk of bushfire talked about how they made

WHAT WAS SAID

On continuing with holiday plans

"Really that crossover between wanting your summer holiday and the good times that come with it, and being able to push the risk away a little bit, because you really just want to have that good time, rather than really be involved in an emergency. 'That can't happen, look, we're on holiday. There's just no way.' But of course, there was."

On prolonged exposure to fire

"So, what I found was really difficult with that planning was, you're on high alert. You're actually constantly on tenterhooks. It's not like something happens, it scares you, and then the threat goes away. The threat is always there, and it's still coming, you just don't know when...the threat's just looming. You don't know when it's coming. So, you have to constantly be in the mode to fight or flight. It's not good."

On fire spread prediction maps

"I saw an ember attack map that included the edges of Conjola Park as coming under ember attack that day. That was the predicted map, so I figured if down south around Moruya and Mogo and all that the ember attack had already hit them by 8:00 o'clock in the morning that weather, that wind, was coming up the coast and so I knew we were stuffed. I knew that we were going to get burned that day."

fire plans for the first time, while others had time to hone their preparations.

The long duration of the fire season influenced some people to change their bushfire plans. Notably, some realised that they no longer accepted the risks involved with staying to defend due to an increased understanding of the likely severity of the fire and witnessing fire impacts in other areas.

FIRES NEAR ME NSW

The Fires Near Me NSW app was extremely popular, with 94% of primary residents surveyed reporting they had downloaded the app, including 39% reporting that it was the most useful source of information (followed by NSW RFS volunteers as the next most useful source at 13%). Most residents thought Fires Near Me NSW was easy to understand (89%) and useful (88%). More than two thirds thought the information was sufficiently localised. However, less than half believed the information was up to date (47%).

While a number of people reported that Fires Near Me NSW was not updated frequently enough, there was still a strong preference for it as a source of information, with 78% of survey respondents indicating it was their preferred source of information in the future.

The NSW RFS had identified issues with Fires Near Me NSW, including the timeliness of maps due to the large number of fires and the speed of fires spreading, and these issues were reflected in many community interviews.

FIRE SPREAD PREDICTION MAPS

Fire spread prediction maps were introduced by the NSW RFS to communicate elevated risk from fire conditions and the large number of dangerous fires burning across the state.

Most people recalled seeing these maps for their area (86%) and found them easy to understand (93%), sufficiently localised (77%) and useful (85%). Around half of these respondents said that seeing the fire spread prediction influenced their decision to leave or avoid travelling to a fire threatened area.

Some tourists and visitors consulted fire spread prediction maps prior to commencing their travel. A small number of people said the fact that their travel destination was not within a fire spread prediction area gave them a false sense of security in continuing with their travel plans.

TOURIST LEAVE ZONES

Tourist Leave Zones were communicated to encourage visitors to leave certain areas due to the fire risk.

Around half (47%) of the tourists, visitors and secondary residents who were surveyed reported that they were in a Tourist Leave Zone during the bushfires. After receiving notification of the Tourist Leave Zone, 54% of people returned home to their primary residence and 14% went to another location outside the zone. Around one-third stayed within the zone. Reasons for staying within the zone included to protect houses and property (mostly occupants of secondary residences; 32%); because police, fire or emergency service advised people to stay (12%); and because attempts to leave were unsuccessful (11%). The majority of interviewees understood the purpose and were supportive of Tourist Leave Zones.

TOURISTS AND VISITORS

While most tourists, visitors and those who owned secondary homes were aware of bushfire activity in the vicinity of their travel destination, many did not think they would be directly affected. Continuing with annual holiday plans and wanting to escape smokier conditions at their primary place of residence were the main motivations for people to travel during the bushfire threat.

Some tourists and visitors sought assurance from accommodation providers that it was still safe to visit. Others reported hearing local councils and tourism agencies say it was safe to travel. Some felt there were mixed messages about whether it was safe to visit or remain in particular areas, with NSW RFS telling people to leave or

SUMMARY OF KEY RESEARCH STATISTICS[1]

Engagement with NSW RFS programs and materials:

- 57% had read the *NSW RFS Guide to Making a Bush Fire Plan*.
- 44% had participated in a local NSW RFS brigade event.

Fire spread prediction maps:

- 86% recalled seeing a fire spread prediction map for their area.
- 93% found it easy to understand, 77% sufficiently localised and 85% useful.

Official warnings:

- 78% received official warnings with sufficient time and 71% with sufficient information to take protective action.

Fires Near Me NSW:

- 94% had downloaded the Fires Near Me NSW app.
- 78% indicated that it was their preferred source of information in the future.

Neighbourhood Safer Places:

- 44% were familiar with the term 'Neighbourhood Safer Place'.
- 72% of those who were familiar with the term were aware of a Neighbourhood Safer Place in their area.

Experiences of tourists and visitors:

- 38% considered it likely that a bushfire could occur in the area they were visiting and 33% considered it unlikely. Just 2% had not considered the risk.
- 27% indicated that a bushfire was already burning in the area they were going to visit.
- 45% of those who travelled to an area where a fire was already burning did so to defend a property or assist family or friends. 26% did not think the fire would affect them and 11% wanted to continue with holiday or business plans.
- 52% had not done anything to prepare for the possibility of bushfire on their trip.
- 47% reported that they were in a Tourist Leave Zone during a period of bushfire threat.
- 34% found out about the Tourist Leave Zone via radio, 13% via television, 13% via social media, 11% from people in the surrounding area and 10% via Fires Near Me NSW.
- 54% returned to their primary residence after receiving notification of the Tourist Leave Zone, 14% went to another location outside the Tourist Leave Zone and 32% remained within the Tourist Leave Zone, mostly to defend property (typically holiday home owners) or because they were unable to leave.

1 Statistics are for survey respondents who were threatened or affected by bushfire at their primary place of residence.

avoid fire threatened areas and some local businesses encouraging people to visit.

CONCLUSION

The findings presented in this *Hazard Note* and in the full report, *Black Summer – how the NSW community responded to the 2019-20 bushfire season,* present numerous opportunities for the NSW RFS, other government agencies and communities to reduce future bushfire risk. Few opportunities are the responsibility of any one stakeholder alone. The findings highlight the complexities of community preparedness and responses to bushfire and the need for integrated and holistic responses to risk reduction. Bushfire risk reduction is a shared responsibility between governments, fire and emergency services, businesses and communities at risk.

Community expectations of warnings and information appear to be growing. In particular, many people expect to receive highly detailed and localised information in near real-time. Analysis of interviews suggests that people want this information in order to make more 'responsive' or 'timely' decisions about protective actions. Messaging is needed about the potential for disruptions to communications during bushfires, underscoring the need for well-planned and decisive action to avoid last-minute evacuation or being unable to leave a fire affected area.

For most people, the Fires Near Me NSW app remains the preferred source of warnings and information during bushfires. People identified ways it could be improved, including by providing more information about where the fire is spreading and, particularly for tourists and visitors, information about roads and transport. While there are benefits of providing more localised and detailed information about the likely spread and impact of bushfires, there is a risk that this would encourage people to delay their protective action. Those who plan to leave during bushfires should do so long before they are directly threatened.

Fire spread prediction maps and Tourist Leave Zone messages were effective in communicating risk and motivating people to take protective action. Consideration should be given to reserving their use so they continue to be taken seriously by the community. Community members must understand that such communications are based on predictions that, while based on the best available science, are inherently uncertain.

Few travellers had prepared for the possibility of encountering bushfire while travelling or at their destination. Tourists and visitors should be encouraged to plan and prepare for bushfire when travelling to and visiting bushfire risk areas.

END-USER STATEMENT

"The 2019/20 bushfire season was described as 'unprecedented' because of the scale of risk across NSW, the forecast fire conditions, the impact of the fires on communities, and the scale of loss.

"We also saw the community respond like never before, such as engaging with our warnings and information, and taking action.

"While any loss is a tragedy, there was the potential for dozens or even hundreds of lives to be lost – and it's testament to the combined efforts of community and emergency services that the losses weren't of that magnitude.

"Large events like this always present an opportunity to consider what works and what needs to be refined, in conjunction with inquiries like the *NSW Bushfire Inquiry* and its recommendations, this research helps map out how we can continue to improve.

"Importantly, the research sets out that while fire services like the NSW RFS are critical in mitigating the risk, it isn't for government or emergency services alone. While the quality and amount of preparedness information and warnings improves, the community can't afford to become overly reliant. The community must do its part to prepare and respond."

Anthony Clark, Director Communications and Engagement, NSW Rural Fire Service

FURTHER READING

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HAZARD **NOTE**

bushfire&natural HAZARDS CRC

ISSUE 83 OCTOBER 2020

TOPICS IN THIS EDITION | COMMUNICATION | DECISION MAKING | FLOOD

HOW DO ROAD CHARACTERISTICS INFLUENCE FLOOD FATALITIES?

ABOUT THIS PROJECT

This research was conducted by the Bushfire and Natural Hazards CRC, Risk Frontiers and Macquarie University as part of the *An analysis of building losses and human fatalities from natural disasters* project.

AUTHORS

Andrew Gissing, Simon Opper, Lucinda Coates and Prof John McAneney, Risk Frontiers; Dr Matalena Tofa, Macquarie University.

Contact andrew.gissing@riskfrontiers.com

SUMMARY

Vehicle-related flood fatalities and rescues are a significant emergency management and road safety problem. This study investigated the influence of road characteristics on a motorist's decision to enter floodwaters, as well as the chance of the vehicle being washed from the road and the chance of survival of occupants in a vehicle that has entered the flooded area. The research proposes a new risk-based procedure for assessing flood-prone roads according to the road's characteristics, which can also be used to improve the future design of roads in flood-prone areas.

▲ **Above:** THIS RESEARCH INVESTIGATED THE INFLUENCE OF ROAD CHARACTERISTICS ON A MOTORIST'S DECISION TO ENTER FLOODWATER, AND THE EFFECT THIS HAS ON FATALITIES. PHOTO: NSW STATE EMERGENCY SERVICE.

CONTEXT

An analysis of flood-related deaths in Australia between 1960 and 2015 revealed that 49 per cent were related to vehicles (Haynes et al 2016). This rate highlights the significance of the need to better understand vehicle-related flood deaths. Most research to date has focused on the circumstances of flood fatalities, the type of flood hazard and the reasoning for why motorists enter floodwater. This study assesses the influence of road characteristics on flood fatalities.

BACKGROUND

The risk to motorists in respect to floodwaters depends not only on drivers' decisions and flood hazard, but also upon the characteristics of the location, which has been the focus of this study. In 2015, Austroads, a peak body for road management in Australia, stated that the vast majority of the approximate 20,000 floodways in Australia and New Zealand were not constructed in accordance with required design and hydraulic standards, lack appropriate signage and that depth gauges where present were liable to misinterpretation by motorists (Austroads 2015).

This research, conducted in 2017, was able to identify road characteristics that are clearly more dangerous than others.

BUSHFIRE AND NATURAL HAZARDS CRC RESEARCH

The characteristics of 21 sites across New South Wales, Queensland, Western Australia, Victoria and the Australian Capital Territory were analysed based on the quality of

information available and ease of access to the site. These sites accounted for 28 deaths, representing approximately 50 per cent of total vehicle-related flood fatalities between 2010 and 2017. Specific details regarding the number of fatalities and associated circumstances were obtained from media outlets, emergency service media releases and publicly available coronial records.

For each site, observational assessments were made about the road characteristics. Descriptions of each of these elements is provided in Table 1 (page 3).

RESEARCH FINDINGS

Characteristics most frequently identified at these dangerous sites were:

- small upstream catchment length that may cause floodwaters to rise rapidly with little warning
- the absence of roadside barricades
- deep flooding immediately adjacent to the roadway
- the absence of lighting
- dipping road grades that resulted in vehicles driving into deeper floodwaters than drivers expected
- the lack of curb and guttering
- the inability of motorists to easily turn around.

Each of these factors were observed in at least 50 per cent of the cases studied. These results demonstrate that some roadways are clearly more dangerous than others. However, emergency planning or floodplain risk management approaches tend to focus on urban flood risk and do not assess risks related to motorists entering floodwater. The large number of flood-prone roads in various areas means that it will be necessary to prioritise those locations that most require safety improvements. This should be done on a risk-informed basis.

Road flood risk factors can be categorised into those that influence a motorist's decision to enter floodwaters; factors that influence whether a vehicle might be washed or driven from the road; and those that influence survivability of occupants once a vehicle is in floodwaters. These factors are listed and described in Table 2 (page four).

HOW COULD THIS RESEARCH BE USED?

There is currently no standard practice for assessing risk of flood-prone roads. Given the large number of road sections that may not have been constructed to safe design and hydraulic standards, it is important that road operators assess and prioritise potentially vulnerable locations based on their relative risk. This study provides the basis for a risk-based assessment procedure. The results can also be utilised to improve the future design of roads in flood-prone areas. Ultimately, policy that considers road characteristics in flood-prone areas, in addition to other interventions such as education, law enforcement and emergency response, has the potential to reduce the number of vehicle-related flood deaths.

FUTURE DIRECTIONS

Through the Bushfire and Natural Hazards CRC, this research work has been extended to look at road characteristics present at sites where flood rescues have occurred. This research should be repeated further over time to contribute further to the evidence base.

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END-USER STATEMENT

"In 2018, the NSW SES conducted an applied research project called Project U-Turn, which aimed to develop strategies in collaboration with local communities to improve motorist safety during floods. Outcomes of this research [in this *Hazard Note*] were beneficial in identifying high risk sites in NSW related to motorists entering floodwater. The research highlighted a range of location-based issues associated with motorist behaviour, allowing the NSW SES leverage in identifying local engagement opportunities that targeted behaviour from a collaborative solutions process, specific to that community context."

David Webber, Coordinator Community Capability, Metro Operations, NSW State Emergency Service

TABLE 1: CHARACTERISTICS OF ROADS THAT MAY INFLUENCE BEHAVIOUR IN FLOODWATERS

CHARACTERISTIC	DESCRIPTION
Road structure type	Road structure present at point of entry, for example bridge, floodway or roadway
Location	Whether the road was in an urban, rural or peri-urban environment
Roadside barriers	Presence of roadside barriers, for example w-beams and wire rope
Downstream depths adjacent to roadway	Height of road pavement above adjacent floodplain or river channel, indicative of the depth of floodwater at the flooded road section
Signage	Presence of flood-related signage, for example road subject to flooding, floodway, causeway and depth markers
Warning systems	Dynamic systems to alert motorists to a flooded road section for example fixed flashing light
Street lighting	Presence of fixed street lighting to illuminate flooded road section
Road pavement type	Road pavement type sealed or unsealed
Road grade	A measure of the incline of the roadway leading into the flooded road section
Speed	Speed restriction in force at flooded road section
Traffic volume	Qualitative estimation of traffic volume at time of assessment
Presence of downstream vegetation or obstacle	Presence of vegetation or obstacle on a floodplain or in a channel downstream of flooded road section that may block the passage of a floating vehicle
Ability for vehicle to turn around	Qualitative judgement of the ability for a driver to easily turn around in a sedan
Road alignment	Presence of a road bend directly before flooded section
Roadside markers	Presence of roadside marker to identify the edge of a flooded road section
Curb and guttering	Presence of roadside curb and guttering

TABLE 2: DESCRIPTIONS OF ROAD FLOOD RISK FACTORS ACCORDING TO THEIR INFLUENCE

FACTOR	DESCRIPTION
Factors that may influence a motorist to enter floodwater	
Absence of signage	Signage is aimed at informing motorists of the likely presence of water over a roadway
Road alignment	A tight bend in a roadway directly before a floodway may limit chances for a motorist to act in order to avoid entering floodwater
Road grade	The falling grade of a road may mean a motorist entering shallow water quickly progresses into much deeper water or that floodwater may be difficult to observe on approach. Such conditions may give a driver a false impression of the degree of flood risk
Road pavement	Gravel road surfaces are easier for a car to slide off the road
Lighting	Lighting of a roadway allows motorists to observe floodwater during evening hours
Traffic volume	Traffic volume controls the number of motorists at risk to entering floodwater whist travelling a specific road section. Large volumes of traffic may also hinder the ability of a motorist to turn a vehicle around
Speed limit	Speed limit may influence the speed a motorist was travelling whilst observing signage and the time for reflection prior to entering floodwaters. It will also influence the ability of a vehicle to safely stop before reaching floodwater
Ease of turning around	The width and lane structure of a road (i.e. one way or two way) influences the ability of a motorist to turn a vehicle around
Factors that influenced whether a vehicle was washed or driven from road	
Depth and velocity of floodwaters	Greater depth and flow velocities of floodwaters increase the likelihood of a vehicle being washed from a road
Rate of rise (catchment size)	Fast rates of rise are associated with smaller catchment sizes, dynamic flood conditions and short warning times
Presence of roadside barriers	Roadside barricades provide protection against a motorist leaving a roadway
Curb and guttering	Curb and guttering provide some degree of protection against a motorist leaving a roadway
Distance water was over the road	Water covering a long distance of a roadway may result in motorists becoming disorientated
Type of vehicle	Smaller vehicles are at greater risk of being washed from roadways
Factors that may influence survivability of motorists once washed or driven from the road	
Rate of rise (catchment size)	Fast rising floodwaters may limit the ability of a vehicle occupants to escape
Flood depths downstream	Vehicles will sink in deep floodwaters
Downstream flood velocities	Fast flowing floodwaters may rapidly sweep a vehicle downstream

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HAZARD **NOTE**

bushfire&natural HAZARDS CRC

ISSUE 82 SEPTEMBER 2020

TOPICS IN THIS EDITION | COMMUNITIES | EMERGENCY MANAGEMENT | RESILIENCE

PROMOTING FIRE-FITNESS: A PROACTIVE APPROACH TO ENHANCING PREPAREDNESS

ABOUT THIS PROJECT

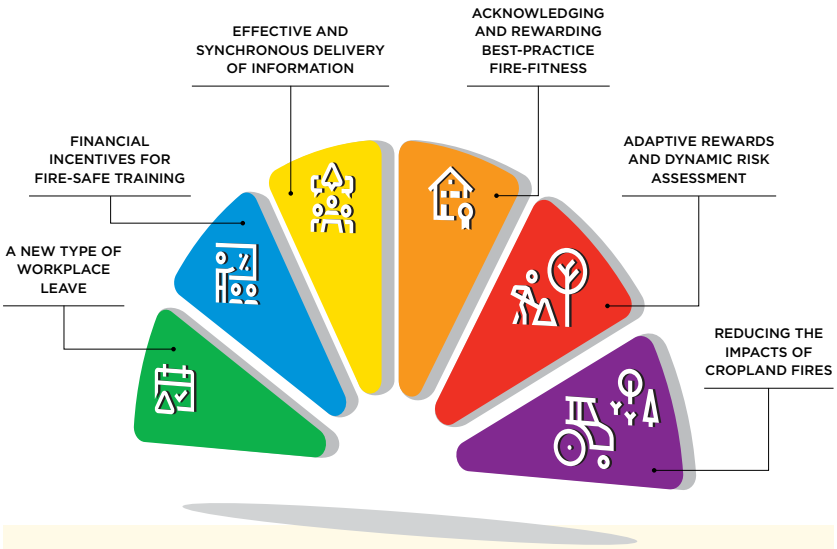
This research was conducted as a PhD study *Advancing public health in the context of natural hazards: normalising preparedness within a framework of adapted protection motivation theory*, under the broader CRC project *Managing animals in disasters*.

AUTHORS

Dr Rachel Westcott, Western Sydney University; Engine Room Solutions Pty Ltd. Contact rachel@engineroomsolutions.com.au

SUMMARY

This research proposes practical processes and new public health policy to assist people to safely negotiate natural hazards in an increasingly climate change affected environment. This is achieved by normalising preparedness – to make fire-fitness routine and commonplace. With data gathered from a diverse regional community in South Australia, this research adapted Protection Motivation Theory to identify strategies that facilitate beneficial outcomes for individuals and communities. This research recommends that the application of fire-fitness principles should be tailored and societal-wide, to help narrow the gap between awareness and action, promote public safety and well-being, and identify topics requiring further research.



FIRE-FITNESS

Processes by which natural hazard preparedness is normalised amongst individuals, families or communities. This precedes preparedness messaging, leading to timely and safe decision-making. While the name refers to fire, the concept is applicable across natural hazards.

CONTEXT

Research shows that many people in high risk natural hazard areas are often not sufficiently prepared or not personalising the risk to themselves. Proactive strategies designed to normalise preparedness need to be developed and evaluated to help save lives (of humans, companion or recreational animals, livestock and wildlife) in a bushfire.

BACKGROUND

Protection Motivation Theory (PMT) describes how individuals are motivated to react in a protective way towards a perceived threat. The mismatch between people's awareness of a hazard threat and their readiness to manage the threat or treat the risk – known as the awareness-preparedness gap – is widely acknowledged as persistently too large. While the gap remains, human morbidity and mortality in bushfire (and other) natural hazards will not be significantly reduced; people will continue to make dangerous decisions, thereby perpetuating a cycle of negative outcomes and ramifications.

Previous studies have contributed to addressing this problem, but none have identified the need to establish fire-fitness– a year-round normalised culture of disaster preparedness that precedes natural hazards and therefore mitigates damage.

BUSHFIRE AND NATURAL HAZARDS CRC RESEARCH

Consistent with other CRC research, this study recognises the importance of animals in the lives of their owners and communities when faced with a natural hazard – whether companion, assistance, livestock, sport or recreational animals, or wildlife. Data were gathered from two demographically diverse groups – animal owners and emergency responders – in Lower Eyre Peninsula (South Australia) between June and August 2015 (eight focus groups, n=72; 32 individual

interviews). Participants in each group were asked about their perceptions of each other's natural hazard preparedness and response, barriers to good decision making, and what information they needed to help them make safe decisions and improve their preparedness. The results were analysed using Thematic Analysis and actively identified a number of relevant and widely applicable strategies that can be used to save lives.

RESEARCH FINDINGS

Findings were grouped into six categories of possible strategies and proactive public policies that could be developed, each aiming to make preparedness as routine as buying the groceries or fuelling a car. These strategies are not intended to replace preparedness campaigns. Rather, they are designed to change the preparedness environment by establishing a preceding culture of fire-fitness as a routine social norm – to develop a prescient suite of lifestyle adaptations to confront the new reality of extreme weather events.

These strategies are:

- A new type of workplace leave, for example, Catastrophic/Code Red day or Extreme fire weather leave.
- Financial incentives, for example, a discount on municipal rates for attendance at fire-safe seminars.
- Effective and synchronous delivery of information, for example, information delivered at the same time to different members of a family via workplace, school and social settings.
- Acknowledging and rewarding best-practice fire-fitness, for example, accreditation for best-prepared properties (which has the potential to positively influence market price of those properties).
- Adaptive rewards and dynamic risk assessment, for example, facilitating trust and positive relationships with local fire authorities by clearing rubbish and vegetation to ensure ease of access.
- Reducing the impacts of cropland fires through, for example, review of the use of firebreaks, crop types, crop placement and planting around assets.

Each of these strategies contributes to cultivating a culture of preparedness over the short-, medium- and/or long-term. Importantly, a fire-fitness program for any given group must be locally relevant and tailored to the particular community.

HOW COULD THIS RESEARCH BE USED?

Considering the damage of the 2019/20 bushfire season and the predicted increase in frequency and severity of extreme weather events, and the fact that Australia's bushfire seasons are becoming longer and more severe, this research can significantly contribute to reinvigorated conversations that recognise the importance of mitigation through prevention and preparedness.

The recommendations from this research are readily achievable. Local advocacy and pilot programs would be a logical first step.

While these strategies are able to be adopted and implemented quickly, they will promote and achieve medium- to longer-term changes in the public's level of improved fire-fitness and also in the perception among the wider population of the need to adapt to a worsening natural hazard environment.

FUTURE DIRECTIONS

The next stage of the research is utilisation, with outreach underway to attract participant organisations to trial and evaluate some of the fire-fitness strategies. This will involve community consultation and design of bespoke fire-fitness programs. Early trials aim to be completed and reported within the next two years.

Given the fires in South Australia in 2019/20, an agricultural application of fire-fitness programs will focus on croplands and cropland fires – specifically the use of firebreaks, crop type and placement and planting around assets.

END-USER STATEMENT

"Prevention and preparedness is where we as a community have traditionally been poor. Actions to build this will assist the response agencies by reducing the workload at the time and more importantly reduce the amount of recovery that is required within the community after the event. An increase in preparedness activities is a major step in building the resilience of a community and a resilient or prepared community is the outcome that all participants in emergency management aim to support."
Senior Sergeant First Class Russell Dippy CStJ LEM, Emergency Management Coordinator, South Australia Police

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HAZARD **NOTE**

bushfire&natural HAZARDS CRC

ISSUE 81 SEPTEMBER 2020

TOPICS IN THIS EDITION | COMMUNICATION | COMMUNITIES | WARNINGS

EMERGENCY WARNING MESSAGES: DO COLOURS AND ICONS IMPROVE COMMUNITY READINESS TO ACT?

ABOUT THIS PROJECT

This is the third of three concurrent *Hazard Notes* for the Bushfire and Natural Hazards CRC project, Creating effective multi-channel communication during disaster response and recovery, conducted as part of the Communication and Warnings cluster. This research adopts a multi-hazards approach to examine the effectiveness of response and recovery communication in communities affected by natural hazards. It applies well-established risk communications and psychological theory of human behaviour to determine whether existing emergency messages could be revised to improve comprehension.

This *Hazard Note* explores whether colours and icons help to encourage action during emergencies. *Hazard Note 79* outlines opportunities for emergency services to improve their communication and messaging. *Hazard Note 80* details which types of specific messages encourage community readiness.

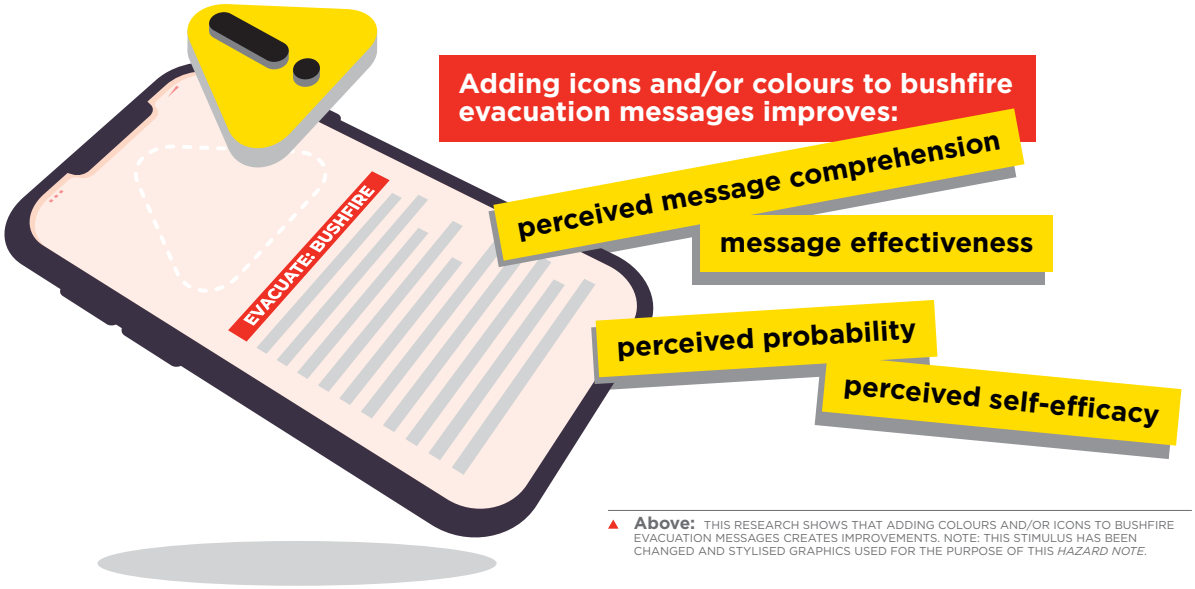
AUTHORS

A/Prof Dominique Greer, Dr Paula Dootson, Dr Sophie Miller and Prof Vivienne Tippett, Queensland University of Technology. Contact dominique.greer@qut.edu.au

SUMMARY

Current Australian emergency warning messages, that have been refined to match evidence-based practice, strongly encourage community members' readiness to act on emergency instructions (see *Hazard Note 80*). Assuming that the written elements of warning messages are already optimised to encourage readiness to act, this research draws on a socio-psychological model of precautionary adaption to examine the effect of adding icons and/or colours to official warnings for bushfire and flood.

The results show that adding colours and/or icons to a bushfire evacuation message creates improvements, albeit small ones, in perceived message comprehension, message effectiveness, perceived probability and perceived self-efficacy. Messages for riverine floods, as well as preparatory bushfire messages, showed no change in message comprehension, effectiveness, threat appraisal, or coping appraisal as a result of adding colours and/or icons. However, as these message design elements increase rapid recognition of a hazard warning and encourage protective action, these redundant message elements may aid interpretation of more poorly worded emergency warning messages in times of stress.



Above: THIS RESEARCH SHOWS THAT ADDING COLOURS AND/OR ICONS TO BUSHFIRE EVACUATION MESSAGES CREATES IMPROVEMENTS. NOTE: THIS STIMULUS HAS BEEN CHANGED AND STYLISED GRAPHICS USED FOR THE PURPOSE OF THIS *HAZARD NOTE*.

CONTEXT

Since 2014, emergency service agencies across Australia have adopted a range of evidence-based practice when constructing emergency warning messages. As the written elements of warning messages are working well to encourage readiness to act (Greer et al. 2019; see *Hazard Note 80*), this research examines the effect of adding colour and/or icons to official warning messages.

BACKGROUND

Emergency warning messages aim to capture attention, aid understanding and communicate risk. Both national and international bodies (e.g. the International Organization for Standardization; ISO) have developed generic warning design guidelines that incorporate elements such as colour (e.g. red, orange), icons (e.g. pictures) and signal words (e.g. WARNING) to increase the salience of a warning (Wogalter et al. 2015; Wogalter et al. 2006). These design elements are intended to improve community safety through rapid recognition of the hazard warning (Wogalter et al. 2015; Wogalter et al. 2006) and encourage appropriate protective actions to be taken (Braun & Silver 1995).

Examining the impact of adding colours and/or icons to Australian warning messages for natural hazards is critical because these design elements are (i) ubiquitous in society, (ii) powerful ways to communicate and aid the interpretation of warning information, and (iii) may be proposed as part of a national multi-hazard warning system in Australia.

This research draws on a socio-psychological model of precautionary adaption (Grothmann & Reusswig 2006) underpinned by Protective Motivation Theory (PMT; Rogers 1975, 1983; Rogers & Prentice-Dunn 1997) to investigate whether adding colours and/or icons to emergency warning messages encourages even higher levels of readiness to act on emergency instructions.

BUSHFIRE AND NATURAL HAZARDS CRC RESEARCH

To examine whether current emergency warning messages can be further optimised with colours and/or icons to encourage community members' readiness to act on emergency instructions, researchers conducted a survey of 2,482 Australians living across all states and territories during November 2019. Participants read one of 16 mock emergency warnings (see Figure 2, page four), about either a bushfire or a riverine flood, that were variously presented without icons, with icons, in greyscale and in colour (see Figure 1, page three).

The 16 mock emergency warnings comprised variations of a *Prepare to Evacuate (Bushfire)* message, a Prepare to *Evacuate (Flood)* message, an *Evacuate Now (Bushfire)* message, and an *Evacuate Now (Flood)* message. Messages contained either a grey header strip only, a coloured header strip only, a grey header strip and hazard icon, or a coloured header strip and hazard icon. The *Prepare to Evacuate* messages contained orange header strips and icons, while the *Evacuate Now* messages contained red header strips and icons. The icons, which depicted a flame or flooded house, were developed for this research.

Mock emergency warnings not attributed to any particular emergency service were developed using examples of real emergency warnings issued by emergency services to improve realism and maximise the usefulness of the findings. Sample warnings were provided by Country Fire Service (SA), Department of Fire and Emergency Services (WA), Metropolitan Fire Brigade (VIC, now Fire and Rescue Victoria), Metropolitan Fire Service (SA), NSW State Emergency Service (SES), Tasmania SES, Victoria SES, and Queensland Fire and Emergency Services.

The survey captured each participant's demographic characteristics, message comprehension and effectiveness, threat appraisal (i.e. perceived probability and severity of event) and coping appraisal (i.e. perceived self-efficacy, protective response efficacy and protective response cost). Data were analysed using two-way between-groups analyses of variance (ANOVAs).

RESEARCH FINDINGS

The results show that adding colours and/or icons to the *Evacuate Now (Bushfire)* message creates small improvements in perceived message comprehension, perceived message effectiveness, perceived probability and perceived self-efficacy. This is perhaps unsurprising given that this message is likely considered the most 'threatening' of the set. While these improvements are small from a statistical standpoint, the effect small changes can have at a population level are likely impactful, especially when message improvements can save lives, properties and reduce harm. The other three types of messages [*Prepare to Evacuate (Bushfire), Prepare to Evacuate (Flood)* and *Evacuate Now (Flood)*] showed no change in message comprehension, effectiveness, threat appraisal or coping appraisal as a result of adding colours and/or icons.

The results highlight three key findings:

First, they demonstrate that a red header serves as a significant cue to assist community members to perceive, interpret and respond to warning messages appropriately. The red header increases the perceived probability that the recipient will be exposed to the hazard, but also increases their perception of their own ability to cope with the event. This finding aligns with previous research that shows that red-danger pairings obtain the highest hazard risk ratings (e.g. Braun & Silver 1995; Chapanis 1994; Ng & Chan, 2018). Interestingly, adding orange headers to the *Prepare to Evacuate (Flood or Bushfire)* messages does not result in any significant change in message comprehension, effectiveness, threat appraisal or coping appraisal. This may be because the colour is a redundant cue at this level of threat.

Second, the results demonstrate that the communicative role of icons in warning

END-USER STATEMENT

"As QFES implements evidence-based emergency warning message design, it is important to understand how community members perceive and respond to updated warning messages. This research by Greer, Dootson, Miller and Tippett provides several findings that affirm our current practice and provide some direction for the future.

"Firstly, it is useful to know that warning messages similar to ours are perceived to be highly comprehensible and effective. We will continue to include instructions to the community that they perceive to be easily undertaken, protective, and low in cost (i.e., time, money and effort).

"Secondly, it is valuable to understand the impact of warning colours and icons on how community members interpret warning messages. Looking ahead, QFES will draw on this research and use colour more prominently to enforce warning levels and severity. Our messages will continue to be reviewed in light of these findings to continue encouraging protective action in the community."

Hayley Gillespie (Executive Manager, Media), Queensland Fire and Emergency Services

messages is less clear. Although icons can be used to clarify, illustrate and supplement written information, they did not appear to create any significant change in message comprehension, effectiveness, threat appraisal or coping appraisal, with one exception. In the *Evacuate Now (Bushfire)* message, risk probability was perceived differently when colour and icons were combined. When this message was presented in greyscale, the addition of an icon reduced the perceived probability that the recipient would be affected by the event. This result suggests that deeper investigation is needed into the role that icons play in signalling risk probability when they are not presented in colour.

Finally, these research findings highlight an interesting future research opportunity to investigate the impact of colour and/or icons on less optimised messages. Although colour and/or icons appear to have little impact on optimal warning messages, they might be more useful to aid interpretation of more poorly worded emergency warning messages if they reduce uncertainty.

In conclusion, the results show that adding colours and coloured icons to a bushfire evacuation message creates improvements, albeit small ones, in perceived message comprehension, message effectiveness, perceived probability and perceived self-efficacy. However, messages for riverine floods, as well as preparatory bushfire messages, showed no change in message comprehension, effectiveness, threat appraisal or coping appraisal as a result of adding colours and/or icons. However, as these message design elements increase rapid recognition of a hazard warning and encourage protective action, these redundant message elements may aid interpretation of more poorly worded emergency warning messages in times of stress.

HOW IS THE RESEARCH BEING USED?

By adopting current evidence-based practice, Australian emergency service agencies have created effective emergency warnings that encourage readiness to act and may be incrementally improved with colour and icons. This research complements the increasing industry interest in developing a national multi-hazard warning system, including colours and icons, that can promote clear understanding of warnings and appropriate protective action across Australia.

▲ **Figure 1:** EXAMPLE MOCK WARNING GRAPHICS, IN COLOUR.

FURTHER READING

Dootson P, Greer D, Tippett V & Miller S (2020) Addressing conflicting cues during natural hazards: lessons from emergency agencies, *Hazard Note 72*, Bushfire and Natural Hazards CRC, Melbourne, available at www.bnhcrc.com.au/hazardnotes/72

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EVACUATE NOW

Fire services advise there is a bushfire approaching your local area.

Follow your bushfire survival plan now. If you do not have a plan, your safest option is to **leave immediately** if it is clear to do so. If you cannot leave, **identify where you will seek shelter** from the bushfire. If you are not in the area, **do not return**, as conditions are too dangerous.

Fire crews are working to contain the fire but firefighters may not be able to protect every property. You should not expect a firefighter at your door. Power, water, and mobile phone service may be lost.

People in the area will be affected by smoke, which will reduce visibility and air quality.

An evacuation centre has been opened at the local community centre.

Call Triple Zero (000) immediately if you believe you are under threat.

How to Evacuate:

- If the way is clear, leave now for a safer place.
- Check for road closures and then advise family and friends of your intended travel route.
- Put on protective clothing (e.g., a long-sleeved cotton shirt, boots with thick soles).
- Take the items you need to be away from home for three days. Include clothing, medications, important documents (e.g., passports, birth certificates), food and water, and personal care essentials like nappies.
- Secure your pets for safe transport.
- Drive with caution in low-visibility conditions.
- Drink plenty of water to stay hydrated.
- Listen to your local radio station or visit the Rural Fire Service (RFS) website for regular updates.
- If you cannot leave, you need to get ready to shelter in your home and actively defend it.
- If your home catches on fire and the conditions inside become unbearable, you need to get out and go to an area that has already been burnt.

Keep up to Date:

- Following EMS on Facebook (@EmergencyManagementService) and Twitter (@AusEMS)
- Staying tuned to your local radio station. Find your local ABC radio station at https://radio.abc.net.au/help/offline and your local commercial radio station at http://www.commercialradio.com.au/find-a-station/queensland
- Visiting the EMS website at www.emsfire.gov.au/maps
- For bushfire preparation tips, visit the EMS website at www.emsfire.gov.au/bushfiresafety
- For information about road closures, call 13 55 77 or visit www.traffic.gov.au

▲ **Figure 2:** ONE OF THE MOCK EMERGENCY WARNINGS GIVEN TO PARTICIPANTS. THIS IS THE EVACUATE NOW – BUSHFIRE WARNING.

The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

Hazard Notes are prepared from available research at the time of publication to encourage discussion and debate. The contents of *Hazard Notes* do not necessarily represent the views, policies, practises or positions of any of the individual agencies or organisations who are stakeholders of the Bushfire and Natural Hazards CRC.

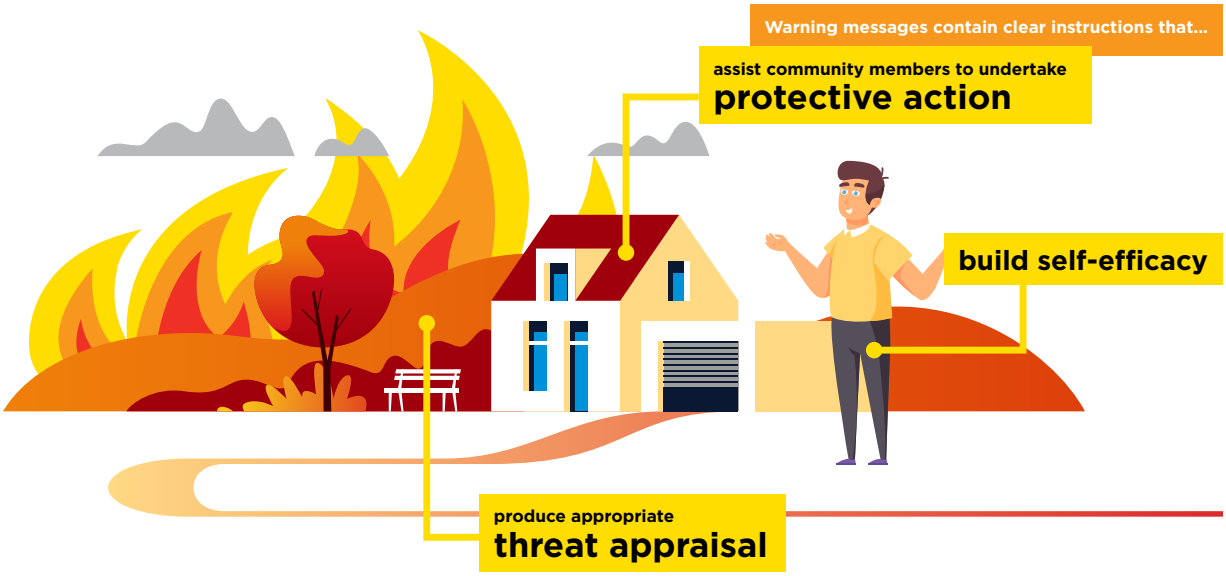
HAZARD **NOTE**

bushfire&natural HAZARDS CRC

ISSUE 80 SEPTEMBER 2020

TOPICS IN THIS EDITION | COMMUNICATION | COMMUNITIES | WARNINGS

EMERGENCY WARNING MESSAGES: ENCOURAGING READINESS TO ACT



ABOUT THIS PROJECT

This is the second of three concurrent *Hazard Notes* for the Bushfire and Natural Hazards CRC project, *Creating effective multi-channel communication during disaster response and recovery*, conducted as part of the Communication and Warnings cluster. This research adopts a multi-hazards approach to examine the effectiveness of response and recovery communication in communities affected by natural hazards. It applies well-established risk communications and psychological theory of human behaviour to determine whether existing emergency messages could be revised to improve comprehension.

This *Hazard Note* details which types of specific messages encourage community readiness. *Hazard Note 79* outlines opportunities for emergency services to improve their communication and messaging. *Hazard Note 81* explores whether icons and graphics help to encourage action during emergencies.

AUTHORS

A/Prof Dominique Greer, Dr Paula Dootson, Dr Sophie Miller and Prof Vivienne Tippett, Queensland University of Technology. Contact dominique.greer@qut.edu.au

SUMMARY

In the six years since the *National Review of Warnings and Information* (Emergency Management Victoria 2014), Australian emergency service agencies have proactively adopted evidence-based practice to better construct their emergency warning messages. This research investigates how well current emergency warning messages, which have been optimised to match current best practice, encourage community members' readiness to act on emergency instructions.

Four types of warning messages were analysed: *Prepare to Evacuate (Bushfire)*, *Prepare to Evacuate (Flood)*, *Evacuate Now (Bushfire)* and *Evacuate Now (Flood)*. This research, conducted between September and October 2018, suggests that these warning types encourage appropriate protective action and thus readiness to act. They were found to be highly comprehensible and effective, provoke a moderate and appropriate threat appraisal, and contain instructions that participants perceived (i) they could execute well, (ii) would be highly protective and (iii) were low in cost (e.g. expense, difficulty, inconvenience). However, messages that contain higher perceived response costs, such as instructions that require financial expense, difficulty, or inconvenience to execute, are more likely to result in maladaptive coping such as denial, wishful thinking or fatalism.

HAZARD **NOTE**

CONTEXT

Since the *National Review of Warnings and Information* was published in 2014, emergency service agencies across Australia have iteratively redesigned their warning messages to incorporate evidence-based good practice in the construction of emergency warning messages. After five years of development and refinement, it is prudent to investigate whether the instructions included in current warning messages encourage readiness to act. This research draws on a socio-psychological model of precautionary adaption (Grothmann & Reusswig 2006), underpinned by Protective Motivation Theory (PMT; Rogers & Prentice-Dunn 1997; Rogers 1975, 1983) to investigate how well current emergency warning messages encourage community members' readiness to act on emergency instructions. More specifically, it investigates whether the written content of emergency warnings generate appropriate threat appraisal, coping appraisal and protective motivation.

BACKGROUND

Natural hazards provoke considerable uncertainty in the community, but community members sometimes 'under-react' when warned about imminent natural hazards. Consequently, it is critical to investigate how warning messages can best generate an appropriate behavioural response. One key model that explains the motivation of community members to engage in protective action is Protection Motivation Theory (Prentice-Dunn & Rogers 1986; Rogers 1983).

Protection Motivation Theory proposes that individuals will engage in protective behaviour in accordance with:

- the perceived severity of the threat they face
- their vulnerability to the threat
- the perceived effectiveness of the protective behaviour proposed by the emergency service agency and
- their perceived self-efficacy (or ability) to engage in protective behaviour.

Clear, specific and consistent instructions are most likely to arouse a threat appraisal but also build self-efficacy, which in turn assists community members to undertake protective action. High perceived response costs, such as expense, difficulty or inconvenience, are more likely to result in maladaptive coping such as denial, wishful thinking or fatalism.

This research investigates how well current emergency warning messages encourage community members' readiness to act on emergency instructions by investigating whether their written content generates appropriate threat appraisal, coping appraisal, and protective motivation.

BUSHFIRE AND NATURAL HAZARDS CRC RESEARCH

To examine whether current emergency warning messages generate appropriate threat appraisal, coping appraisal and protective motivation, researchers conducted a survey of 1,595 Australians living across all states and territories from September to October 2018. Participants read one of four mock emergency warnings (see Figure 1, page four), about either a bushfire or a riverine flood, and were then asked a series of questions relating to their protective motivations.

Mock emergency warnings not attributed to any particular emergency service were developed using examples of real emergency warnings issued by emergency services to improve realism and maximise the usefulness of the findings. Sample warnings were provided by Country Fire Service (SA), Department of Fire and Emergency Services (WA), Metropolitan Fire Brigade (VIC, now Fire and Rescue Victoria), Metropolitan Fire Service (SA), NSW State Emergency Service (SES), Tasmania SES, Victoria SES, and Queensland Fire and Emergency Services. The four mock emergency warnings comprised a *Prepare to Evacuate (Bushfire)* message, a *Prepare to Evacuate (Flood)* message, an *Evacuate Now (Bushfire)* message and an *Evacuate Now (Flood)* message.

▲ **Above:** THIS RESEARCH EXPLORED WHICH TYPES OF SPECIFIC MESSAGES ENCOURAGE COMMUNITY READINESS.

The survey captured each participant's demographic characteristics, message comprehension and effectiveness, threat appraisal (i.e. perceived probability and severity of event), coping appraisal (i.e. perceived self-efficacy, protective response efficacy and protective response cost), protection motivation, and maladaptive coping behaviour (i.e. fatalism, denial and wishful thinking).

RESEARCH FINDINGS

The results show that current warning messages encourage appropriate protective action and thus readiness to act. Current warning messages:

- are highly comprehensible and effective, with only marginal differences between the performance of bushfire and flood messages, and *Prepare to Evacuate* and *Evacuate Now* messages.
- provoke a moderate and appropriate threat appraisal (which comprises the perceived probability and perceived severity of the risk, as well as any fear it generates), again with only marginal differences between bushfire and flood messages, and *Prepare to Evacuate* and *Evacuate Now* messages.
- contain instructions that participants perceived (i) they could execute well (perceived self-efficacy), (ii) would be highly protective (protective response efficacy) and (iii) were low cost (response cost), again with only marginal differences between bushfire and flood messages, and *Prepare to Evacuate* and *Evacuate Now* messages.

Together, threat and coping appraisal accounted for nearly 60% of the variation in protection motivation, which demonstrates that emergency warning messages should aim to generate a moderate level of threat and also support appropriate coping behaviours in their instructions. Perceived response efficacy is most strongly associated with protection motivation.

While protection motivation is the most desirable outcome of a warning message, researchers also investigated the potential for three maladaptive coping responses: fatalism, denial and wishful thinking. Threat and coping appraisals accounted for just over 20% of the variation in fatalism, 34% of the variation in denial, and 15.7% of the variation in wishful thinking. Response cost has the strongest association with all three maladaptive coping responses, which suggests that reducing perceived response costs (in terms of the time, money or effort it takes to undertake suggested protective action) may reduce potential maladaptive responses.

These results show that the instructions contained in current warning messages do encourage readiness to act in the face of a bushfire and flood. Optimised emergency warning messages that contain clear instructions produce a moderate threat appraisal but also build self-efficacy, which assists community members to undertake protective action. Messages that contain higher perceived response costs, such as instructions that require financial expense, difficulty, or inconvenience to execute, are more likely to result in maladaptive coping such as denial, wishful thinking or fatalism.

HOW IS THIS RESEARCH BEING USED?

By adopting current evidence-based practice, Australian emergency service agencies have created effective emergency warnings that encourage readiness to act. Much of this good practice is currently shared across the emergency management sector and this research reinforces the effectiveness of this evidence-based approach. Further research could investigate additional mechanisms to encourage readiness to act on emergency instructions. Such mechanisms might involve adding design elements such as colour, icons or headers to emergency warning messages to improve their effectiveness (see *Hazard Note 81*). Given the strong performance of the message text, existing warning messages may now be effectively optimised for their ability to prompt behavioural intent.

END-USER STATEMENT

"VICSES and QUT have been collaborating on a range of risk communication research projects to ensure Victorians continue to receive high-quality information and warnings during emergencies. This project has examined the effectiveness of current warning messages and the extent to which individuals perceive risk and take action. The innovative research led by A/Prof Dominique Greer, in conjunction with the VICSES Communications and Community Resilience Directorate, has reaffirmed that VICSES warnings are highly effective when they contain clear instructions. The research findings will support VICSES to further refine its robust warnings doctrine and templates to ensure people can continue to make informed decisions, take action to protect their lives and property and avoid engaging in fatalism during emergencies. VICSES looks forward to continuing to work alongside QUT to ensure it can continue to deliver on its vision of 'safer communities – together'."

Jacob Riley, Senior Advisor, Readiness and Intelligence, Victoria State Emergency Service

FURTHER READING

Dootson P, Greer D, Tippett V & Miller S (2020) Addressing conflicting cues during natural hazards: lessons from emergency agencies, *Hazard Note 72*, Bushfire and Natural Hazards CRC, Melbourne, available at www.bnhcrc.com.au/hazardnotes/72

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Grothmann T & Reusswig F (2006) People at risk of flooding: why some residents take precautionary action while others do not. *Natural Hazards, 38*, pp.101-120. DOI: 10.1007/s11069-005-8604-6

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SAMPLE WARNING USED IN THE RESEARCH

EVACUATE NOW
Fire services advise there is a bushfire approaching your local area.

Follow your bushfire survival plan now. If you do not have a plan, your safest option is to **leave immediately** if it is clear to do so. If you cannot leave, **identify where you will seek shelter** from the bushfire. If you are not in the area, **do not return**, as conditions are too dangerous.

Fire crews are working to contain the fire but firefighters may not be able to protect every property. You should not expect a firefighter at your door. Power, water, and mobile phone service may be lost.

People in the area will be affected by smoke, which will reduce visibility and air quality.

An evacuation centre has been opened at the local community centre.

Call Triple Zero (000) immediately if you believe you are under threat.

How to Evacuate:
- If the way is clear, leave now for a safer place.
- Check for road closures and then advise family and friends of your intended travel route.
- Put on protective clothing (e.g., a long-sleeved cotton shirt, boots with thick soles).
- Take the items you need to be away from home for three days.
- Include clothing, medications, important documents (e.g., passports, birth certificates), food and water, and personal care essentials like nappies.
- Secure your pets for safe transport.
- Drive with caution in low-visibility conditions.
- Drink plenty of water to stay hydrated.
- Listen to your local radio station or visit the Rural Fire Service (RFS) website for regular updates.
- If you cannot leave, you need to get ready to shelter in your home and actively defend it.
- If your home catches on fire and the conditions inside become unbearable, you need to get out and go to an area that has already been burnt.

Keep up to Date:
- Following EMS on Facebook (@EmergencyManagementService) and Twitter (@AusEMS)
- Staying tuned to your local radio station. Find your local ABC radio station at https://radio.abc.net.au/help/offline and your local commercial radio station at http://www.commercialradio.com.au/find-a-station/queensland
- Visiting the EMS website at www.emsfire.gov.au/maps
- For bushfire preparation tips, visit the EMS website at www.emsfire.gov.au/bushfiresafety
- For information about road closures, call 13 55 77 or visit www.traffic.gov.au

Note: This warning has been stylised for the purpose of this Hazard Note but the text and ordering of information is as used in the research.

Figure 1: ONE OF FOUR MOCK EMERGENCY WARNINGS USED IN THE RESEARCH.

The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

HAZARD **NOTE**

bushfire&natural HAZARDS CRC

ISSUE 79 SEPTEMBER 2020

TOPICS IN THIS EDITION | COMMUNICATION | COMMUNITIES | WARNINGS

EMERGENCY WARNING MESSAGES: HOW DO COMMUNITY MEMBERS COMPREHEND THEM?

ABOUT THIS PROJECT

This is the first of three concurrent *Hazard Notes* for the Bushfire and Natural Hazards CRC project, *Creating effective multi-channel communication during disaster response and recovery*, as part of the Communication and Warnings cluster. This research adopts a multi-hazards approach to examine the effectiveness of response and recovery communication in communities affected by natural hazards. It applies well-established risk communications and psychological theories of human behaviour to determine whether existing emergency messages could be revised to improve comprehension.

This *Hazard Note* outlines opportunities for emergency services agencies to improve their communication and messaging. *Hazard Note 80* details which types of specific messages encourage community readiness. *Hazard Note 81* explores whether icons and graphics help to encourage action during emergencies.

▲ **Above:** THIS RESEARCH IS HELPING EMERGENCY SERVICES IMPROVE COMMUNICATION MESSAGES. CREDIT: SOUTH AUSTRALIA STATE EMERGENCY SERVICE

AUTHORS

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SUMMARY

The negative impacts of natural hazards in Australia can be lessened by community members responding appropriately to emergency warning messages during disasters. Using case studies conducted in Queensland, New South Wales, Victoria and Western Australia in 2015, this research draws on a social psychological framework of information processing (Mileti 1995) to explore how emergency warning messages are comprehended by community members. By understanding how community members process information and reflect on their behavioural intentions, this research provides a means to enhance message design to ensure protective action can be undertaken.

This research shows that emergency services agencies can improve information processing by:

a. removing barriers to information and making information easy to access;
b. connecting with local community groups, including those on social media, to ensure the information is received;
c. using simple language that translates impact;
d. personalising messages by naming the affected location and using visuals;
e. improving readability through stylised messages and content ordering;
f. assuming no preparation, no hazard knowledge and no geographic knowledge, to appeal to the majority of the population;
g. understanding how time between updates can become an (unintended) signal of risk;
h. repeating instructions in escalated messages, i.e. assume that the community will not (or, in the case of warnings received via the radio, cannot) go back to check what they should have been doing prior to evacuating;
i. understanding that the presence of emergency responders can lead to over-reliance on these responders or optimism bias that the event is being handled, delaying community action; and
j. understanding that there is a tolerance for uncertainty in weather-related information.

HAZARD **NOTE**

CONTEXT

Australia experiences a broad range of natural hazards that can lead to loss of life, negative sustained impacts on community wellbeing, and up to $9 billion a year in economic expenses (Deloitte 2016). This significant impact can be lessened by individuals undertaking protective action for each hazard (Burns and Slovic 2012). However, for an individual to take protective action following the receipt of an emergency warning message, they first need to accurately comprehend the warning message they receive. This research examined how community members comprehend (and translate into action) emergency warning messages during the response phase of a natural hazard.

BACKGROUND

Even small changes in protective behaviours can make valuable impacts during disaster response (Lindell and Perry 2012). Mileti's (1995) social psychological framework of information processing can be used to understand how emergency warning messages are comprehended in order to drive protective behaviour. The framework suggests there are five stages of information processing: (1) hear, (2) understand, (3) believe, (4) personalise and (5) respond. This process is repeated for each emergency warning message an individual receives. By investigating how community members process information and reflect on their behavioural intentions, this research aims to enhance message design to ensure better protective action.

BUSHFIRE AND NATURAL HAZARDS CRC RESEARCH

To examine emergency warning message comprehension, 10 focus groups were conducted across seven urban and regional locations in Australia (Brisbane and Hervey Bay, Queensland; Kempsey, New South Wales; Melbourne and Dandenong, Victoria; Kalamunda and Busselton, Western Australia) from June to October 2015. In the focus groups, researchers tested how members of the community comprehended emergency warning messages about an imminent tsunami, severe storm, cyclone, storm surge, fire and flood, which were supplied by end-users as stimuli for discussion. More than 900 minutes of data were collected from 55 respondents across Australia.

RESEARCH FINDINGS

The findings present 10 opportunities for emergency services agencies when issuing warnings:

1 Remove barriers to information and make information easy to access

Community members do not always know where the exact information is that they need, and barriers to information can lead to abandonment of information seeking.

As most individuals seek to confirm information distributed by official or unofficial sources during an emergency, this research identified an opportunity to aggregate hazard information in one accessible place. Emergency warning messages can ask the community to remain informed, to check for road closures and consider public transport options. Aggregating this information reduces the barriers to confirming the information and taking protection action. Many emergency services agencies across Australia have already begun the aggregation process (see the South Australian Government Alert SA website, for example).

While aggregating all the key sources helps address the barriers of information seeking, emergency services can additionally direct people to the exact source of the information (e.g. using the exact URL in a message as opposed to providing a link to the homepage that requires recipients to dig for further information).

However, aggregating the information does not mean emergency services should stop using multiple channels to disseminate their messages. The use of multiple channels is consistent with emergency management policy in Australia and is valuable for a community with diverse needs. Multiple channels mean an individual has a greater opportunity to be exposed to the emergency warning message before and during an event.

Another barrier to information seeking is awareness around the SMS or app-based alerting systems that are available to the community. Increasing awareness about what systems are available to the community would encourage information access.

Opportunity
Emergency services agencies have an opportunity to remove any potential barriers to information seeking by (a) continuing to use multiple channels of communication that can then be aggregated in one easy-to-access location, (b) using direct URLs/links to the exact sources of further information and (c) raising awareness of local SMS alert systems available to the community.

2 Connect with local community groups, including those on social media, to ensure the information is received

Emergency services agencies may benefit from collaborating with local community groups on different social media sites that community members already use as their first point of reference to triangulate emergency information (e.g. dedicated Facebook pages).

Opportunity
Connect and build relationships with local community groups, including those on social media, prior to an event to ensure that, when an event hits, the groups are sharing accurate and timely information.

3 Simplify language and translate impact

Continuing to simplify the language used in emergency warning messages will assist with better comprehension of the messages. If the removal of some technical information is not possible, visuals can translate the location into something meaningful to the recipient, making it easier to comprehend the information. For instance, what damage would be expected from 150km/hr winds? Where exactly is the Wide Bay Burnett forecast district? Illustrating the impact helps inform protective action.

Findings also suggest that community members refer to past events to help them translate the impact described in emergency messages. However, there was variability in whether the past event the participant was referring to was similar to the current event. To improve the accuracy of community references to past events, emergency services agencies could use a specific event as an anchor to encourage more accurate risk assessments and subsequent behaviours.

Opportunity
Continuing to simplify the language used in emergency warning messages and translating the technical language into something meaningful for the community, will improve comprehension of the messages. Using past events as a reference point in the messages also helps to translate the technical language about the hazard, highlighting the potential consequences of the current event.

4 Personalise messages by naming the affected location and using visuals

Research shows that the community has a strong desire for visuals, including images of the hazard and relevant maps. Visuals are valuable in personalising the information presented in the emergency warning message. When a participant saw they were in the affected area on a map, they claimed they were more likely to read the whole message, rather than dismiss it.

Being able to personalise the risk presented in the message is not only valuable for attention to the message, but also effective in triggering action. Where visuals are not available, personalisation can be achieved by mentioning the affected location/s early in the message.

Messages that included visuals were considered more appealing, and easier to read. Visuals also have the potential to overcome limitations in geographic knowledge of the affected region and knowledge of how the hazard may track throughout an event. Moreover, using images to illustrate the impact of the hazard can overcome technical language barriers.

Opportunity
There is an opportunity for greater use of visuals and maps to overcome limitations in geographic knowledge, hazard knowledge, language barriers and other technical information. It also facilitates the personalisation of risk, which is required to trigger protection action.

5 Improve readability through stylised messages

Findings suggest that stylised messages – those using bolding, headings, colours and textboxes – are preferred over large chunks of text in an emergency warning message. Stylised messages aid message comprehension, enable content to be processed more quickly, and promote longer engagement with the message.

Opportunity
Emergency services should use styling tactics – bolding, headings, colours and textboxes – where possible and appropriate in warning messages to highlight important information, such as location and level of warning.

6 Assume no preparation, no hazard knowledge and no geographic knowledge, to appeal to the majority of the population

All emergency warning messages should assume the community has not completed preparation activities and has no knowledge of the hazard or the geography of the region. This structure of the message appeals to the majority of individuals. The message can then include a link to further information for those in the community who want tailored information to suit specific knowledge sets or requirements. For example, farmers may need specific information that the rest of the community doesn't need. Further, some members of the community need specific weather information from the Bureau of Meteorology regarding tides, which the majority of the community doesn't need.

Opportunity
All emergency warning messages should assume the community has not prepared for the event and should include instructions and direct links to preparation information. Also, agencies should craft messages to assume the recipient has no geographic or hazard knowledge.

7 Use time between updates to signal risk

Research suggests that the community is using time between updates to signal the severity of the event, which is an unintended outcome of including update times in messages. Emergency services could leverage this and actively use time to signal the severity of the event by having a short time between updates (e.g. 15 minutes or less) to signal a severe event, or stating a long time between updates (e.g. one hour) to signal a less severe event. Signalling the severity of the event can activate the community to seek further information or act on the message, depending on the instruction of the message.

Opportunity
Emergency services agencies can use time to signal the severity of the event by having a short time between updates (e.g. 15 minutes or less) to signal a severe event or stating a long time between updates (e.g. one hour) to signal a less severe event.

8 Repeat instructions in escalated messages, as the community cannot go back to check what they should have been doing prior to evacuating

Instructions presented on the radio need to be repeated for those who do not initially perceive a threat. Unlike a written warning, the individual cannot go back and read the instructions a second time. Repetition of instructions is also important in the evacuation order message, as it is difficult for an individual to go back and double check what instructions they were supposed to follow in the evacuation preparation stage.

Opportunity
Instructions should include consistent and still-relevant instructions repeated across all messages during an event. Instructions should not build on one another as the event escalates, as it is not easy for individuals to go back and check what they should have done at an earlier event stage.

9 Exercise caution when mentioning the presence of emergency responders, as this can lead to over-reliance on emergency services or optimism bias that the event is being handled, delaying protective action

Mentioning the presence of emergency responders (e.g. fire trucks, swift water rescue teams) appears to have unintended consequences for community perceptions of risk. Knowing there are responders around makes the community feel overconfident that the situation is being handled and could suggest that help is available if they delay enacting their emergency preparedness plans, including evacuation. Mentioning the presence or absence of responders should be done so with caution.

Opportunity
Emergency services should disclose the presence of emergency responders with caution as it can lead to overconfidence in, or over-reliance on, support from emergency services during an event.

10 Acknowledge the tolerance for uncertainty in warning information

The findings suggest that, contrary to popular belief, participants preferred to receive information and have an event not eventuate than not receive information

to act when an event occurs. The balance between under-warning to avoid message fatigue and over-warning to avoid crying wolf is complicated. While the results in these focus groups are not generalisable to the entire population, they signal a tolerance for uncertainty in predictions.

Recommendation
The amount of information shared by an emergency service agency during an event is at the discretion of that agency, bearing in mind individuals do have a tolerance for uncertainty in weather events.

HOW IS THIS RESEARCH BEING USED?

By adopting current evidence-based practice, Australian emergency service agencies continue to create and refine effective emergency warnings that encourage readiness to act. Good practice exists across the sector and this research has supported broader initiatives in emergency communications and warnings, not just for individual organisations, but also at the national level by providing reviews and assisting with the development of evidence-based warning doctrine. Agencies now have an evidence base for continued changes to warnings so that they better meet community needs. One example of this impact is a guideline – called *Warning Message Construction: choosing your words* – published in 2019 as part of the Australian Institute of Disaster Resilience Handbook Collection.

FUTURE DIRECTIONS

This research identifies 10 opportunities to continue to refine emergency warning messages in Australia. By exploring the effectiveness and efficiency of official emergency warning messages in the response and recovery phases, this research aims to promote both community and end-user understanding of the psychological motivators for maximising engagement with emergency instructions. The findings from this research offer a number of contributions that align with recommendations from the National Review of Warnings and Information.

Primarily, this research adds to the gap in sector knowledge on designing warnings that are capable of interrupting the lives of busy Australians to ensure they protect themselves from imminent natural hazards.

This research also has the potential to contribute an evidence base to conversations around nationally consistent warning frameworks.

Finally, the findings provide empirical evidence for developing a congruent warnings framework across all hazards.

END-USER STATEMENT

"This research is a really important piece of the puzzle. It is a game-changer for us as we had been sending out information and warnings in a format that met the needs of the emergency services. This research tips the process on its head and puts the community first and foremost. Emergency services are forming warning messages with the community in mind, so we can get the best possible response from the community in a time of disaster."
Anthony Clark, Director Corporate Communications, NSW Rural Fire Service

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The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

HAZARD **NOTE**

bushfire&natural HAZARDSCRC

ISSUE 72 APRIL 2020
TOPICS IN THIS EDITION | COMMUNICATION | COMMUNITIES | WARNINGS

ADDRESSING CONFLICTING CUES DURING NATURAL HAZARDS: LESSONS FROM EMERGENCY AGENCIES

ABOUT THIS PROJECT

This study forms part of the *Effective risk and warning communication during natural hazards* project, applying well-established risk communications and psychological theory of human behaviour to examine the effectiveness of response and recovery communication in communities affected by natural hazards.

AUTHORS

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▲ Above: THIS RESEARCH OFFERS STRATEGIES THAT EMERGENCY AGENCIES COULD USE TO MINIMISE THE NEGATIVE EFFECT OF CONFLICTING INFORMATION DURING A NATURAL HAZARD. PHOTOS: BUSHFIRE AND NATURAL HAZARDS CRC.

SUMMARY

Australia's emergency services agencies face immense challenges when responding to natural hazards, including the challenge of conflicting cues. In *Hazard Note* 59 (Dootson *et al.*, 2019) evidence was provided for the impact of conflicting cues on protective action intentions in the Australian context. This next phase of research explores strategies that might mitigate the negative effects of conflict between emergency warning instructions and socio-environmental cues to encourage protective action. A sample of 11 end-user representatives from Australian emergency services agencies were invited to participate in an interview. Participants worked in, or closely with, communications or public information teams. Representatives comprised of participants from New South Wales, Victoria, Western Australia, South Australia, Queensland and Tasmania.

Results show that conflicting cues do exist in practice, and while a lot of these conflicting cues are outside of agency control, there are strategies that agencies can employ to minimise the creation and extent of conflicting cues that are present during a natural hazard.

These strategies may be one of two categories. The first is **proactive strategies**, such as provision of public information and warnings training for media, volunteers, staff and stakeholders, together with formal partnerships with stakeholders to coordinate messaging, generating content to meet real-time media and community needs to inform protective action decision making, and cross-jurisdictional deployments.

The second is **reactive strategies**, such as dedicated monitoring online (e.g. social media platforms) and offline (e.g. town halls, radio) roles during events, embedding the agency in community groups, using technological solutions for warning design, and verifying visuals.

This research offers lessons from emergency services agencies about what works to minimise the negative effects of conflicting cues during a natural hazard.

CONTEXT

This project responds to the concern that people do not always act in a timely or appropriate way in response to official warnings about natural hazards. Many will tend to verify official warnings with other sources, which are sometimes in conflict with the instruction the lead agency is issuing. These conflicting cues exacerbate the largely unintentional noncompliance with emergency warning instructions.

BACKGROUND

Public information is as much a frontline job as the operational responders.

- (Interviewee D paraphrased)

As discussed in detail in *Hazard Note* 59, emergency services agencies face the ongoing challenge of encouraging people to take protective action during a natural hazard. In addition to the inherent uncertainty of a natural hazard, emergency services agencies are not the only source of information the public uses when

considering how to respond. When the community perceives that social cues, such as what is being shared by the media, and environmental cues, such as the weather outside, are in conflict with the formal instruction agencies are issuing, it creates uncertainty about the right action to take and the perceived urgency of when to do it. Previous research found that conflicting cues have an impact on how the community might respond during a natural hazard (Dootson *et al.*, 2019). This *Hazard Note* explores strategies that agencies could employ to minimise the effect of conflicting cues on the instigation of protective action.

RESEARCH FINDINGS

EVIDENCE OF CONFLICTING CUES IN PRACTICE

The participants verified that there was evidence of conflicting cues, specifically conflict between the instruction being issued by the lead agency and socio-environmental (weather, media, unofficial organisation and peers) cues. The participants also identified an additional source of conflict – when the lead agency issued conflicting instructions to a community or when the warning language itself was in conflict with the specific instruction. Examples are provided in the table on the following page.

STRATEGIES TO MINIMISE THE IMPACT OF CONFLICTING CUES

The issue of conflicting cues was present for all agencies to varying degrees. A review of all interviews suggests that agencies with formal strategies or policies in place, to proactively or quickly react to conflicting cues, were better placed to mitigate the negative impact of conflicting cues present in an event.

PROACTIVE STRATEGIES

Training for media, volunteers, staff and stakeholders

Volunteers and other staff rely on training to equip them to respond during an event. However, interviewees identified three clear challenges with the current training approach. First, pre-season training can mean that attendees have forgotten the content by the time an event comes around. The second challenge occurs during large scale events, where staff may end up working in an area that is not directly related to what they were trained in, or stakeholder agencies not trained in a specific area step in to assist with support tasks.

Opportunity: Consider designing in-situ (on-the-job) training for volunteers, staff, or other stakeholders who are tasked with roles that require updated or refreshed training (e.g. writing warnings), as not everyone adopting that role has the same level of experience.

The third challenge was the different training approaches for fire compared to other natural hazards. There are clear distinctions between how conflicting cues are managed across fire and wet weather (flood, cyclone, storm) hazards. While most agencies have protocols in place for emergency broadcasting, more specialised training is offered to the media for fire than wet weather hazards – for which there is almost no formalised training. Participants suggested this could be why we see visuals of journalists reporting from wet weather events and not from dangerous fire grounds. This could implicitly signal that wet weather events are less severe than fire events and possibly trigger public imitation, where other people think it is ok to go outside to watch the cyclone or flood.

Opportunity: Agencies could explore replicating the comprehensive training and procedures for media reporting in fire events for other weather events (including flooding and cyclone), as training, policies and procedures in the fire context appear beneficial for curbing non-compliant behaviour during an event (i.e. being in locations against agency instructions or sharing content in conflict with agency instructions).

Formal partnerships with stakeholders to coordinate messaging

Most agencies have formal arrangements in place to involve certain agencies or media in their incident control centre. However, some are supported by more efficient processes than others to ensure a coordinated response in key talking points, incorporating additional insights for public information, and feeding media with timely content to design-out opportunities for media to get in harm's way to get footage of the event. Where formal partnerships were not in place, interviewees explained they would reactively contact the media outlet or community group and request the conflicting image or message be removed or changed to better match the warning or threat level that agencies were signalling.

Opportunity: Where more formalised relationships with stakeholders are not common practice, agencies could explore how similar formal arrangements might be operationalised. This could remove duplication of tasks and reduce time for information to flow through shorter communication channels, minimising the impact of conflicting cues. Resource constraints could also be mitigated if stakeholders empowered specific staff to be the voice of the event.

Generating content to feed media and community informational needs

Interviewees reported proactively deploying incident photographers, capturing videos from helicopters and response vehicles, and disseminating that content to meet real-time information needs about the hazard severity, status and progression. Proactively generating content has several benefits, for example, reducing the need for the verification of user-generated content from community or media and avoiding the over-reliance on using outdated event imagery. Visual content specifically helps to reduce the conflict between an emergency warning and an absence of environmental cues (i.e. smoke, fire, rain, wind) – a conflict that can cause confusion in the community. However, interviewees stressed that, in the absence of appropriate resourcing, it was difficult to generate enough variety in content to keep up with the real-time information needs of the media and the community.

Opportunity: Agencies could explore what the proactive generation of new, educational and behind-the-scenes event content might look like in their jurisdiction. However, more resourcing is required for agencies to proactively meet the informational needs of media and the community during an event. One suggestion is to include this as an additional role for volunteer brigades and units as part of formal intelligence reporting.

Cross jurisdictional deployments

There is value in staff from media, communications and public information teams being deployed to other jurisdictions during events, to learn from one other about what is working and what is not. Interviewees each had their own stories of deployment and agreed it was valuable to build capabilities in areas that had less resourcing than their home agency and to learn from

CONFLICTING CUE	EXAMPLE
Conflict with environmental cues	We [provide visuals] fairly well but we're not always able to do it. Cyclones are probably a good example ... I think **people were under a red alert for a long period of time,** it was more than 24 hours ... Because it was so huge, some people weren't experiencing crazy winds, and they were like, **'well, it's not that bad and why am I under a red alert?'** ... So, if we were able to give them visual evidence of what was actually happening within that area, I think continuing to do that will really help us. (Interviewee B).
Conflict with social cues from the media	... but we do find situations where people are **standing in places where we just don't want them to be.** So, whether they're reporting on these high intensity winds and they're saying emergency services are telling everyone to stay inside but they're standing out in the weather. Or **emergency services are telling people not to drive through flooded waters and they're filming all the crews driving through flooded waters and all the people driving through flooded waters. That's what they're choosing to broadcast. Playing in drains is another big one** for us. So, kids playing in drains. As soon as people see that on TV, someone thinks it's a good idea and then the drain rescues go up. (Interviewee H)
Conflict with social cues from an unofficial organisation	... we have these informal sorts of information that community go to ... like a storm chaser's type ... Facebook page for example ... they might have a large number of subscribers and they'll push out information ahead of a weather event, so in the days **leading up to a weather event that's not necessarily aligned to what we're saying,** so they might over-blow the weather event, or they might **inadvertently question what we're telling the community** by saying words to the effect, oh, "it's not [going] to be that bad, yes; or **government are overdoing it**", whatever it might be. (Interviewee K)
Conflict with social cues from peers	... we had one instance at the [fire name withheld], where they were **told to shelter-in-place** ... So a lady sheltered-in-place, however she then **saw all of her neighbours leaving** and the power had been disconnected ... So it was a really interesting example of how **she actually read it correctly and was doing what we told her to do, and everyone around her was leaving. So that made her question us and her decision**. (Interviewee A)
Conflict with cues from the agency itself	... the incident management system ... can **conflict [with] what's on a warning because the definitions of 'under control' in the context of our responders can be different to what obviously the community think.** Because 'under control' in a fire context means the crews I have on scene are sufficient. But that doesn't mean the fire is not still burning and doing stuff ... **there'll be an advice icon and then also there'll be the incident icon. One will say 'under control', or one will say 'not yet under control'**. So whenever we see that, we then get that sorted, but that does happen sometimes. (Interviewee E)

▲ Table 1: EXAMPLES OF TYPES OF CONFLICTS, AS REPORTED BY INTERVIEWEES.

those coming from agencies that had more resourcing.

Opportunity: Where possible, agencies could continue and expand opportunities for cross-jurisdictional deployments, to share lessons from events in real-time.

REACTIVE STRATEGIES

Dedicated monitoring roles during events

Some interviewees from agencies with more resourcing explained their monitoring practices during an event, which help to identify when conflicting cues are present and enable swift intervention to reduce the negative impact on community decision making. Not all interviewees had resourcing to constantly monitor the information being circulated either online or in-person at evacuation centres or town hall meetings. Some tried to overcome these resourcing constraints by relying on the public to self-correct.

Opportunity: Agencies could develop a designated monitoring role during an event, to rapidly identify and address instances of conflicting cues that may lead to poor decision making in the community.

Embedding the agency in community groups

There were divergent views and practices across interviewees on whether an agency will actively identify, join, and contribute to community groups (e.g. on Facebook) as part of the monitoring or public information roles. The variety of existing approaches reflects the divergent resources available to agencies in different jurisdictions, or the cultural perspective of the agency. Some agencies choose to watch the community self-correct, while others take a light-touch approach by directing the community back

END-USER STATEMENT

"Hazards such as severe storms, flooding and tsunami can create more complex communication challenges when community action must be triggered by forecasts of damaging weather systems or distant natural events such as heavy upstream rainfall, dam failure or earthquakes. Especially when these emergency situations are in contrast to the current environmental conditions being experienced in potential impact zones; are in contrast to people's past experiences; or they conflict with the opinions of other peers and social commentators. Information, behaviour and visuals in conflict with instructions being issued by lead agencies during an event create uncertainty in the community and delay or prevent protective action from being taken. While there are always going to be conflicting cues in an event, especially these large-scale events we are experiencing more and more often, it is important for agencies to understand where these conflicting cues are coming from, whether it's the media or community or the agency itself. Understanding the source of conflict means we can then explore strategies to mitigate the negative impacts that result from conflicting cues being present in an event. As each agency and each state have tried different approaches, this research from the CRC is a great opportunity to learn from one another and deploy successful strategies in our own jurisdictions. The shared lessons presented in this research have the potential to be readily applied by agencies in these key situations where comprehension, trust and validation plays an important role for the community in understanding and believing public information and warning messages and acting upon them in a timely manner."

– Marc Unsworth, Lead Officer, Operational Communication Capability, Emergency Management Victoria

to the one-source-of-truth point. Some agencies only interact via their own platforms (e.g. their official pages), while others will join community pages to monitor or push out information and engage in two-way communication with the community.

Opportunity: Agencies could explore the implementation of consistent approaches for how to engage with community groups across different jurisdictions. Some agencies have asked for better guidance on how to identify who to connect with at a local level to make sure the right community members can champion the warnings and public information provided in an event. This request applies to online (i.e. social media groups) and offline (i.e. local football clubs).

Using technological solutions for warning design and verifying visuals

Some participants described their warnings platforms as useful to design warnings in a programmatic way, but sometimes this comes at the cost of being able to adjust the warnings to better match the information needs of the community.

Opportunity: Agencies could review the warning platform systems across all jurisdictions to better enable a balance between standardisation of warning design and flexibility in providing information that the community needs in a rapidly evolving complex event. A system that can integrate across jurisdictions would also assist with reducing conflicting cues between agencies in large scale events.

While monitoring is proposed as a strategy to spot images being used from a previous natural hazard, the verification of these images is recognised as a resource-intensive, manual task that is not possible for all agencies. There are many image-verification tools that are free and publicly available. However, they require time, skill and literacy that may not be available to all agencies, and few interviewees had used these tools. None of the agencies interviewed discussed the use of paid tools to verify images circulated during an event.

Opportunity: The Verification Handbook (Silverman 2014) is a useful, publicly available tool for verifying images during emergencies, providing information and tips from journalists and aid-responders on how to verify user-generated content during emergency coverage. The handbook and associated tools could be adapted to align with agency specific policies and the Australian Institute of Disaster Resilience handbook series (AIDR 2020), which currently includes products such as the Public Information and Warnings Handbook and Choosing Your Words Guidelines for effective communication during natural hazards. Further, agencies themselves could identify locations and dates in images that they use, as a demonstration of best practice.

CONCLUSION

There is no 'silver bullet' to managing conflicting cues, and resourcing will always be a constraint that agencies must operate within. The shared lessons here cumulatively work to minimise the negative social, physical and economic consequences of conflicting cues that impact decision making. To continue the peer learning offered in this *Hazard Note*, agencies could explore implementing evaluation processes that are inclusive and accessible by multiple agencies for lessons to be shared across the industry during and following events. Emergency service agencies and the media will need to continue collaborating to manage conflicting cues to ensure the community can make the best decisions with the information they have.

HOW THIS RESEARCH IS BEING USED

This study is part of a broader project being undertaken in four phases. The first phase – as presented in *Hazard Note* 59 – sought to identify whether there is a conflict between emergency warnings and cues from other sources, for example, the environment, media, unofficial sources and peer groups. The second phase – as presented in this *Hazard Note* – explores interventions to mitigate the negative effects of conflicting cues to improve protective action. The third and fourth phases of the project are translating these findings via briefings and workshops, and develop strategies with end-users to optimise emergency warnings and encourage community compliance.

FURTHER READING

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The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

HAZARD **NOTE**

bushfire&natural HAZARDSCRC

ISSUE 70 MARCH 2020

TOPICS IN THIS EDITION | FIRE | RISK ANALYSIS | VULNERABILITY

A STEP TOWARDS ZERO: UNDERSTANDING PREVENTABLE RESIDENTIAL FIRE FATALITIES

MFB

afac

ABOUT THIS PROJECT

This research was led by the Metropolitan Fire Brigade on behalf of the AFAC Community Engagement Technical Group, as part of the Tactical Research Fund project, *A strategic analysis of preventable residential fire fatalities*. The research was undertaken by Risk Frontiers, the Metropolitan Fire Brigade and Macquarie University.

AUTHORS

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SUMMARY

On average, more than one preventable fire-related death occurs in a residential context every week in Australia.

That equates to approximately the same number of deaths as occurred during the Black Saturday bushfires (173), every three years. Since 2003, at least 900 people have died in residential fires – deaths that could have been avoided. Deaths from residential fires have significant social, economic and emotional impacts on individuals, families, communities, and on the firefighters and other emergency service volunteers and employees who attend these incidents.

This research draws on 14 years of data to provide an update on the evidence around the extent of preventable residential fire fatalities in Australia, those people most at risk of dying in residential fires, and the details of fire incidents and residences where fatal fires have occurred. The research found that deaths from preventable residential fires in Australia averaged 64 fatalities per year between July 2003 and June 2017. This is more than one preventable residential fire fatality per week. Most of these deaths occur in single fatality incidents. In the timeframe studied, there was no clear declining trend in preventable fire fatalities.

The results from this study highlight that reducing residential fire fatality risk is complex. The presence of a single risk factor on its own is unlikely to significantly increase a person's risk of dying in a residential fire. Rather, it is the combination of a range of risk factors surrounding the person – their behaviours, their residential environment, any disability or disadvantage that they are experiencing and other external factors – that is likely to impact their overall level of risk of having a fire that results in their death.

This research provides a set of data that fire services can use to develop evidence-based policy and practice to reduce the occurrence of preventable fatal residential fires.

▲ Above: THIS RESEARCH WILL ALLOW LIFESAVING INFORMATION TO BE BETTER TARGETED TO THOSE MOST AT RISK FROM HOUSE FIRES. PHOTO: METROPOLITAN FIRE BRIGADE.

CONTEXT

The last published national study into residential fire fatalities in Australia was by AFAC in 2005. This research builds on that report and looks in greater depth at who is most at risk. This new data provides fire services and other stakeholders with an analysis of preventable residential fire fatalities to inform evidence-based policy and practice to reduce the number of future deaths.

BACKGROUND

Numerous studies have shown that certain groups of people are more at risk of dying in residential fires. The identification of risk groups enables fire services to apply a preventative, rather than a reactive, approach to residential fire safety.

The findings from this study enable fire agencies and other stakeholders to improve their knowledge about preventable residential fire fatalities, the nature of the victims and the circumstances surrounding

DEFINITIONS

Preventable fires: Preventable fires are fires where individuals, fire agencies or other stakeholders may have been able to identify the risks (related to a person and/or a physical environment) and take action or develop intervention strategies which, if applied, may have reduced the risk of a fire taking place.

Fatality: A fatality is a death where causation, as determined by a coroner, is related primarily to the effects of fire, including causations such as smoke inhalation or burns. The death may have occurred at the time of the fire or any time after, including months after the fire incident.

the fatalities. This information is assisting the design of improved community safety programs to reduce residential fire fatalities in the future.

The 2005 AFAC study found that the most at-risk groups for residential fire fatalities in Australia included males, those aged 65 or over, children under four and adults who had consumed alcohol. This current project aimed to assess the data since 2005 and confirm at a national level findings from Aufiero *et al* (2011), who found that in metropolitan Melbourne, older people and people with a disability were at higher risk and that many residential fire victims were recipients of funded home and community care programs.

Demographic trends, such as an aging population, aging in place strategies and more people living alone, indicate a potential increase in future risk. The literature commonly identifies that often the variables associated with residential fire deaths appear in combination. These can be factors associated with the person and their behaviour, or a more complex combination of risks incorporating the person, the residential environment and other social and economic factors.

BUSHFIRE AND NATURAL HAZARDS CRC RESEARCH

The objectives of this study were to:

- identify specific socio-demographic characteristics, risk factors and other related information associated with victims of residential fire that are noted in coronial reports
- identify, for the largest cohort of fire victims (those aged 65 or older), how many were recipients of government funded services prior to their death
- better understand the prevalence of socio-demographic characteristics associated with fire victims in the community-based data from the Australian Bureau of Statistics, including a projection of future risk, where appropriate

The research analysed records from the National Coronial Information System (NCIS) database, supported by the analysis of publicly available Coronial reports. The NCIS database contains records from all states and territories in Australia from July 2000 onwards (except for Queensland, which is from January 2001 onwards).

Australian records from 1 July 2003 to 30 June 2017 were accessed in the NCIS by a variety of searches. After refinement of the applicable dataset, relevant structured and non-structured data from the NCIS (comprising the summary page, police, autopsy and toxicology reports and coroner's findings) were coded for 41 fields and entered into a specially constructed database. Once complete, the data was statistically analysed.

Fatality rates by age group

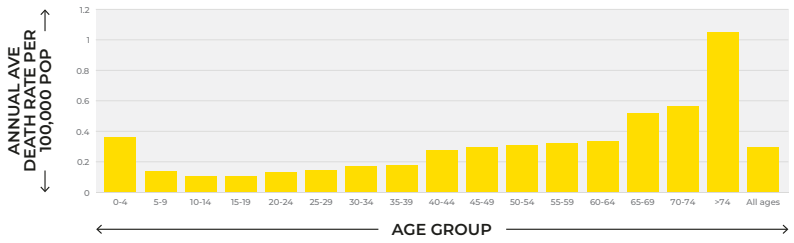


Figure 1: FATATLITY RATES BY AGE GROUP.

Fatalities by age and gender

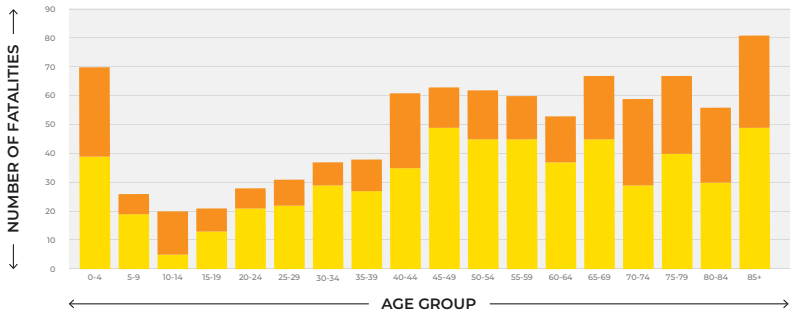


Figure 2: FATATLITIES BY AGE AND GENDER.

RESEARCH FINDINGS

This study found that at least 900 people have died in preventable residential fires in Australia from July 2003 to June 2017, averaging approximately 64 deaths per year, or more than one preventable residential fire death every week. Between 2003 and 2017 there was no clear declining trend in fire fatalities.

THE PEOPLE

Single variable, contingency table and machine learning analyses from the current research found that those most at risk are:

- Older people – people aged over 65 represent 36 per cent of fatalities
- Young children - those aged 0-4 represent 8 per cent of fatalities
- People with a disability - 62 per cent of fatalities
- Aboriginal and Torres Strait Islander people – over-represented by a factor of 2.5
- Smokers - 65 per cent of fatalities
- People on medications (34 per cent) or with alcohol (33 per cent) present in their blood

- Males – 64 per cent of fatalities, particularly those aged over 45
- People who lived alone - 45 per cent of fatalities
- People who live in the most socially and financially disadvantaged locations

The presence of a single risk factor on its own is unlikely to significantly increase a person's risk of dying in a residential fire. Rather, it is the combination of a range of risk factors that increase the risk. Significant risk groups and trends relating to those groups are outlined below.

OLDER PEOPLE

People aged over 65 are the group most at risk of dying in a residential fire, and the fatality rate increases with age. The data indicates that the other factors that increase risk in older people include smoking, having a disability, the presence in their blood of alcohol and/or medications, living alone and requiring support to live at home. Where these factors are present in combination, an older person's risk increased significantly.

YOUNG CHILDREN

Children aged under four had the largest number of deaths of any five-year age range. The cause of fire was more often lighters or matches, which may indicate that a significant number of fires were lit by children during fire play. The link to social and financial disadvantage was particularly significant in this cohort, with almost half of deaths in the 0-4 age bracket occurring in locations in the top 10 per cent of greatest socio-economic disadvantage, and 87 per cent of fatalities occurring in the top 40 per cent of locations of greatest disadvantage.

PEOPLE WITH A DISABILITY

Within the fire fatality data, 47 per cent of decedents were identified as having at least one disability present (physical disabilities 46 per cent, mental health 28 per cent and neurological disorders 10 per cent). The data suggests that people with a disability more often died between the hours of 8am and midday. This contrasts with the overall data, where fatal fires more often occurred overnight during sleeping hours. This may indicate that for people with a disability, their disability rather than being asleep may have contributed to their inability to safely escape the fire. Similarly, people with a disability more often had a working smoke alarm.

ABORIGINAL AND TORRES STRAIT ISLANDER PEOPLE

Over eight per cent of decedents were identified as Aboriginal, Torres Strait Islander, or both. Approximately three per cent of the Australian population identify as Aboriginal or Torres Strait Islander, meaning that this cohort are over-represented in the data by a factor of 2.5. Aboriginal and Torres Strait Islander people comprised 12 per cent of fatalities under 65 years of age and three per cent of people over 65 years, likely reflecting the younger age structure of the Aboriginal and Torres Strait Islander population.

THE RESIDENCE

Free-standing houses/villas were the housing type where the majority (67 per cent) of fatal fires occurred. However, these free-standing houses comprise 78 per cent of the housing stock in Australia, so other housing types may be over-represented in the fatality data. Similarly, owner occupiers were the most commonly identified property tenure (53 per cent), but owner occupiers account for approximately 67 per cent of all property tenures in Australia. This indicates that other tenure types, such as private and public rentals, may be over-represented in fire fatalities.

THE LOCATION

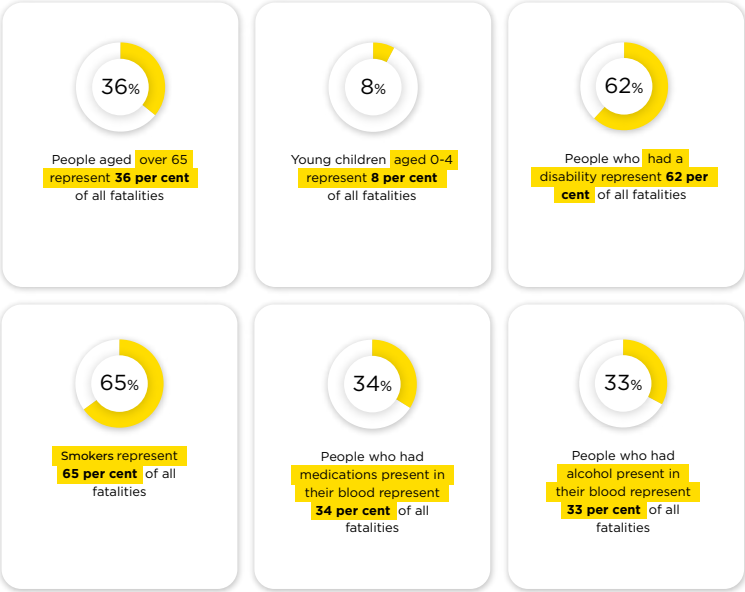
Geographically, most fatal residential fires occurred in major cities, but there was over-representation of deaths in regional and remote areas. The analysis of the fatality data in relation to areas of relative socio-economic advantage and disadvantage shows that most fatalities occurred in locations where there is relatively greater socio-economic disadvantage. Fatal preventable residential fires start most commonly in the living room/lounge or bedroom. They are not necessarily large or severe fires, with approximately half of fatal fires burning one room or less of the structure.

SEASONALITY

Most fatal residential fires occur during the winter months. They occur most commonly between the hours of 8pm and 8am, and particularly from midnight to 4am.

END-USER STATEMENT

"The majority of fatal house fires are preventable, which is concerning. As firefighters, our job is not just to extinguish fires but to stop them from occurring in the first place. Studies like this one provide vital intelligence to assist fire and rescue services better understand why these incidents are happening and who is most at risk. This enables us to develop evidence-based policies and practices to hopefully reduce the number of fatal fires. Even one person dying in a house fire is one too many."
– Acting Chief Executive Officer/Chief Officer David Bruce, Metropolitan Fire Brigade



▲ Figure 3: THE RESEARCH IDENTIFIED KEY STATISTICS FROM AT RISK GROUPS.

▲ Above: FIRE INVESTIGATORS EXAMINING A HOUSE AFTER A FIRE. PHOTO: METROPOLITAN FIRE BRIGADE

SMOKE ALARMS

In a large majority of cases (66 per cent) it is unknown if a smoke alarm was present, despite smoke alarms being a requirement by law in all residential properties. The extent that the presence of a smoke alarm was noted by coroners is low considering their importance and that the absence of a smoke alarm may have had an impact on the fatality outcome (e.g., by providing an earlier warning to the fire victim).

SMOKING

People who smoke are over-represented to a large extent in residential fire fatalities. Of cases where the smoking status of the decedent was known, 65 per cent of people were smokers. During the study period, smoking rates in Australia decreased significantly and reduced-fire-risk cigarettes were mandated in Australia in 2010. In the 2004/05 financial year, 23 per cent of Australians were smokers. By 2014/15 this had decreased to 16 per cent. The fatality data does not reflect any decline in the number of smokers who died over the course of the study period. It is unclear why this is the case.

Smoking materials are a major cause of ignition of fatal residential fires. For those cases where the fire cause was known, over a quarter were caused by smoking materials, with just over a third of those relating to smoking in bed. There was a strong link between smoking materials as the cause of fire and the residence being in a relatively disadvantaged area, with 49 per cent of fires caused by smoking materials occurring in the top 25 per cent of the most disadvantaged locations.

HOW IS THIS RESEARCH BEING USED?

This research is informing fire safety programs nationally, with fire and emergency services across Australia, through AFAC, using the data to develop a national residential fire strategy, 'towards zero', to reduce preventable residential fire fatalities.

The groups identified as most at risk are also the groups that are the most difficult to reach in general fire safety campaigns. Lifesaving information can now be better targeted to the areas it is needed most.

FURTHER READING

AFAC (2005), *Accidental fire injuries in residential structures: who's at risk,* Australasian Fire and Emergency Service Authorities Council.

Aufiero M, Carlone T, Hawkins W and Murdy S (2011), *Analysis of preventable fire fatalities of older people and people with disabilities: risk reduction advice for the community care sector,* an interactive qualifying project report submitted to the faculty of Worcester Polytechnic Institute in partial fulfilment of the requirements for the Degree of Bachelor of Science, Metropolitan Fire and Emergency Services Board.

Coates L, Kaandorp G, Harris J, van Leeuwen J, Avci A, Evans J, George S, Gissing A, van den Honert R and Haynes K (2019), *Preventable residential fire fatalities: July 2003 to June 2017*, Bushfire and Natural Hazards CRC.

The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

HAZARD **NOTE**

bushfire&natural HAZARDSCRC

ISSUE 69 MARCH 2020

TOPICS IN THIS EDITION | COMMUNICATION | COMMUNITIES | WARNINGS

UNDERSTANDING BUSHFIRE RISK, WARNINGS AND RESPONSES – LESSONS FROM THE 2018 REEDY SWAMP FIRE

ABOUT THIS PROJECT

The NSW Rural Fire Service (NSW RFS) commissioned the Bushfire and Natural Hazards CRC to undertake research into community preparedness and responses to the Reedy Swamp fire which impacted on Reedy Swamp and Tathra in March 2018.

AUTHORS

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SUMMARY

On Sunday 18 March 2018, a bushfire affected the communities of Reedy Swamp and Tathra in the Bega Valley Shire on the NSW south coast. The fire, known as the Reedy Swamp fire, destroyed 65 homes and 35 caravans and cabins, and displaced about 700 residents, as well as tourists. No human lives were lost. Themes covered in this research are community understanding of fire risk, planning, preparation, and responses during and after the fire.

Key findings centre around the need to educate people further about the role that embers play in spreading bushfire into built-up areas, the dangers of late evacuation, providing greater clarity in official warning messages and how warnings may not be delivered in the event of power or technology failure. The study found that many people consider bushfire preparation as something that is undertaken when directly threatened by fire, not well in advance of an active threat. Many people within Tathra had not thought that a bushfire could impact the town, or had not considered the potential for fire to penetrate beyond the bush at the western edge of town. The research found that many of those who left at the last moment said they would leave earlier in a future bushfire and would be more prepared to gather animals and valuable items to take with them when they evacuated.

Based on this research, the NSW RFS continues to review and refine its approach to public information and warnings, and the structure and content of warning messages. The Service is piloting the use of Community Field Liaison teams to provide consistent messages and advice on the ground.

▲ Above: THE BUSHFIRE THREATENS TATHRA. PHOTO: CALEB KEENEY, TIMBERLINE HELICOPTERS.

CONTEXT

The study addresses key questions relating to people's perceptions of bushfire risk generally and on the day; community planning and preparation; their response to warnings and their experiences in the aftermath. Importantly, it investigates how people intend to plan, prepare and respond to bushfires in the future. The research builds on previous NSW RFS contracted research including major bushfires in the Blue Mountains, Coonabarabran and Southern Highlands areas, and for fire agencies in Victoria, Tasmania, Western Australia and South Australia.

BACKGROUND

Reedy Swamp and Tathra are located in the Bega Valley Shire on the NSW south coast, approximately 450 kilometres south of Sydney. Tathra is a seaside town that is mostly comprised of freestanding houses on residential blocks, and is a popular destination for tourists. Reedy Swamp is located approximately 5-10 kilometres north west of Tathra, on the northern side of the Bega River. The area is mostly comprised of small acreages and rural residential blocks. Many properties are located within the forest and are accessible by long, unsealed roads that are flanked by bush.

Sunday 18 March 2018 was a day of Total Fire Ban for the Far South Coast Fire Area. At 12:26pm emergency services received a Triple Zero call reporting a bushfire at Reedy Swamp Road, Reedy Swamp. While

the matter is subject to a coronial inquiry, an investigation by the NSW RFS identified electrical infrastructure on Reedy Swamp Road as the cause of the fire.

The Severe Fire Danger conditions were unprecedented for the area at that time of year, and the fire destroyed 65 homes, with 48 homes damaged. Thirty five caravans and cabins were also destroyed. The fire displaced approximately 700 residents on the day, as well as an unknown number of tourists and visitors.

The fire, and response by fire agencies, was also the subject of an independent review commissioned by the NSW Government.

BUSHFIRE AND NATURAL HAZARDS CRC RESEARCH

The research involved 87 semi-structured, in-depth interviews with 120 people affected by the fire. Interviews were audio recorded with each participant's consent and were transcribed in full, generating over 1,300 pages of interview transcript. Qualitative analysis of interview data was undertaken using the qualitative data analysis software NVivo 11. This process involved careful reading and rereading of each interview transcript and coding information related to the issues and themes under investigation to derive summary findings.

This *Hazard Note* covers findings related to the perception of risk; actions taken to prepare; how people became aware of the fire; implementation of fire plans; obtaining information about the fire; the responses of visitors to the area; expectations around warnings and effectiveness; the time of year the fire took place; post fire experiences; and what people would do differently if threatened by fire in the future.

Full details are available in the report *Understanding bushfire risk, warnings and responses: A study of the 2018 Reedy Swamp fire* (Whittaker *et al.*, 2020).

RESEARCH FINDINGS

COMMUNITY PERCEPTION OF RISK BEFORE THE FIRE

Many residents within Tathra were not aware of the bushfire risk. Residents with properties within or adjoining the forest tended to be more aware of the risk posed by bushfire and were more likely to have taken action to plan and prepare. Many people within the town had not considered that a bushfire could impact on Tathra or had not considered the potential for a bushfire to penetrate beyond the forest edge (e.g. via embers). As such, these people had not adequately planned or prepared for bushfire.

▲ Above: THE FIRE SPOTTED OVER PARTS OF TATHRA AND BURNT AREAS AWAY FROM THE MAIN FIRE FRONT. PHOTO: BEN SHEPHERD, NSW RURAL FIRE SERVICE

WHAT ACTIONS PEOPLE TOOK TO PREPARE

Many interviewees described preparation as something that is done when a fire is threatening, rather than actions taken in advance of a bushfire. Those who lived in streets adjoining or within the forest were more likely to have planned and prepared for bushfire, although levels of preparedness still varied considerably.

Only a small number of households had dedicated firefighting resources such as water tanks, pumps, and firefighting hoses. Some residents appeared to have planned and prepared for last-minute evacuation, describing measures such as getting cars out of garages and positioning them facing forward for a quick escape. Others, who had not planned to leave, described a last-minute dash around their house while they tried to collect items they considered important to take. Interviewees discussed how in the panic they forgot critical medications, papers and items of sentimental value. Many noted that in future they would keep important documents together and would have a list of what they planned to take.

HOW PEOPLE BECAME AWARE OF THE BUSHFIRE AND HOW THEY REACTED

Most people became aware of the fire by seeing or smelling smoke, or by communication with relatives, friends or neighbours. For some residents, knowledge that there was a fire nearby caused concern and motivated preparatory or protective action. Many others noted the presence of the fire but did not believe it was a threat to Tathra and continued with what they were doing.

WERE PEOPLE ABLE TO IMPLEMENT THEIR FIRE PLAN?

Most of those who intended to leave were able to do so, but many reflected that they left too late. There were people who had not planned or prepared for bushfire who stayed to defend their own and neighbours' houses. Importantly, most of those who did have a plan were able to implement it.

INFORMATION SOUGHT ABOUT THE BUSHFIRE AND HOW IT WAS OBTAINED AND USED

Many people sought information about the fire through direct observation of smoke, flames and the activities of neighbours and emergency services. The loss of electricity, mobile phone reception and issues relating to the broadcast of emergency information into the local area impeded the delivery of warnings, information and advice.

As identified in previous research, including into the Sir Ivan, Currandooley and Carwoola fires (Whittaker J and Taylor M, 2018), many people travelled to places where they could observe the fire for themselves, such as the Mogareeka carpark and Thompsons Drive.

HOW DID VISITORS TO THE AREA RESPOND TO THE BUSHFIRE?

A range of local businesses were hosting non-residents when Tathra came under

threat. These businesses included caravan parks, hotels, motels, restaurants, cafes, and local clubs such as the bowling and golf clubs.

All accommodation providers were able to alert their guests to the bushfire and instructed them to evacuate. Some evacuations occurred as the fire was impacting on Tathra. Mandated evacuation plans and emergency procedures assisted the evacuation process.

COMMUNITY EXPECTATIONS OF WARNINGS AND INFORMATION, PARTICULARLY IN KNOWN MOBILE PHONE COVERAGE BLACK SPOTS

Most interviewees were aware, prior to the fire, of the limited mobile phone coverage in the Tathra and Reedy Swamp areas. Some had considered that they might not receive a SMS warning in an emergency. Some people expected warnings and advice to be provided earlier, before power and communications infrastructure failed. There was an expectation that local media would provide ongoing coverage of emergency warnings and information throughout the fire.

Interviewees identified the need for improved mobile phone network coverage in the area. Some suggested that a siren or klaxon should be installed to alert people of an emergency in the event that telecommunications infrastructure fails.

THE EFFECTIVENESS OF WARNINGS AND THE RESULTING ACTIONS TAKEN

Many people did not receive warnings, or received warnings late, due to power and mobile phone outages and black spots. These factors, along with issues relating to the broadcast of emergency information into the local area, led to uncertainty and confusion about whether, when and where to evacuate to.

Some people who received warnings via landline telephone and SMS found the warnings useful. Although they were already aware of the fire, receipt of an official warning confirmed the threat posed by the fire and the need to take action.

Some of those who received a warning advising them to seek shelter were unsure what 'seek shelter' meant and therefore did not understand what the message was advising them to do.

DID THE TIME OF YEAR INFLUENCE HOW PEOPLE RESPONDED?

Some interviewees had been aware that the day of the fire was forecast to be a day of Severe Fire Danger or were aware of the forecast hot and windy conditions. Nevertheless, some expressed surprise that such a destructive bushfire could occur in mid-March. A small number of interviewees discussed how their belief that the bushfire season was over influenced their preparedness and response.

COMMUNITY EXPERIENCES IN THE AFTERMATH OF THE BUSHFIRE

In the aftermath of the fire people experienced a range of common issues related to: evacuation centres; post-fire communication and information; the conduct of media and politicians; safety issues, including asbestos; and concerns about the local environment.

While most people were impressed with the services being provided at the evacuation centre, some were uncomfortable with the media presence and many were frustrated by rumours that were circulating about the impact of the fire on Tathra. People were distressed to find out via media reports and images, rather than official communications, that their house had been destroyed. The conduct of media within the evacuation centre was questioned by some people. Some questioned whether media should be allowed into evacuation centres.

HOW DO PEOPLE INTEND TO PLAN, PREPARE AND RESPOND TO BUSHFIRES IN THE FUTURE?

Interviewees reflected on specific changes they would make to their properties such as removing mulch from garden beds around the house, removing trees, obtaining longer hoses, and installing sprinkler systems.

Many of those who left at the last moment said they would leave earlier in a future bushfire and would be more prepared to gather animals and valuable items.

Those who stayed to defend identified the need for better equipment and resources such as dedicated firefighting hoses, pumps and water supply, as well as personal protective equipment such as goggles, masks and appropriate clothing.

A number of people who left or evacuated during the fire said they would not leave in a future bushfire, or would be reluctant to leave. Interestingly, some said they would remain within the fire affected area not because they had a strong desire to defend their house and property, but because they wanted to avoid the inconvenience of being prevented from returning.

WHAT WAS SAID

On impromptu property defence

"We wheeled in here and... the smoke and everything had already arrived, and we put the car in the garage... grabbed a hose each... turned the hoses on and got out the front there. It came in through that gap there opposite, virtually opposite here. And it was 100 foot high and the house immediately across the road there virtually blew up straight away. It was on from then... literally a hail of fire... all the embers coming down. We had bare feet... we both had shorts and shirts on. I had no time to put anything on. And it just sort of rained down embers everywhere... there was no air to breathe, that was the thing I found difficult."

On being better prepared to leave early next time

"I'd just take off very quickly. I wouldn't wait. No. I'd take off very quick. And if it [the house] burns, it burns. 'Cause you just don't know where it's going to go, you know. Your life's the main thing."

On how businesses hosting visitors responded to the fire

"There was a lot of hesitation with people not wanting to leave. They had a look at the website themselves. Went, yeah, no, 'I don't think it's gonna come this way', because there were a lot of rumours going around at the time saying it probably wasn't gonna hit that far. So, people weren't overly concerned."

On the time of year that the fire occurred

"Yes, I was surprised at the timing. My word, yeah. This late in the season. We should be hazard reducing. We should be lighting fires now, not preventing them."

CONCLUSION

This research shows that there are opportunities to increase community awareness and preparedness for bushfire in built-up or urban areas through clearer communication of the potential for embers to carry fire into these locations, well beyond what many believe to be the interface between forests and houses. Such messages are extensively covered in community education and engagement resources, as well

as emergency warnings and information, but could be reinforced further.

Bushfires like the Reedy Swamp fire present valuable learning opportunities for people in bushfire risk areas. This fire in particular may present opportunities to increase awareness and understanding of the risks to coastal communities in NSW and elsewhere. Consideration should be given to including experiences and learnings from such fires in community engagement and education materials.

The study highlights that many residents planned or intended to evacuate at the last minute. This suggests a need for more education and advice about the dangers of late evacuation, including late evacuation to nearby places. Education materials and campaigns should emphasise the importance of being prepared and taking action as soon as people learn about a fire, and not waiting until they are directly threatened.

The confusion about the meaning of 'seek shelter' in warning messages suggests a need for greater dialogue and clarity of messages about safe sheltering practices. Education materials and campaigns are needed that encourage planning and preparation for active sheltering (defending a home and seeking shelter as the fire impacts), but discourage planning for sheltering as a sole response (inactive sheltering without attempting to regularly monitor conditions inside and outside the place of shelter, as well as actions to protect the shelter and its occupants). The tendency for people to gather at informally designated refuges or places of shelter reinforces the need for community dialogue about the suitability of local places of shelter. Since the Reedy Swamp fire, the Tathra Beach Country Club change rooms, where many gathered during the fire, has been formally designated as a Bushfire Neighborhood Safer Place.

FURTHER READING

Whittaker J, Blanchi R, Haynes K, Leonard J, Opie K (2017), Experiences of sheltering during the Black Saturday bushfires: Implications for policy and research, *International Journal of Disaster Risk Reduction* 23, pp. 119-127.

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Whittaker J and Taylor M (2018), Community preparedness and responses to the 2017 NSW bushfires, *Hazard Note* 45, Bushfire and Natural Hazards CRC.

Whittaker J and Taylor M (2018), Community preparedness and responses to the 2017 NSW bushfires, Bushfire and Natural Hazards CRC.

END-USER STATEMENT

"The bushfire which impacted on Reedy Swamp and Tathra in March 2018 has had, and continues to have, a long-lasting effect on the community.

"The area is like so many across NSW and Australia, in that it is in a high risk setting, with a large population surrounded mainly by bushland, and limited access options.

"Through this contracted research, the NSW RFS has gained valuable insight into the community's perception of this risk, and what people did to reduce their personal risk of being impacted by a bushfire.

"Of particular note, many in the community understood that areas closest to the bush were at risk but others did not appreciate there was a risk to more built-up areas when embers blew into the town and started numerous spot fires. Some of these destroyed homes well away from the main fire front. It highlights a need to constantly reinforce messages around the risk of embers, and the importance of preparation well before a fire.

"We continue to learn how varied human reactions can be in an emergency, and how many people unfortunately leave their decision making until the last minute.

"The community has also provided insight into the effectiveness of warning messages. While the delivery of official information and warnings has improved significantly in recent years, there is still a strong reliance on technology. As has been seen many times in emergency events, technology can fail and prevent access to up to date information.

"Additionally, the research highlights the importance of partnering with traditional media to ensure information is delivered in a timely manner, and media coverage of a disaster is executed in a respectful way.

"This research builds on an increasing knowledge base of post-incident reviews and analysis, and will help further refine community engagement and warnings well into the future.

"The NSW RFS thanks the community of Tathra and the surrounding area for assisting with the research and ensuring their views are captured, and that lessons are learned for future fires."

– Shane Fitzsimmons AFSM, Commissioner, New South Wales Rural Fire Service

The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

HAZARD **NOTE**

bushfire&natural HAZARDSCRC

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TOPICS IN THIS EDITION | COMMUNICATION | COMMUNITIES | WARNINGS

CONFLICTING CUES WITH EMERGENCY WARNINGS IMPACTS PROTECTIVE ACTION

ABOUT THIS PROJECT

This project, *Effective risk and warning communication during natural hazards*, commenced in 2014 and adopts a multi-hazards approach to examine the effectiveness of response and recovery communication in communities affected by natural hazards. It applies well-established risk communications and psychological theory of human behaviour to determine whether existing emergency messages could be revised to improve comprehension. The project is part of the *Communication and warnings* cluster.

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▲ Above: RESEARCH HAS SHOWN THAT ENVIRONMENTAL CUES, SUCH AS THE WEATHER OUTSIDE, INFLUENCE HOW INDIVIDUALS REACT TO WARNING MESSAGES. PHOTO: CFA

SUMMARY

Australia's emergency services agencies face immense challenges when responding to natural hazards. Evacuating people in affected regions requires time, influence, coordination and expertise.

Triggering large-scale public evacuations in time-critical situations of flood or bushfire is problematic, as there is always some uncertainty about whether, or how, a natural hazard will occur. Compounding this problem is that emergency services are not the only source of information that the public uses when considering taking action. There are also environmental cues, such as the weather outside, what is being said by the media, or what actions peers are taking, all of which can inhibit taking timely protective action.

When cues from different information sources are in conflict, such as when a flood evacuation warning has been issued but the weather conditions in the immediate area appears sunny and fine, it can cause uncertainty about the right action to take. Emergency service providers have suspected that these conflicting cues exist (Bosschaart *et al.*, 2013; Gruntfest *et al.*, 1978; Lindell & Perry, 2004; Perry & Lindell 1990; and Yoo *et al.*, 2009) but this is the first research to offer empirical evidence of the impact of conflicting cues and how they influence public behaviour in Australia.

Results show that conflicting cues do exist and can affect information processing of risk perceptions, and therefore prevent appropriate protective action. The significant results were evenly spread across hazards, suggesting the problem is not unique to one hazard.

CONTEXT

This project responds to the concern that people do not always effectively act on official warnings about natural hazards. Conflicting cues are proposed to exacerbate the largely unintentional non-compliance with emergency warnings.

BACKGROUND

This project draws on two models to explain the effect of conflicting clues: the Risk Information Seeking and Processing model (Griffin *et al.*, 1999) and the Protective Action Decision model (Lindell & Perry, 2012).

The Risk Information Seeking and Processing model proposes seven factors that influence the extent to which people seek out information and the time they spend analysing it. These include individual characteristics, perceived hazard characteristics (i.e. risk perceptions),

▲ Above: THIS IS THE FIRST RESEARCH TO OFFER EMPIRICAL EVIDENCE OF THE IMPACT OF CONFLICTING CUES AND HOW THEY INFLUENCE PUBLIC BEHAVIOUR IN AUSTRALIA. PHOTO: SOUTH AUSTRALIA SES

affective response to the risk, social pressures to possess relevant information, information sufficiency, one's personal capacity to learn, and beliefs about the usefulness of information in various channels. The Risk Information Seeking and Processing model is built on the idea that just because information is available does not mean people will do anything to respond to it.

The Protective Action Decision model suggests that an individual's decision to engage in a protective action is informed by how they process socio-environmental cues alongside official communications. Environmental cues include smells and sights, while social cues incorporate behaviours of others. This can produce modelling behaviours, media coverage as a form of authority to effect behaviours, and information from unofficial sources as another behavioural influence.

Previous research indicates that many situational and individual factors will affect public behaviour in an emergency (Glick, 2007; Guion *et al.*, 2007; Mayhorn, 2005; Mileti, 1995 and Sharma & Patt, 2012) such as past experience with hazards, age, gender, language and country of birth.

BUSHFIRE AND NATURAL HAZARDS CRC RESEARCH

The project team surveyed 2,649 adults across all Australian states and territories about bushfires and floods. The respondents were randomly assigned to one of the 32 experimental conditions that presented them with an emergency warning ('**prepare to evacuate**' or '**evacuate now**') and either an environmental cue (i.e. a gif - an image file that supports both animated and static images - of a sunny day, bushfire or flood) or one of three social cues (i.e. a media article suggesting evacuating or staying, an organisation releasing an unofficial warning suggesting evacuating or staying, or observed behaviour of neighbours evacuating or staying).

Taking protective action in the event of bushfire or flood can mean any number of things, including preparing property and family for evacuation, calling for emergency assistance, or telling friends or family about the event.

The survey also collected information on past experience with hazards, age, gender, language and country of birth to see if these impacted the likelihood of taking protective action.

RESEARCH FINDINGS

This research has confirmed emergency services agencies' suspicions that conflicting cues can affect information processing of risk perceptions, and therefore prevent appropriate protective action. The significant results were evenly spread across hazards, suggesting the problem is not unique to one hazard.

CONSISTENT CUES

Consistent cues refer to when the instruction in the emergency warning was consistent with the environmental cue and social cues of media, a warning from an unofficial organisation, and peer behaviour.

When presented with consistent cues, participants were more likely to intend to evacuate, perceive risk about the event, share information with friends, family and peers, find emergency warnings to be effective, and comprehend the information.

Behavioural intentions to evacuate: participants were more likely to intend to evacuate under the '**bushfire, evacuate now**', condition when the emergency warning was consistent with a social cue from the media.

Sharing information with friends, family, and peers: information sharing was more likely for participants who received consistent environmental and media cues across '**flood, prepare to evacuate**' and '**bushfire, evacuate now**' warnings.

Risk perceptions about the flood/ bushfire: perceived hazard characteristics were higher for participants when they received consistent instructions from emergency warnings, environmental cues and social cues of media and unofficial warning organisations, across bushfire and flood, and across both escalations of warnings.

Perceived effectiveness: perceived effectiveness has to do with how attention grabbing, powerfully informative, meaningful, and convincing the emergency warning was, and whether it was worth remembering. Participants perceived emergency warnings to be more effective when social cues from the media and unofficial warning organisations were consistent with emergency warnings for '**evacuate now**' messages across flood and bushfire.

Perceived comprehension: perceived comprehension has to do with how easy it was for participants to understand the message and comprehend the information in the message. Perceived comprehension was higher for participants who received a '**bushfire, evacuate now**' warning that was consistent with the social cue of an unofficial warning organisation.

Current information level: current information level refers to the participants present perceived knowledge of a hazard. Participants perceived they had a higher current information level when they received a '**flood, evacuate now**' emergency warning consistent with a social cue from an unofficial warning organisation.

CONFLICTING CUES

Conflicting cues refer to when the instruction in the warning message

conflicted with the environmental cue, and social cues of media, unofficial warning organisations, and peer behaviour. When faced with conflicting cues, participants were more likely to seek out additional information, whilst their information processing and self-efficacy were affected.

Seek out further information: information seeking refers to the participants' likelihood of searching for information about a hazard in order to understand it better, as opposed to tuning out when the topic of the hazard comes up. Participants were more likely to seek information when a '**bushfire, prepare to evacuate**' emergency warning conflicted with the social cue of an unofficial warning organisation. While seeking out additional information is sometimes encouraged and thus could be considered a protective action, it can result in milling behaviour, a communicative process whereby individuals come together in an attempt to define the situation, confirm the threat/risk, and propose and adopt new behaviors, known as protective actions (Kuligowski & Dootson, 2018). Getting stuck in the milling process for extended periods of time can potentially place individuals in danger (Lindell & Perry 2004).

Process the information: heuristic information processing explains when individuals skim through information, do not spend much time thinking about the information, or believe they have been presented with far more information than they personally need about that topic. Heuristic information processing was higher for participants who received a '**flood, evacuate now**' warning that was consistent with the social cue of peers evacuating. Seemingly, the social cue was enough confirmation so they did not need to read more of the warning or seek further confirmation. Conversely, heuristic information processing was found to be higher for participants who received a '**flood, prepare to evacuate**' emergency warning that was in conflict with the social cue of an unofficial warning organisation.

Ability to follow the instruction: self-efficacy has to do with a person's perceived ability to complete a task or engage in a specific action. Participants perceived their self-efficacy to be higher when the emergency warning was consistent with the social cue of peers performing evacuation actions in the bushfire context. Interestingly, participants perceived their self-efficacy to be higher when the '**bushfire, evacuate now**' emergency warning conflicted with the media social cue.

Of all the individual differences tested, gender was the only significant factor influencing protective behaviour. In other words, the results did not change when investigating different ages, language spoken at home, country of birth, or past experience with a hazard. The results did vary when splitting the data into

SAMPLE WARNING USED IN THE RESEARCH EMERGENCY WARNING

Prepare to evacuate

People in Pebble Bay in the mid-north coastal region should prepare to evacuate due to flooding.

The Bureau of Meteorology has advised that a strong upper trough will move east into the mid-north coastal region today and then will move off the east coast tomorrow. A surface trough will deepen near Pebble Bay today, with a low pressure system most likely developing and slipping southwards over the mid-north coastal region this evening and tomorrow morning.

The heavy rain areas should contract southeast today, gradually clearing Longtime Bay tomorrow morning. The low will also most likely generate large swells as it slips southwards today and early tomorrow with dangerous surge developing about Matten Point and Longtime Bay beaches. Locally heavy falls are also expected today though are more likely to be associated with thunderstorms. Severe thunderstorm warnings will be issued as necessary.

You do not need to evacuate at this time but you should prepare to evacuate if the situation changes.

Note: This stimulus has been changed and stylised graphics used for the purpose of this Hazard Note.

How to prepare for evacuation:

- Raise belongings by placing them on tables, beds and benches. Put electrical items on top. You may be able to place light items in the roof space
- Collect together medicines, personal and financial documents, mementos and photos
- If possible, check to see if your neighbours need help
- Make arrangements for care of pets and other animals, or take pets with you when you evacuate
- Collect together space clothing, medicines and personal hygiene supplies
- Find out where to turn off the electricity and gas
- Continue to listen to your local ABC radio station for updates

If you are prepared and wish to evacuate early, your safest option may be to visit family or friends who live away from the affected area. Alternatively, you may evacuate to a temporary evacuation centre that has been set up at Castooli Community Centre.

Never drive, swim or walk through floodwater as it is dangerous and potentially toxic.

Consistent cue instructions (presented after the emergency warning message): You look outside the window and see it is raining.

Conflicting cue instructions (presented after the emergency warning message): You look outside the window and see it is a sunny day.

male/female. This is contrary to most of the research findings from the emergency literature in the United States, which shows that individual differences play a role in impacting propensity to take protective action. Further exploration is required to understand this result.

HOW THE RESEARCH IS BEING USED

This study is part of a broader project being undertaken in four phases. The first phase – as summarised in this *Hazard Note* - sought to identify whether there is a conflict between emergency warnings and cues from the environment and other sources, such as the media, unofficial sources, and peer groups. The second phase will continue in 2019 and will develop and test an intervention to mitigate the negative effects of conflicting cues to improve protective action. Among other things, the intervention could include an acknowledgment of the potential existence of conflicting cues in official emergency warnings. It could also require emergency warnings to better convey a sense of urgency. The third and fourth phases of the project will attempt to translate these findings via briefings and workshops, and develop strategies with end-users to optimise emergency warnings and encourage community compliance.

FUTURE DIRECTIONS

Building on this project and previous research, future research will attempt to mitigate the issue of conflicting cues and find ways to translate these findings for the community. It is incredibly important for emergency services to provide communities with strategic information designed to instill specific preparation and response behaviours in order to save lives and properties and reduce harm.

END-USER STATEMENT

"To have empirical evidence of how conflicting cues can impact what the community thinks and how they act is important for us because it helps emergency services agencies tailor the information and warnings it delivers to the community during emergency events. These findings, combined with the next stage of the research project, will help us develop ways to address ambiguity caused by conflicting cues to encourage the community to take protective action. Specifically, we will use these findings and future work to inform how we can tailor warnings and the key messages delivered by operational personnel to acknowledge the lack of environmental and visual cues of the immediate threat."

– Hayley Gillespie, Executive Manager Media, Queensland Fire and Emergency Services

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The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

HAZARD **NOTE**

bushfire&natural HAZARDSCRC

ISSUE 57 DECEMBER 2018

TOPICS IN THIS EDITION | COMMUNICATION | COMMUNITIES | WARNINGS

COMMUNICATING FOR MAXIMUM COMPREHENSION

ABOUT THIS PROJECT

This project, *Creating effective multi-channel communication during disaster response and recovery*, adopts a multi-hazards approach to examine the effectiveness of response and recovery communication in communities affected by natural hazards. It applies well-established risk communications and psychological theory of human behaviour to determine whether existing emergency messages could be revised to improve comprehension. The project is part of the *Communication and warnings* cluster.

AUTHORS

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▲ Above: THIS RESEARCH IS LEADING TO HELPING PRODUCE BETTER EMERGENCY WARNINGS. CREDIT: NSW RURAL FIRE SERVICE

SUMMARY

Natural hazards, where risks are often high and lives and property are at stake, raise considerable uncertainty and anxiety in the community (in this context, community comprises individuals, groups and businesses). Providing the community with information that is designed to instil specific preparation and response behaviours is an important strategic activity for emergency services providers. This research has investigated a body of risk communications and psychological theory to determine whether well-established, theoretical principals could be applied effectively in warning messages for natural hazards. For example, the principles of risk-information seeking and processing, and protective action, have been used to shape warning messages that are tested to ascertain people's understanding. That is, to establish what their 'takeaway' is from emergency warnings. Emergency management agencies continue to revise their messages, but preliminary tests in simulated settings suggest that community comprehension of emergency messages can be improved by using these principles. However, field testing is needed to determine whether or not improved understanding and good intentions actually translate into actions that minimise risks to people and property, through better preparedness or other responses.

CONTEXT

Devising and delivering natural hazard information and warnings that prompt community members to take protective action is a continuing challenge for emergency management agencies. This project shows how to apply principles from risk communications and psychological theory to warning messages.

BACKGROUND

Why do individuals behave in unanticipated ways when faced with high-risk natural hazards? Why, for example, do people drive through flooded causeways or attempt to stay and defend indefensible properties in the face of bushfire? Why do people ignore official emergency instructions and rely instead on their friends' local knowledge or the opinions of family members?

Human behaviour is complex, and it is well established that during times of high stress decisions can often be illogical and unpredictable. Consequently, emergency service organisations devote significant resources to designing and delivering risk and warning communications that persuade Australians to respond to natural hazards

with specific and immediate behaviours. These warnings, which vary from simple messages (not driving through floodwater) to complex messages (how to safely evacuate from a hazard-affected area), are designed to protect community health, welfare, and safety. The Protective Action Decision Model (PADM), however, shows that an individual's decision to take a protective action is shaped by many cues. Stimuli from the environment (for example, smelling smoke, seeing torrential rain), the behaviour of others, and official warning messages all combine to elicit a perception of threat. A lack of exposure to, attention to, and comprehension of these cues interrupts protective-action decision making.

The unpredictable nature of natural hazards makes the composition and issuing of warnings even more complex. Some warnings encourage people to take protective action for events that may never occur, or may happen far into the future. Incentives for specific behaviour work best when they are offered close to an event. With a plethora of message sources and channels to choose from, 'cut through' of trusted source information and instruction is critical.

In this complex environment, it is not feasible to determine linear relationships between a specific message and an individual's behaviour, and such relationships could not be ethically tested in live environments. However, overcoming any issues of exposure, attention and comprehension should result in better protective action decision making.

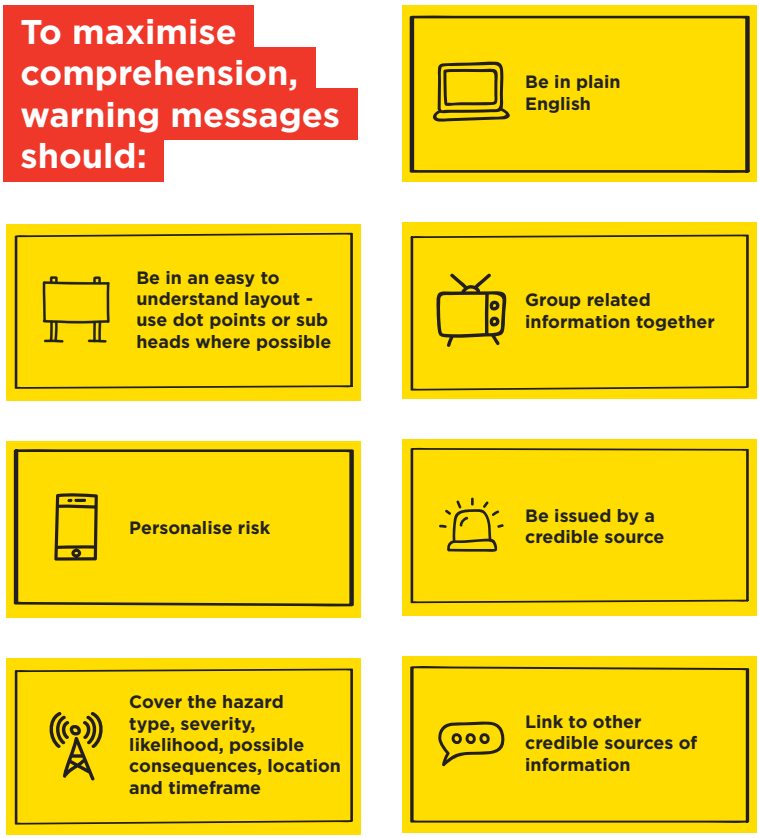
BUSHFIRE AND NATURAL HAZARDS RESEARCH

The findings reported below are the summarised result of five years' of multi-method research. Methods for data collection have included community consultation; simulated lab-based testing of message comprehension; and consultation with message developers across many agencies nationally.

Established theory, based on multiple research sources, suggests that the following principles could maximise comprehension:

- Community members often struggle to understand operational or technical language; this difficulty limits their ability to process the information. Messages that use plain English are more likely to be understood and used in decision making.
- Editing devices such as dot points and sub headings help community members to more quickly understand messages and then retain the information for longer. Simple changes to message layout can increase community attention to official information and its use in decision making.
- Community members are more likely to attend to and act upon messages that personalise risk.
- Community members are more likely to comply with an instruction when it is issued by a credible source that the recipient regards as a legitimate and expert authority. However, an individual may not always see the lead emergency management agency as that source during a hazard, despite its official role.
- Being exposed to many possible cues and having access to multiple sources

▲ **Above:** THE RESEARCH TEAM IS CONTINUING TO WORK WITH EMERGENCY SERVICES TO EVALUATE WARNINGS AND HELP IMPROVE COMMUNICATION. CREDIT: NATHAN MADDOCK, BUSHFIRE AND NATURAL HAZARDS CRC



▲ Figure 1: TO MAXIMISE COMPREHENSION, WARNING MESSAGES SHOULD FOLLOW THESE GUIDELINES.

END-USER STATEMENT

This long term research project by the Bushfire and Natural Hazards CRC comprehensively investigates the complexities of emergency communications. Emergency service agencies face ongoing challenges in how to devise warnings and information that prompt communities to appropriately prepare for and respond to disasters. This involves a fundamental issue: what factors will influence communities at crisis points, when their capacity to act rationally may be impaired? The research results are highly valuable in addressing this, and provide emergency service agencies with sound principles to follow. These include using clear, direct language, structuring information in easily understood formats, and linking agency communications to other credible information sources. All of these strategies, and others the research covers, will help people to quickly make sound decisions that could save lives and property. QFES will continue to incorporate the principles highlighted in this evidence-based research in its emergency warning and information communications.

– Hayley Gillespie, Executive Manager Media, Queensland Fire and Emergency Services

of information increases the likelihood that community members will be exposed to a warning and triangulate that information to make an informed decision to act.

- Providing information about the hazard's nature (that is, its type, severity, likelihood, and possible consequences), location and timeframe enhances hazard knowledge. This, in turn, shapes risk perceptions, improves the likelihood of message compliance and counteracts sensational information sources.
- Emergency warning messages can provide direct links to other credible sources of information, such as the Bureau of Meteorology, and thereby significantly influence community members to take protective action.
- Grouping related information together helps community members to process information more efficiently during times of high cognitive load.

Together, these principles increase the attention to and understanding of official warning messages during natural hazards.

HOW IS THE RESEARCH BEING USED?

The researcher team is working with emergency management agencies around the country to reconfigure and revise their emergency warning messages based on the above principles. This includes being involved with specific agencies as well as in the current redevelopment of the national communication doctrine.

FUTURE DIRECTIONS

The emergency management sector will require field testing of the revised messages that use these principles. Developing an evidence base for positive change that improves community compliance will be challenging.

Some of the most significant dilemmas that remain a challenge are:

- It is unlikely that the community will fully comply with instructions during an event. People facing complex individual, social and environmental circumstances may understand the message, but may not be in a position to respond appropriately.
- It is very difficult to identify acceptable metrics to measure improvements to communication strategies (such as whether improved community comprehension influences actual behaviour during these events).
- Balancing community expectations of operational responses and their own personal responsibility for preparation and action is an ongoing challenge.

These issues will continue to test the emergency services sector, despite their deep commitment to continuous improvement.

▲ **Above:** ISSUING WARNINGS THAT PROMPT PEOPLE TO TAKE PROTECTIVE ACTION IS A CONSTANT CHALLENGE FOR EMERGENCY MANAGEMENT AGENCIES. CREDIT: MARK THOMASSON, CFS

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HAZARD **NOTE**

bushfire&natural HAZARDSCRC

ISSUE 54 NOVEMBER 2018

TOPICS IN THIS EDITION | PREPAREDNESS | COMMUNICATION | COMMUNITIES

HOW PERCEPTIONS ABOUT COMMUNITY PREPAREDNESS INFLUENCE HOUSEHOLDERS' OWN HAZARD READINESS

ABOUT THIS PROJECT

This research was conducted as part of the *Improving the role of hazard communications in increasing residents' preparedness and response planning* project, which sits within the *Communications and warnings* cluster. This research concluded in 2017.

AUTHOR

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SUMMARY

Telling residents about how and why to prepare for bushfires and floods is not always effective in prompting them to act. This research explored the potential of a different motivational strategy, which is based on a theoretical model of behaviour called the Reasoned Action Approach. Specifically, the researchers investigated the extent to which residents' preparedness could be explained by their perceptions of the culture of preparedness in their local community.

Data about bushfire and flood preparation from residents across several states was collected to measure the perceived attitudes and social norms around preparing held by different portions of the community.

Among the key findings were that to effectively influence natural hazard preparedness, it is important to 1) consider which aspects of preparedness need to be influenced, 2) which community groups have the most influence on that aspect of preparedness, and 3) whether this influence should be based on how prepared the community group is in relation to this aspect, or how prepared the community group expects others to be in this regard.

Above: THIS RESEARCH FOUND THAT RESIDENTS WHO THOUGHT THE SES HELD HIGH EXPECTATIONS ABOUT COMMUNITY PREPAREDNESS WERE MORE LIKELY TO HAVE AN EMERGENCY KIT READY. PHOTO: ELIOT COHEN, SUPPLIED BY NSW SES

CONTEXT

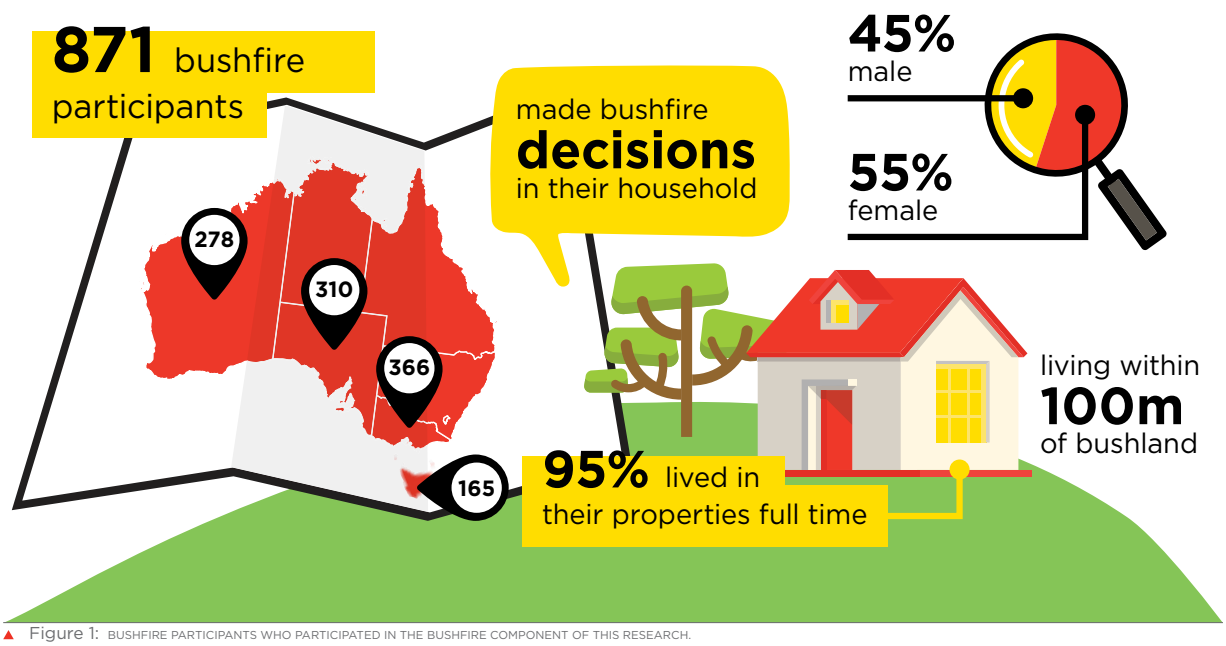
Previous research has shown that the effectiveness of traditional ways of encouraging residents to prepare for natural hazards has been limited. This research is based on the Reasoned Action Approach motivational model, and focuses on residents' perceptions of community attitudes, behaviours and expectations as levers for influencing residents to prepare.

BACKGROUND

Past research using the Reasoned Action Approach has shown that the likelihood of an individual performing a behaviour is influenced by:

- their attitude towards the behaviour (was it seen as something positive or negative, for example)
- the extent to which individuals think others are performing the behaviour, which is referred to as the descriptive norm
- the individual's perceptions of whether others expect them to perform the behaviour, which is referred to as the injunctive norm, and
- individuals' perceived ability to perform the behaviour.

Although some studies have used this model to understand preparedness for natural hazards, these studies have several



▲ Figure 1: BUSHFIRE PARTICIPANTS WHO PARTICIPATED IN THE BUSHFIRE COMPONENT OF THIS RESEARCH.

limitations. For example, most looked at intentions to prepare rather than actual preparedness, and none of the studies that examined actual preparedness took all of the above aspects into account simultaneously. In addition, none of these studies looked at whether it matters which group in the community was presenting the attitudes or norms, (for example, local peers versus the local council). Finally, these past studies generally looked at one type of preparedness (for example, preparing your property for bushfires) or used a very general measure, rather than examining different aspects (planning how to evacuate, for example).

This project conducted two field studies, involving quantitative surveys of residents regarding bushfire and flood, that were designed to fill these data gaps.

BUSHFIRE AND NATURAL HAZARDS CRC RESEARCH

Bushfire participants

The bushfire data was collected at two time points: at the start of the 2016/2017 fire season (wave 1), and towards the end of the season (wave 2). Of the 871 respondents who completed the first wave, 291 residents lived in Victoria, 265 in South Australia, 209 in Western Australia and 106 in Tasmania. A total of 248 respondents completed the survey at both time points, with 75 residents from Victoria, 45 in South Australia, 69 in Western Australia and 59 in Tasmania.

The recruitment criteria included that respondents made bushfire decisions in their household, were aged 18 years or over, and their house was within 100 metres of bushland (for example, a park, reserve, undeveloped public or private land, etc that was at least one hectare).

Fifty-five per cent of respondents were female, and the average age of respondents was 55 years. Most residents lived in their properties full time (95%), most of which were houses on residential blocks (70%).

Flood participants

The flood data was collected at one time point, in February 2017. Of the 297 respondents, 151 residents were in Queensland and 146 in New South Wales.

The recruitment criteria included that respondents lived in a community that was at risk of flooding, they made flood-related decisions in their household and were aged 18 years or over.

Sixty per cent of respondents were female, and the average age of respondents was 47 years. Most residents lived in their properties full-time (97%), most of which were houses on residential blocks (64%).

Method

The researchers used a quantitative methodology to measure respondents' personal attitude towards preparing for bushfires/floods and their perceived ability to prepare for bushfires/floods (these were the control variables). As well, the researchers measured participants' beliefs about the attitudes towards preparing and their perceptions of the community norms around preparing of:

1. local residents in general
2. local friends, relatives, and neighbours (their peers)
3. the local council, and
4. the locally active fire agency/State Emergency Service.

Finally, the researchers measured the following aspects of preparedness:

- *Physical preparedness (preparatory actions)*

For the bushfire study, this measure focused on whether the respondent had prepared in ways that would increase the fire resistance of their property (27 items), and prepared themselves for defending (23 items) and evacuating (six items). For the flood study, this focused on whether the respondent had completed actions on an emergency checklist (16 items). Both studies measured physical preparedness as a percentage of actions completed.

- *Planning*

This was measured with 13 items for both the bushfire and flood study. It was also measured as a percentage of actions completed.

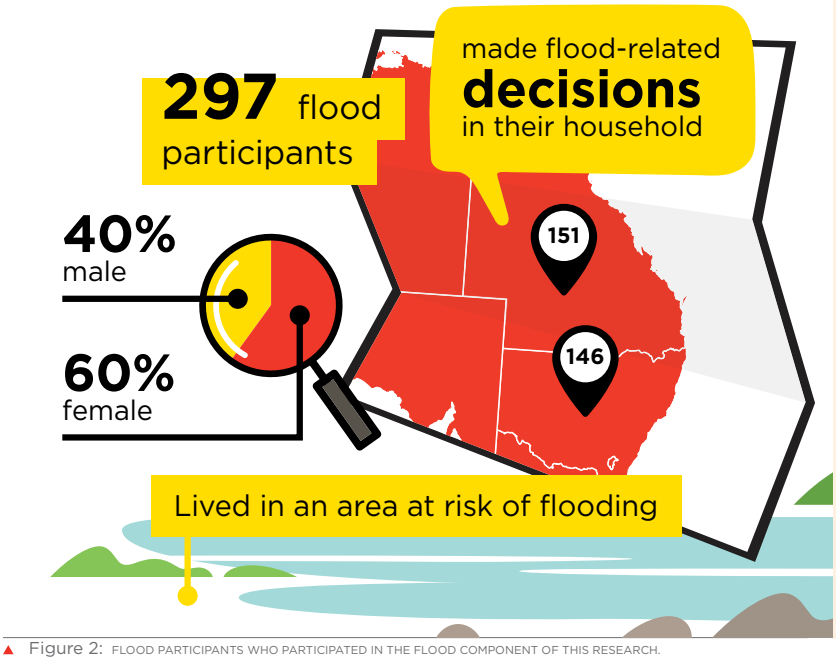


Figure 2: FLOOD PARTICIPANTS WHO PARTICIPATED IN THE FLOOD COMPONENT OF THIS RESEARCH.

END-USER STATEMENT

This research has established and helped communicate some helpful insights into the cultural norms that shape people's behaviour and attitudes towards preparedness and planning for flood and bushfire. As emergency service agencies across Australia develop and enhance community engagement, education and awareness programs, we seek increasingly innovative ways to encourage residents to proactively develop and discuss emergency plans and take actions to reduce their risk. I'm confident these findings should help emergency managers to optimise their techniques to account for and activate these norms in future programs and community development.

– Andrew Richards,
NSW State Emergency Service

- *Perceived availability of social support for response and recovery*

This was measured with six items for social support for response and six items for social support for recovery, all scored on a Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). Scale scores were calculated as the average across the six items, with a higher score indicating greater availability of social support.

- *Perceived ability to respond and recover*

This was measured with seven items of response and seven items for recovery, all rated on a Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). Scale scores were again calculated as the average across the items, with a higher score indicating greater perceived ability.

- *Financial resilience*

This was measured with three items rated on a Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). Scale scores were again calculated as the average across the items, with a higher score indicating greater financial resilience.

RESEARCH FINDINGS

The pattern of results showed many similarities between the bushfire and flood samples. Some of the key findings are broadly summarised here; for more detail please see McNeill *et. al.* 2017 in further reading.

- *Personal ability versus attitude:* overall, residents were more likely to prepare for bushfires or floods if they felt capable of doing so than if they merely had a positive attitude towards preparedness.
- *Actions speak louder than words:* respondents' perceptions of how prepared community groups were tended to be better predictors of their own bushfire or flood preparedness than perceptions of the extent to which community groups held positive attitudes towards preparing.
- *Residents versus official bodies:* Overall, preparedness appeared more strongly related to perceptions of what other residents (especially peers) thought and did than to perceptions of what the local council or emergency service thought and did.
- *What matters most depends on the group:* For local peers and residents, preparedness appeared to be more strongly connected to how prepared these groups were, rather than to how prepared these groups expected the respondents to be. The opposite was true for the local council and fire agencies; for the latter, preparedness appeared to be more strongly connected to how prepared these groups expected respondents to be rather than to how prepared these groups appeared to be themselves.

However, there were also some noteworthy differences between findings from the bushfire and flood studies.

- *Attitudes:* residents' and peers' attitude towards preparing seemed unrelated to planning and physical preparedness for bushfires, but were negatively related to these aspects of preparing for floods. For the latter, respondents who thought their peers viewed flood preparation more positively did less preparation than respondents who thought their peers' flood preparation attitudes were more negative.
- *Expectations:* the SES appeared to have a stronger influence on residents' preparedness for floods than the local fire brigade had for fire. That is, perceived expectations set by the local fire brigade appeared unrelated to physical preparedness for bushfires. However, respondents were more likely to prepare an emergency kit for floods if they believed the local SES strongly expected them to do so.
- *Financial resilience:* for floods, higher perceived preparedness of the emergency service was related to higher reported personal financial resilience by residents. This was not replicated for bushfires.
- *Emergency kit preparations:* for floods, residents who thought the SES held

higher expectations for residents' preparedness did more emergency kit preparation than those who thought the SES held milder expectations.

HOW THE RESEARCH COULD BE USED

The research results show that in formulating strategies and interventions to influence bushfire and flood preparedness through community culture, it is important to ask:

1. What aspect of preparedness needs to be influenced?
2. Which community group is mostly likely to influence this aspect of preparedness?
3. Which aspect of this community group's culture could most effectively influence this type of preparedness?

The results suggest that it might be more fruitful to give residents the perception that others in their community are well prepared than the perception that others have a positive attitude towards preparing.

It also indicates that fire and emergency services should focus on shifting residents' perceptions of social norms set by other community groups, rather than predominantly communicating the social norms held by the agencies themselves.

FUTURE DIRECTIONS

The research presented in this *Hazard Note* provides valuable information on the potential role of perceptions around community preparedness in increasing residents' preparedness for bushfires and floods. However, there are still several gaps that need to be filled by future research. The most important of these is the gap between correlation and causality. Current studies were correlational in nature, and therefore lacked any conclusive evidence around causality. Future research needs to test the extent to which intervention strategies based on these findings are effective at 1) changing the targeted community perceptions of preparedness, and 2) subsequently increasing the targeted aspects of preparedness.

FURTHER READING

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▲ **Above:** THE STUDY FOUND THAT RESIDENTS WERE MORE LIKELY TO PREPARE FOR BUSHFIRES OR FLOODS IF THEY FELT CAPABLE OF DOING SO THAN IF THEY MERELY HAD A POSITIVE ATTITUDE TOWARDS PREPAREDNESS. PHOTO: NSW SES

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HAZARD **NOTE**

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TOPICS IN THIS EDITION | COMMUNICATION | COMMUNITIES | FIRE SEVERITY | WARNINGS

COMMUNITY PREPAREDNESS, WARNINGS AND RESPONSES: NSW FIRES 2017

ABOUT THIS PROJECT

This research was conducted for the New South Wales Rural Fire Service to help to understand community preparedness and responses to bushfires in NSW in 2017.

AUTHORS

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SUMMARY

In January and February 2017, New South Wales faced some of the worst bushfire conditions ever forecast for the state, including Catastrophic fire danger ratings for many communities. During this time, a number of large and damaging fires occurred.

Following this period of activity, the New South Wales Rural Fire Service (NSW RFS) commissioned the Bushfire and Natural Hazards CRC to conduct research into community preparedness and responses by affected communities.

The research involved interviews with people affected by the Currandooley, Sir Ivan and Carwoola fires, and an online survey of residents in bushfire risk areas throughout NSW.

Key findings centre around warnings, the behaviour of those under threat and public expectations of fire and emergency service agencies. The study found that people greatly value the Fires Near Me smartphone application and NSW RFS website for warning information, believing the information to be easy to understand, useful and sufficiently localised. However, there is a need to more clearly communicate that destructive fires occur at all fire danger conditions, not just at the Catastrophic level, as well as the limitations of directly attacking a fire front when conditions are too dangerous.

The research also confirms the tendency for people to wait and observe the fire directly before getting ready to defend themselves or confirm the need to leave, even after receiving a warning.

Based on the research, the NSW RFS has put new processes in place to better liaise with communities during major fire events, and is looking to further strengthen its approach to public information through websites, smartphone applications and face-to-face communication.

▲ **Above:** FIREFIGHTERS AND LANDHOLDERS RESPONDING TO THE SIR IVAN FIRE. PHOTO: NICK MOIR, FAIRFAX MEDIA.

CONTEXT

This research looks at the experiences and insights of communities impacted by three bushfires in January and February 2017. It also investigates the perceptions of fire risk and experiences through an online survey, including responses to Catastrophic fire danger warnings during this period. The research builds on previous post-bushfire research undertaken since 2009 in NSW, Victoria, Tasmania, South Australia and Western Australia.

BACKGROUND

Following an intense period of hot and dry weather, NSW faced a period of significantly elevated fire danger during January and February 2017, peaking with large areas of the state's north experiencing Catastrophic fire danger in mid-February.

During this time, a number of significant bushfires occurred which impacted on communities. Fortunately, no human lives were lost during the worst of the conditions.

This research focused on three of these fires. The Currandooley fire, approximately 40km north west of Canberra, began on 17 January and ignited when a bird made contact with high voltage powerlines and landed in dry grass. The fire, which burned under Severe fire danger conditions, burned 3,378 hectares of land and destroyed a house, sheds, two vehicles, fences, pasture and an estimated 200 sheep and cattle. The Sir Ivan fire began on 11 February from lightning strikes near Leadville, approximately 250km

END-USER STATEMENT

In January and February 2017, NSW was faced with its most dangerous fire conditions ever forecast. During this period, there was a significant threat to the community, and a number of large and destructive fires which impacted on homes, farms and businesses.

Despite the very worst of conditions, no human lives were lost as a direct result of these fires.

The events provide the NSW RFS with an opportunity to objectively review the community's response to this period of increased danger and fire activity, and assess how we can continue to improve on the concept of a shared responsibility when it comes to fire safety.

Large emergencies like this also present the NSW RFS with an opportunity to learn and improve.

Already, the NSW RFS has put new processes in place to better liaise with communities during major fire events, and is looking to further strengthen our approach to public information through websites, smartphone applications and face-to-face communication.

The NSW RFS is also pleased to contribute to the growing national collection of post-fire research, which is providing valuable guidance to the further refinement of community safety programs across the country.

– Anthony Clark, Director Corporate Communications, NSW Rural Fire Service

north west of Sydney. The fire, which burned under Catastrophic fire danger conditions, burned 55,372 hectares of land and destroyed 35 houses, 131 outbuildings, a church and a community hall. Agricultural assets including livestock, fences, pasture and machinery were also damaged and destroyed. The Carwoola fire began on 17 February from sparks caused by a metal cutting wheel, approximately 20km south east of Canberra. The fire, which burned under Severe fire danger conditions, burned 3,134 hectares of land and destroyed 11 houses and 45 outbuildings.

BUSHFIRE AND NATURAL HAZARDS CRC RESEARCH

The research built on similar studies, including following fires in the Blue Mountains, Port Stephens, the Southern

▲ **Above:** RESEARCHERS AND NSW RFS PERSONNEL PREPARING FOR COMMUNITY INTERVIEWS AT CARWOOLA. PHOTO: NSW RFS.

Highlands, Coonabarabran, Yass and the Shoalhaven in 2013. It followed a qualitative and quantitative methodology and involved 113 interviews during June and July 2017 with people affected by the Currandooley (36 interviews), Sir Ivan (39) and Carwoola (38) fires. An online survey was also carried out in August and September 2017 of people (549 responses) threatened or affected by bushfires throughout NSW in 2017.

The interviews and surveys collected information about: the effectiveness of warnings; Catastrophic Fire Danger messages; information people sought out in relation to bushfires; the drivers and motivators for those who sought to enter fire grounds; perceptions of risk; how people value assets and prioritise their protection; the influences of previous fire history or experience on decisions and actions; public expectations of fire and emergency services; and opportunities for greater utilisation of local knowledge and participation.

This *Hazard Note* covers findings related to warnings, including understanding of Catastrophic Fire Danger, how information was accessed during the fires, perceptions of risk to homes and agricultural assets, motivations for entering fire grounds and public expectations of fire and emergency services. Full details of the research are available in the report *Community preparedness and responses to the 2017 NSW bushfires* (Whittaker J and Taylor M, 2018).

RESEARCH FINDINGS

Information and warnings

A majority of survey respondents found warnings easy to understand, up-to-date and useful. Survey respondents and interview participants expressed a preference for highly localised information.

Survey respondents most often identified the Fires Near Me smartphone application and website as their most useful information source. Fires Near Me was seen as easy to understand (88%), useful (82%) and sufficiently localised (76%). Two-thirds (66%) felt the information was up-to-date. Interviewees commonly expressed strong support and a high degree of satisfaction with Fires Near Me.

Compared to SMS warnings, landline telephone warnings were more often seen as useful (78% versus 67%), up to date (72% versus 66%) and timely (68% versus 66%). Nevertheless, survey respondents most often identified SMS as their preferred mode for delivery of warnings. Most people expected to receive warnings from multiple sources.

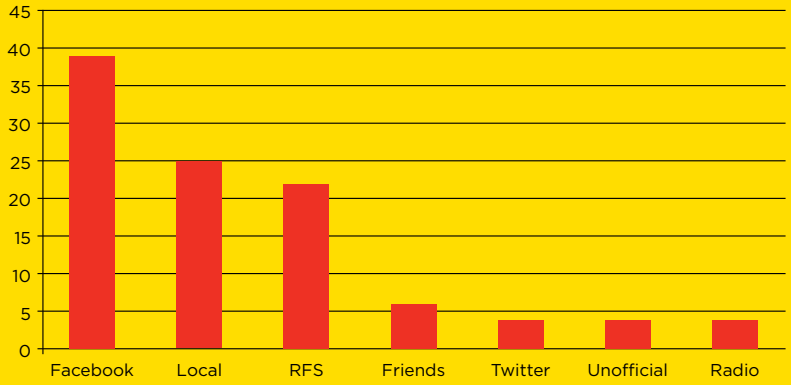
Limited mobile phone coverage, particularly in the Sir Ivan and Currandooley fires, meant that some people did not receive SMS warnings.

Catastrophic Fire Danger warnings

After the 2009 Black Saturday fires in Victoria, the fire danger warnings were revised nationally and Catastrophic was introduced as the highest level of fire danger. These conditions do not occur regularly – this was only the second time large population centres in NSW had been subject to Catastrophic Fire Danger ratings since their introduction.

Survey respondents considered Catastrophic Fire Danger warnings to be easy to understand (88%), timely (83%) and

Words and phrases used by respondents (%) when describing most useful social media source (n=143)



useful (78%). However, most people do not intend to leave before there is a fire on days of Catastrophic Fire Danger. Those who intend to leave will wait until there is a fire, and others intend to stay and defend. The research also shows that some people may underestimate the risks to life and property if the fire danger is not Catastrophic.

Receipt of an official warning about Catastrophic Fire Danger prompted survey respondents to discuss the threat with family, friends or neighbours (63%) and look for information about bushfires in their area (62%). Equal proportions began preparing to defend (39%) or leave (39%) and a smaller proportion (12%) left for a place of safety.

When asked what they would do next time they received a message about Catastrophic Fire Danger, 12% of survey respondents said they would leave before there is a fire and 24% said they would wait until a fire started, then leave. 27% reported that they would get ready to stay and defend, while 24% said they would wait for a fire before deciding what to do.

Analysis of interview data highlights that many people believe it is impractical to leave on days of Catastrophic Fire Danger before there is a fire. Many are also committed to defending, despite being aware of the increased risks to life on such days.

Interviews with people affected by the Carwoola and Currandooley fires suggests that some people underappreciate the risks to life and property on days that are not Catastrophic. In contrast, some interviewees affected by the Sir Ivan fire did not anticipate the size or severity of the fire, despite forewarning of the Catastrophic Fire Danger they would experience. Many felt that they were prepared to respond to smaller fires, which were more common in the area, but believed there was little they could have done to prepare for a fire of the size and severity that was experienced.

How people accessed information

Half of all survey respondents accessed information via the internet (53%). They most commonly sought information about the location of the fire (91%), traffic and road blocks (64%) and weather conditions (60%). Around half looked for information about firefighting activities (54%) and the likely time of impact (43%). Websites most commonly used included Fires Near Me (in addition to the app), the NSW RFS, Bureau of Meteorology and various Facebook pages (including local RFS and community pages). Almost two-thirds (62%) of all survey respondents used social media during the fires.

Interviewees and survey respondents often sought information about the fire through direct observation. Consistent with findings from past research, many residents left their homes and properties to go and look at the fire. For some people, observing the fire appears to have helped ready themselves to defend and, for others, confirmed the need to leave.

Perception of risk to and value of agricultural assets versus homes

Perceptions of value and risk to agricultural and domestic assets are complex. Economic value is important in decisions about what to protect, but is balanced against utility and sentimental values.

Many farm properties were large, with a wide distribution of assets. Some landholders also had additional blocks that came under threat. They often did what they could to prepare, for example by ploughing fire breaks and moving livestock, then 'fell back' to protect what was manageable, typically the house and nearby paddocks and sheds. This appears to have been based on an assessment of what was possible with available resources and not necessarily what was valued most.

Drivers and motivators for returning

The majority of survey respondents were at home when they found out about the bushfire (60%). Of those who were not at home, 71% indicated that they tried to return to their house or property.

The drivers for returning to fire-affected areas are many, but most often revolve around the desire to protect houses and property, rescue or assist vulnerable people, and protect animals.

While some interviewees complied with roadblocks, others described passing through or circumventing roadblocks in order to return. Some interviewees used backroads or gates through private property to return, sometimes on foot or in vehicles that were unsuitable for the roads, tracks

WHAT WAS SAID

'The Fires Near Me app was very good actually because I could see exactly where the fire was going and the local area and all that sort of stuff. That was good because I could see that it got out of hand, and it had jumped the highway and that's when I knew it was gone.'
- Cassilis

'That day wasn't even really high on my radar in terms of fire danger. It was a hot day, and there was a bit of wind, but it wasn't Catastrophic. It wasn't like two or three weekends prior to that when it was 45 degrees and blowing a gale. It just proves that accidents can create a big fire.'
- Carwoola

'When we came out here we knew that we had a responsibility to manage our fire risk and we did what we could to reduce the fuel load and have a good plan in place to save ourselves … We've sometimes found it a bit daunting about how we do all of that … We did not expect that council or the RFS would come in and save us. We believed that it was our responsibility to be aware of the risk and manage it.'
- Carwoola

and paddocks that were used. There was a perception that some people were exposed to more danger than if they had passed through the roadblock.

Public expectations of fire services

It is generally well understood that there are resource constraints during major fires (e.g. "there are not enough fire trucks for every property"). However, there is less appreciation of the operational constraints of large and dangerous fires, and that often it can be too dangerous for firefighters to directly attack the fire front.

Most interviewees affected by the Currandooley and Carwoola fires praised the efforts of firefighters and did not expect to receive personal firefighting support. Residents in Carwoola were particularly cognisant of the limits of support from fire agencies, a message that had been clearly communicated by the local brigade over time.

Some interviewees affected by the Sir Ivan fire were more critical of the firefighting response. Criticisms were varied but centred on the perceived lack of firefighting in the agricultural lands between Leadville and Cassilis. Some saw the fire service as overly bureaucratic and risk averse. These criticisms reflect a mismatch in expectations and should be viewed in the context of a large, destructive bushfire that burnt under Catastrophic conditions, where there was limited operational capacity or opportunity to deal with such fires due to dangerous conditions.

▲ **Above:** BURNT LAND SURROUNDS A HOUSE THAT SURVIVED A NSW FIRE. PHOTO: NSW RFS

FURTHER READING

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CONCLUSION

The research confirms the tendency for people to wait and observe the fire directly before getting ready to defend themselves or confirm the need to leave. This behaviour presents opportunities for emergency service personnel to meet people at a time when they are seeking and receptive to information and advice.

While there is strong appreciation for the danger of fires under Catastrophic conditions, there is a need to more clearly communicate the risks posed by fires burning under non-Catastrophic conditions. Such messages could be incorporated into community education and engagement resources, as well as emergency warnings and information.

There is potential to develop additional resources to assist agricultural landholders to plan and prepare for bushfire. Resources are needed to help businesses more systematically identify assets and values, prioritise, and plan for their protection. These materials could include best practice case studies and information about insurance.

There is a need to more clearly communicate the limits to response capacity. In addition to limitations due to resource constraints, which are generally well-understood by the public, there is potential for enhanced communication about the dangers large and fast-moving fires pose to firefighters and that it can be too dangerous for direct attack on the fire front. Findings suggest that local brigades could be effective in communicating these messages; however, this may require considerable engagement and training.

The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

HAZARD **NOTE**

bushfire&natural HAZARDSCRC

ISSUE 35 JUNE 2017

TOPICS IN THIS EDITION | ANIMALS | COMMUNICATION | COMMUNITIES

COMMUNITY TAKING LEAD IN EMERGENCY PLANNING FOR THEIR ANIMALS

ABOUT THIS PROJECT

This research was conducted as part of the *Managing animals in disasters* project. The project has identified best practice approaches to animal emergency management that result in improved outcomes for community members, emergency responders and animals.

AUTHORS

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▲ **Above:** 63% OF AUSTRALIAN HOUSEHOLDS OWN PETS AND 90% OF OWNERS CONSIDER THEIR PETS TO BE FAMILY MEMBERS. THIS HAS SERIOUS IMPLICATIONS DURING AN EMERGENCY.

SUMMARY

During a disaster, animal owners are responsible for their animals. However, owners are often ill-prepared to protect both themselves and their animals. This can endanger the lives of both if, for example, owners evacuate too late or not at all. As noted by United States' experts in emergency management: "There is no other factor contributing as much to human evacuation failure in disasters, that is under the control of emergency management when a threat is imminent, as pet ownership." (Heath and Linnabary, 2015.)

Australia's National Strategy for Disaster Resilience states that communities should be empowered to share responsibility for disaster resilience. Animals provide an avenue to connect communities, and to enable community members to work together in disaster preparedness and planning. To explore this further, the *Managing animals in disasters* (MAiD) project has teamed with a newly formed community-led group in the New South Wales Blue Mountains called Blue Mountains Animal Ready Community (Blue ARC). The project takes a novel approach, which is believed to be an Australian first, by focusing on animal owners and community groups. It explores a 'community-to-community' approach to enhancing awareness, preparedness, and planning for animals in emergencies; identifying key activities, outputs, and processes that can be translated for use by other communities; and providing emergency response agencies with another route to community engagement.

By highlighting the impact of animals on the behaviours of people in natural hazards, this project has reinforced the need to support communities to be prepared and to plan for animals.

CONTEXT

This study focuses on a bushfire-prone area, engaging and working with community members to develop local resources to support planning and preparedness for animals in emergencies. The outputs will be transferable to other communities and natural hazard contexts, such as floods and cyclones, and will provide opportunities for individuals, communities, and emergency response organisations to work collaboratively.

BACKGROUND

In recent years there has been increasing recognition that animals need to be considered and integrated into emergency management and disaster preparedness, response and recovery. In the domestic context alone, this recognition is reinforced by the pervasiveness of pet ownership: 63% of Australian households own pets and 90% of owners consider their pets to be family members.

The consideration of animals in emergency management poses more challenges for traditional responding. It demands extra preparation, knowledge and skills to ensure the safety of animals, their owners, and responders. In this context, animal emergency management has emerged as a relatively new area, with a more complex and often less experienced set of stakeholders who require integration and coordination

into emergency management policy and planning.

Most research in animal emergency management has emerged from the United States following extensive and widely reported animal-related challenges associated with Hurricane Katrina and subsequent natural hazards. Although animal owners in the US and Australia have much in common, emergency management and the typical scale of disasters are quite different, making translation of US research to Australia difficult.

The MAiD project has addressed the lack of Australian research by identifying challenges for end-users, studying the disaster experiences of animal owners and responders, and identified best practice approaches.

BUSHFIRE AND NATURAL HAZARDS CRC RESEARCH

The MAiD team proposes animal emergency management as a novel way to engage animal owners to prepare for emergencies, to improve response compliance with official direction, and to improve the psychosocial outcomes for people after disasters. The Blue ARC study detailed in this *Hazard Note* identifies routes for engagement with, and within, communities to promote emergency planning and preparedness for animals (and their owners) and reinforce a community culture of shared responsibility.

This research builds on previous studies completed during the project that have revealed that emergency response organisations and other stakeholder groups face challenges and uncertainty in animal emergency management. These challenges include their responsibilities and role in the management and rescue of animals and in their interactions with, and management of, animal owners (Taylor *et al.*, 2015). Working with Blue ARC takes a novel approach to consider the perspectives and experiences of animal owners and community groups, and the role they can play in supporting themselves before, during and after an event. Different perspectives were explored within the Blue Mountains community, including individuals, animal interest groups, community groups (for example, neighbourhood centres), veterinarians and official response organisations.

The researchers conducted an online survey to understand the experiences and needs of the local community. The survey targeted:

- Residents living in or around the Blue Mountains, who either own, care for, and/or work with companion animals, livestock, and/or wildlife
- Previous residents of the Blue Mountains and surrounding areas who experienced an emergency event that impacted the animals in their care, and
- Anyone who was employed, or had a voluntary role, helping animals and/or their owners during a previous emergency event in or around the Blue Mountains.

The survey was completed by 386 people between February and May 2017. It collected information that aimed to:

- Assess local community emergency preparedness for animals
- Learn about experiences and identify issues that have occurred in previous emergencies regarding animals, and
- Identify local needs and gaps in preparing and planning for animals.

The researchers also interviewed representatives of emergency services, NGOs, and local stakeholders to discuss previous emergency events and local issues. As of June 2017, an audit of local veterinary services was also underway.

Above: THIS RESEARCH HAS REINFORCED THE NEED TO SUPPORT COMMUNITIES TO BE PREPARED AND TO PLAN FOR ANIMALS WHEN CONSIDERING THEIR EMERGENCY ARRANGEMENTS.

END-USER STATEMENT

This research has allowed us to map animal ownership, and to survey animal owners about their response arrangements in a disaster. We are seeing some more tailored tools and products for the industry as a result of this research, which will be a real blessing for what has been a bit of a wicked problem for emergency services in the past.

– Andrew Richards, Manager Community Engagement, NSW State Emergency Service

RESEARCH OUTCOMES

General preparedness

The survey revealed that most respondents (82%) had considered what they would do in an emergency situation and of those, 70% had considered their animals in their emergency planning. However, combined, this only amounted to 57% of the sample overall being prepared in planning for their animals. Most planning was low level, that is, restricted to thinking about and discussing what to do in an emergency. Only one fifth of respondents felt 'very prepared' and had a written or well-rehearsed emergency plan. Only 47% knew with certainty where they would take their animals if they had to evacuate, and only 20% had asked a neighbour, nearby friend or family member if they would help evacuate their animals in their absence. As more than 50% of employed residents in the Blue Mountains commute away from the mountains for work, having this back-up support is extremely important.

Forty-nine per cent reported that they needed more information to be able to prepare and plan for their animals and 62% expected that emergency services would provide that information. Respondents relied more on emergency services for information than any other groups, including local veterinarians (58%), RSPCA (40%), social media (46%) or family and friends (44%). This reinforces why it is essential that emergency services engage with local communities in this area.

Evacuees' experiences

Those who evacuated with animals in a previous emergency reported a low level of planning beforehand. Emergency preparedness for animals is important as it can be time consuming and stressful for owners to search for items, such as a cat carrier, or consider where they can evacuate to with animals. As one respondent recalled during an evacuation: "*We could not access two cat carriers as they were in storage in garage. Police escorted us out and we had to leave immediately so we just put cats in the*

▲ **Above:** SES PERSONNEL TRAINING FOR A HORSE RESCUE.

BLUE MOUNTAINS EVACUEES' EXPERIENCES WITH ANIMALS

"The first time [we evacuated] I just took the dogs out and sat in the park with them. The second time we took the dogs and the cat and took the dogs to our daughters and the cat we temporarily put into board with a vet in Sydney. We had no options for the chickens, we had to leave them."

"I took two horses to a neighbour's house, around the corner. I then came home, loaded the other two horses and then went back to the neighbours where someone else offered to take the first two to the showground so we could get there in one trip. I left my dog at home with my husband."

"Rang Lithgow Vets and they found room for the cats. Did not know of anybody else that I could contact – information is scarce if you don't know where to get it from."

car." In contrast, another respondent valued being prepared for her animals: *"I always keep an emergency bag next to the door with food, water, bowls and blankets – reduced the stress enormously on the day knowing we could just scoop up the cat and go."*

Not all animals are equal. Residents reported having many animals with special needs, for example, behavioural or health issues. Residents also keep multiple animals of different species, which makes evacuation more complex. Although most respondents reported taking animals with them, some reported leaving a person behind to look after the animals, and others had to choose which animals to leave. This points to a need for advice on how to prepare for specific types of animals. As one resident who evacuated during the October 2013 bushfires reported: *"Worrying about the animals was one of the most stressful parts of the entire process for me."*

On reflection, many of those who experienced a disaster suggest that planning be done within the community, and include neighbours, family, and veterinarians. Being prepared and having community support can also assist with recovery. Seven per cent reported that their animals went missing or died, and reported that it had a significant impact on their recovery from the fires.

HOW COULD THE RESEARCH BE USED?

This research will inform the production of a community guide to establishing an Animal Ready Community (ARC; see Future Directions below).

The MAiD project has addressed gaps in evidence in Australian animal emergency management, moving from anecdotal knowledge to targeted studies. The project's audit of animal emergency management has provided a national overview of its status. The provision of an up-to-date evidence base enables end-users and stakeholders to make better informed decisions on planning and targeting of resources.

By highlighting the impact of animals on the behaviours of people in natural hazard emergencies, this project has reinforced the need to support communities to be prepared and to plan for animals. The researchers have identified the issues owners have encountered in a range of jurisdictional operational contexts and natural hazard events. By identifying the concerns and problems faced in preparedness, response, and recovery, this project has been providing emergency services and other stakeholders with information on priority community issues that can be addressed for the greatest gains in public and responder safety. These areas also provide pointers for emergency services as potential routes to engagement with communities.

In a high risk, fire-prone area such as the Blue Mountains, it is critical that the community is engaged in emergency preparedness and has a strong sense of shared responsibility for preparedness and planning. The MAiD collaboration with Blue ARC is providing a proof-of-concept approach to addressing animal emergency management with similar at-risk communities.

The benefits to CRC end-users of having a self-organised community in this area have been documented in case studies by another CRC project (Out of uniform: building community resilience through non-traditional emergency volunteering). In animal emergency management specifically, such initiatives can provide extra capacity and reach for emergency services. Such groups, with their broader community networks, can harness additional community capacity, including access to those with animal-specific handling skills.

The community is the end-user for the outputs from the collaboration with Blue ARC. Identified local barriers to community planning and preparedness for animals are now being discussed with local emergency

▲ **Above:** A POSTER ADVERTISING THE RESEARCH IN THE BLUE MOUNTAINS AREA.

management groups, including the local councils, NSW Rural Fire Service, NGOs, and neighbourhood centres. The mapping and availability of local resources for veterinary services and animal boarding facilities will enable community members to plan ahead. The 'community-to-community' activities of Blue ARC ensure that local solutions to identified problems are communicated back to the community.

FUTURE DIRECTIONS

The experience of observing and supporting a community-led group, such as Blue ARC, provides the opportunity to learn from the group start-up process in this area of emergency management. A future goal is to create a 'how to' guide and resource pack, that would be available for other communities. This guide could be used to promote emergency preparedness and planning through a focus on animals. Its advice could include the networks and collaborations required, how to identify the needs of local animal owners, and suggestions for community activities. The resource pack will include materials developed as part of the current project, including a question bank for surveys, templates for posters and fact sheets and plans for low-cost community training.

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The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

HAZARD **NOTE**

bushfire&natural HAZARDSCRC

ISSUE 20 OCTOBER 2016

TOPICS IN THIS EDITION | FLOOD | WARNINGS | DECISION MAKING

WHERE, WHY AND HOW ARE AUSTRALIANS DYING IN FLOODS?

ABOUT THIS PROJECT

In order to provide an evidence base for policy and practise, the *Analysis of human fatalities and building losses from natural disasters* project is measuring and gaining a greater understanding of the impacts of natural hazards in terms of the toll of human life, injuries and building damage. Trends over time are being analysed in the context of emerging issues such as an ageing population, population shifts and changing building codes.

▲ **Above:** THE HIGHEST PROPORTION OF FLOOD FATALITIES IN AUSTRALIA HAVE OCCURRED WHEN VICTIMS WERE ATTEMPTING TO CROSS FLOODWATERS. PHOTO: COUNTRY FIRE AUTHORITY.

AUTHORS

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SUMMARY

This *Hazard Note* documents the analysis of the circumstances surrounding fatalities due to flooding in Australia from 1900 to 2015. The investigation includes exploring the socio-demographic and environmental factors surrounding the deaths. Overall there have been 1,859 fatalities within the 115 years, with distinct trends in relation to gender, age, activity and reason. The most deaths have occurred in Queensland and New South Wales. The majority of fatalities are male (79%) with children and young adults (<29) making up the greatest proportion of the fatalities.

The data shows a statistically significant decreasing death rate from 1900 to 1960. Although a very slight decrease in death rates is discernible between 1960 and 2015, it is not statistically significant. The female-to-male fatality ratio has increased since 1960, increasing from 16.9% females from 1900-1959 to 28.3% from 1960-2015.

An increase in fatalities associated with motor vehicles is evident in recent decades, and in particular, 75% of all fatalities associated with 4WD vehicles has been observed in the last 15 years.

Measuring and understanding the impacts of natural hazards in terms of the toll on human life is a fundamental first step to enabling efficient and strategic risk reduction. Outcomes of this research have significantly contributed to the Prevention of Flood Related Fatalities Working Group of the Community Engagement Sub-committee of the Australia and New Zealand Emergency Management Committee with their investigations into preventing flood fatalities. The research will also influence policy, practise, education initiatives and resource allocation across emergency management.

CONTEXT

Fatalities from floods are a major cause of natural hazard deaths around the globe. Here in Australia, floods are ranked second (following heatwaves) in terms of the total number of natural hazard fatalities since 1900 (see Table 1, right). The June 2016 flooding in New South Wales and Tasmania led to a number of deaths and hundreds of rescues, while the September and October 2016 flooding across South Australia and Victoria also resulted in a number of rescues. These recent cases, once again, highlight the significant dangers of floodwaters. This research suggests that many flood deaths are avoidable.

TABLE 1: AUSTRALIA'S TOP FIVE NATURAL HAZARD KILLERS

HAZARD	PERIOD OF COVERAGE	FATALITIES
Extreme heat[1]	1900-2011	4,555
Flood[2]	1900-2015	1,859
Tropical cyclone[4]	1900-2015	1,208
Bushfire[3]	1900-2011	825
Wind storm[4]	1900-2015	495

[1] Coates *et al.*, 2014
[2] Haynes *et al.*, 2016
[3] Blanchi *et al.*, 2014
[4] Recent updates to PerilAUS

BACKGROUND

Despite the significance of flood mortality, both within Australia and worldwide, few studies have explored the trends and characteristics associated with flood fatalities in detail. Within the Australian context a number of questions remained unanswered, including:

- What are the socio-demographics of people who die in floods?
- What were the circumstances, capacities, knowledge and motivations that led to the choices that ended in a fatality?
- What are the spatial and temporal trends within the data?
- What is the relationship between the fatalities and the hazard characteristics?
- Were any of these deaths avoidable?

In order to answer these questions, this study provides a longitudinal and in-depth analysis of the social and environmental circumstances that led to each fatality. The results show clear trends over time in terms of exposure and vulnerability. A scientific approach to the collection and analysis of this information provides governments, emergency service agencies and the wider community with the empirical evidence on which to base effective decision-making.

RESEARCH ACTIVITY

The project was completed in two steps:

1. **Updating the data held within PerilAUS, Risk Frontiers' database of historical natural hazard impacts.**

PerilAUS is a database of impacts and consequences of natural hazards in Australia, largely based on material collected from the media, government departments and published literature. It was deemed a good basis for this project due to the length of period covered, the wealth of descriptive detail concerning the hazard impact and the inclusion of data about any fatalities caused by that hazard. However the database needed to be augmented and verified through the use of coronial inquest reports. This information provided additional and more detailed data about the social, demographic and environmental circumstances of each fatality.

2. **Statistical analysis to determine the lives lost and the environmental and social circumstances surrounding those fatalities.**

The data was analysed in relation to informing the understanding of the circumstances surrounding the deaths and how this information could best be utilised for emergency management policy and practise. This included a longitudinal analysis of the resulting statistics, examining demographics (age, gender), location (state), seasonality and circumstances surrounding the fatality – both environmental (e.g. the event intensity) and social (e.g. factors around the decisions or actions which led to death).

RESEARCH OUTCOMES

Demographics

Overall there have been 1,859 fatalities since 1900, with distinct trends in relation to gender, age, activity and reason. The majority of these deaths occurred in events where one or two people died. The analysis of flood severity against numbers killed per event indicates that the majority of fatalities occurred in minor or moderate floods. The greatest percentage of women died in urban settings in a local flash flood or a low-level short duration flood.

The majority of the fatalities are male (79.3%), with children and young adults (<29) making up the greatest proportion of the fatalities. Overall, flood death rates show an interesting trend (Figure 1, below).

FIGURE 1: DEATH RATES DUE TO FLOOD 1900-2015

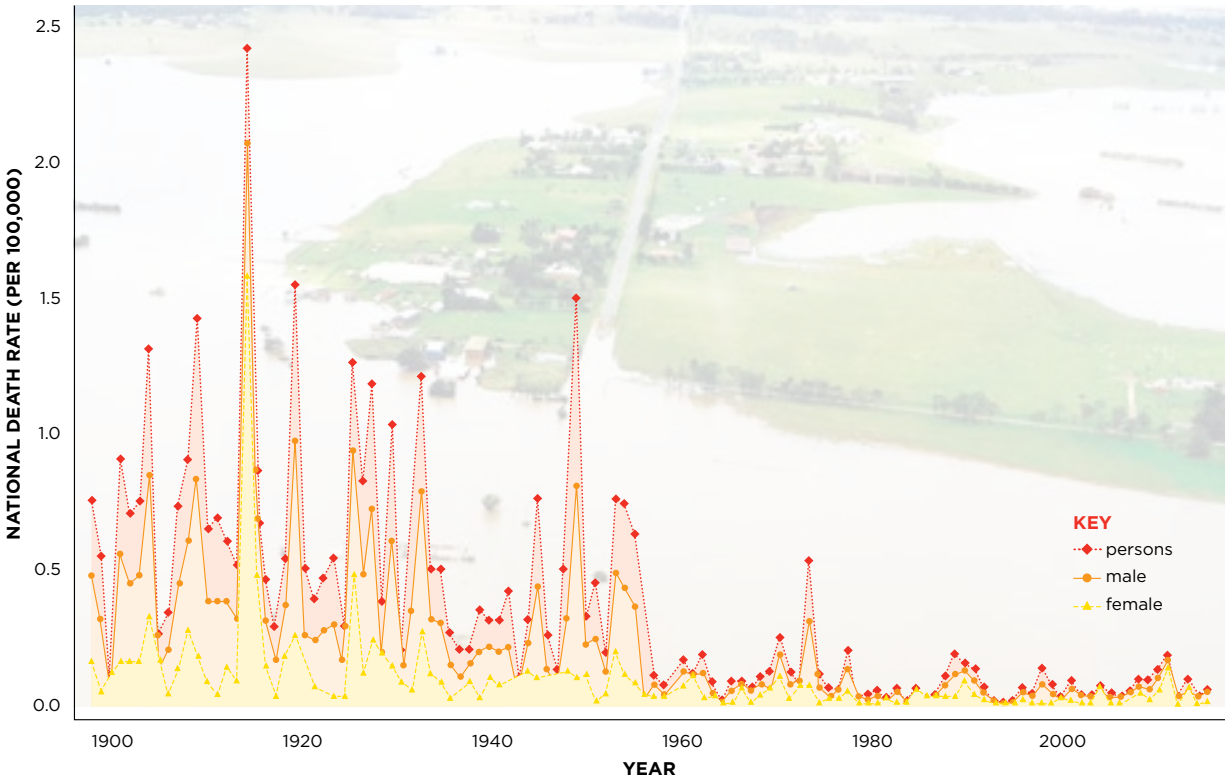

TABLE 2: FLOOD FATALITIES BY ACTIVITY PRIOR TO DEATH AND GENDER, 1960-2015 (% OF COLUMN TOTALS)

ACTIVITY	MALE FATALITIES	FEMALE FATALITIES	FATALITIES WHERE GENDER UNKNOWN	TOTAL FATALITIES
Attempting to cross bridge/causeway/ crossing/culvert/ford/watercourse	183 (46.6%)	80 (55.2%)	2 (25%)	265 (48.5%)
Attempting to cross floodwaters away from watercourses (water over fields/town)	17 (4.3%)	3 (2.1%)	0 (0%)	20 (3.7%)
Engaged in an activity near the water (on the bank/bridge)	32 (8.1%)	11 (7.6%)	0 (8.3%)	43 (7.9%)
Engaged in an activity in/near stormwater drain	21 (5.3%)	9 (6.2%)	0 (0%)	30 (5.5%)
Engaged in an activity in the water (rescue, swimming)	48 (12.2%)	12 (8.3%)	0 (0%)	60 (11%)
Engaged in an activity on the water (boat)	22 (5.6%)	1 (0.7%)	0 (0%)	23 (4.2%)
Engaged in an activity not near usual watercourse (e.g. in their home)	28 (7.1%)	18 (12.6%)	0 (0%)	46 (8.4%)
Other	2 (0.5%)	1 (0.7%)	0 (0%)	3 (0.6%)
Unknown	40 (10.2%)	10 (6.9%)	6 (66.7%)	56 (10.3%)
Total	**393 (100%)**	**145 (100%)**	**8 (100%)**	**546 (100%)**

Between 1900 and 1959 there is a significant decrease in flood fatality rate (slope = -0.05449, p <0.02). This means the fatality rate was decreasing by 0.055 deaths per million in the population per year. In contrast, from 1960-2015 the fatality rate has been decreasing by 0.00645 per million in the population per year. However, this decrease in flood fatality rate is not statistically significant. It is likely that investments in flood mitigation, technology, warning and communication systems, and the work of emergency service organisations such as the State Emergency Service, have had a major impact on death rates, particularly in the years following World War II. However, the negligible decrease in flood fatalities since the 1960s raises questions about the efficacy of current risk mitigation and education strategies. With all the work in this area, should the death rate have decreased further? It may even be possible that structural mitigation, such as levees, have actually increased risks – as development continues people may assume they are protected and as such do not prepare or evacuate in time. Furthermore, the significantly different proportion of female-to-male fatalities suggests that a gendered approach to risk education and warnings is necessary.

Given the differences in the way of life, and the trends seen in the data since 1960, a detailed exploration of this data will be provided below. There have been 546 fatalities since 1960; similar to the overall dataset the majority are male (72.2%, n=394), with children and young adults (<29) making up the greatest proportion (44.5%, n=243).

Geographic and seasonal trends

The highest numbers of fatalities since 1960 have occurred in Queensland and NSW, with the toll in these two states accounting for 76.7% of the fatalities during this period across the nation. However, the death rates per capita highlight the increased level of risk in the Northern Territory, where the fatality rate per capita since 1960 has been five times as great as NSW and more than three times as great as Queensland. A seasonal breakdown of deaths by states and territories shows that the majority of fatalities in Queensland, NSW and the NT occurred during summer (the monsoon season in Queensland and the NT, while NSW is often subject to intense downpours), predominantly in December to March. There is also a fairly high proportion of deaths in NSW in June to August that are associated with winter storms. In contrast, deaths in the other states are more evenly distributed throughout the year.

A spatial analysis of fatalities between 2000 and 2015 found that 58% of people died within 20 kilometres of their home.

END USER STATEMENT

Flood fatalities and rescues, as a consequence of risky behaviour, are a constant issue for emergency services. Hundreds of flood rescues were conducted during the September and October 2016 South Australian and Victorian floods, the June 2016 floods in NSW and Tasmania and the April 2015 floods in NSW and Queensland. Many rescues involved motorists trapped in or on their cars. Unfortunately, these floods also resulted in a number of deaths.

This study has highlighted the significant number of fatalities that have occurred as a consequence of flooding compared to other hazards, particularly as a result of driving through floodwater.

Outputs to date have provided significant input to the national Attorney-General's Department-funded project within the Australia and New Zealand Emergency Management Committee, looking at the way forward within government policy and practise to reduce the number of flood fatalities. The project has also assisted the understanding within emergency services of the causal factors of flood fatalities, along with internal awareness within NSW SES.

– Dr Elspeth Rae, Planning and Research Officer, NSW State Emergency Service

Activities and motivations

Information on activities at the time of death and the motivations for these were obtained from coronial inquest reports, particularly witness statements. Results are presented in Table 2 (page 3). The highest proportion of fatalities occurred while victims attempted to cross a bridge, causeway, culvert, or road (men: 46.6%, n=183; women: 55.2%, n=80). The most common intended destination of those who died was their home. The second highest activity for females at the time of death, accounting for 12.6% of all female fatalities, was being engaged in an activity not near a usual watercourse, for example, driving through a town or near their home and being surprised by flash flooding. For men this was the fourth highest cause of death (7.1%).

Engaging in activity in the water (e.g. attempting a rescue, swimming etc), was the second highest for males and the third highest for females, accounting for 12.2% and 8.3% of fatalities respectively. Engaging in an activity near the water was the third highest action resulting in a fatality for men (8.1%) and the fourth for women (7.6%). The majority of these victims who were in or near the water at the time of their death were recreating, with children and young people (<19 years) accounting for the greatest proportion of these fatalities. A significant cause of these deaths was children playing in or near stormwater drains.

Capacity to act

Analysis of flood fatalities since 1960 suggests that the majority of victims were capable of independent action (55.5%) and aware of the flood (60.8%). However, the speed and/or depth took them by surprise, reducing the victim's capacity to act.

Higher proportions of deaths occurred amongst two clear demographic groups – children and women who were following the decisions of others, and children and youths who were on their own or in a group. Of this latter group, the majority were boys.

Car-related fatalities

The numbers of fatalities on foot have remained steady since 1960 and this remains a high proportion of flood-related fatalities (25.3% of all fatalities since 1960). However, fatalities associated with vehicles make up the greatest proportion, accounting for 41.9% of fatalities since 1960 (n=229). In particular, fatalities associated with 4WD vehicles have increased steeply over the last two decades (75% of 4WD deaths have occurred since 2000). The vast majority of those driving a motorised vehicle were men (81.1%), while the gender breakdown of passengers shows that 53.4% were female and 46.6% were male. A fairly large proportion of the fatalities among children and youth are associated with vehicles (34.1%), the majority of whom were passengers. Where the time of death was known, the majority of all those in a vehicle perished at night or during twilight (63.4%), when visibility was poor.

RESEARCH IMPACT

The results of this research have significantly contributed to the Prevention of Flood Related Fatalities Working Group of the Community Engagement Sub-committee of the Australia and New Zealand Emergency Management Committee with their investigations into preventing flood fatalities. This report was prepared by the NSW State Emergency Service, with a working group comprised of policy makers, practitioners and researchers involved in flood risk management from Australia and New Zealand. In addition, the NSW SES has used the findings of the research for community outreach, internal awareness raising and training purposes.

The research received a high commendation award at the 2016 Floodplain Management Australia conference. The award was given to highlight excellence in terms of the quality of the research, its utility for end-users and the interactive presentation delivery.

FUTURE DIRECTIONS

There has been limited research to date that rigorously evaluates the efficacy of existing education, incentives and structural measures (e.g. the use of barricades to prevent a car being washed off a road) in reducing loss of life in floods. In order to prevent life loss and ensure efforts are targeted effectively this needs to be addressed. In relation to the findings of this project and in discussion with end-users, particularly the NSW SES, the following research priority areas are highlighted:

- Evaluate messaging and terminology used with different socio-demographic groups – women, men and children;
- Evaluate the efficacy of education, incentives and enforcement of new laws relating to floods;
- Evaluate signage options and smart technology for warning people about flood waters and dangers well ahead;
- Better understand the decision-making processes of those who do and do not drive through floodwaters;
- Investigate the behaviour of people in vehicles, and in particular, how passengers can be educated and empowered to influence driver behaviour.

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The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

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HAZARD **NOTE**

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TOPICS IN THIS EDITION | COMMUNITY SAFETY | RISK

SAMPSON FLAT COMMUNITY BUSHFIRE EXPERIENCES

SUMMARY

After a major bushfire impacted communities less than two kilometres from Adelaide's suburban edge in January 2015, the South Australian Country Fire Service (CFS) commissioned this research to explore three key questions: what factors affected residents' planning, preparation and actions on the day; the influence of CFS Community Fire Safe groups on bushfire safety; and the effectiveness of information and warnings for people living in the rural/urban interface. The approach followed studies conducted after other major bushfires. The findings were similar, however they provided some new insights, including that although the majority of people felt physically prepared for a fire, only half felt emotionally prepared for the impacts of the fire and its aftermath. Just over one quarter of respondents had a written bushfire survival plan (a strong result compared with the average seen in previous studies of five percent) and nearly 90% had had a discussion about what to do in the event of a bushfire. Being part of a Community Fire Safe group had a positive impact on both planning and preparation. This project showed that the collective learnings from other post-fire studies and the actions being taken by CFS to implement these learnings are being translated into actions in the community.

ABOUT THIS PROJECT

This research was conducted for the CFS by the Bushfire and Natural Hazards CRC through the South Australian-based Appleton Institute of CQUniversity. The CFS aims to use the findings to better support communities in preparing for bushfire and understanding its consequences. The study delivers valuable knowledge on key issues of emotional preparedness, Community Fire Safe groups, and messaging for those living in the rural/urban interface.

AUTHORS

Dr Danielle Every, Dr Amy Reynolds, Dr Larissa Clarkson, A/Prof Chris Bearman, Dr Raymond Matthews, Laura Haigh and Prof Drew Dawson, CQUniversity.

▲ **Above:** COMMUNITY MEMBERS AND CFS PERSONNEL WATCH THE SAMPSON FLAT FIRE. PHOTO: ANGRY PLANET.

CONTEXT

The research into the 2015 Sampson Flat bushfire in the northern Adelaide Hills provides a valuable insight into the community and organisational challenges that may arise in other rural/urban interface fires. The research draws on the community experiences of this fire to provide a greater understanding of how to meet these challenges, focusing particularly on three issues: 1) planning, preparation and action; 2) CFS Community Fire Safe groups; and 3) information and warnings in the rural/urban interface.

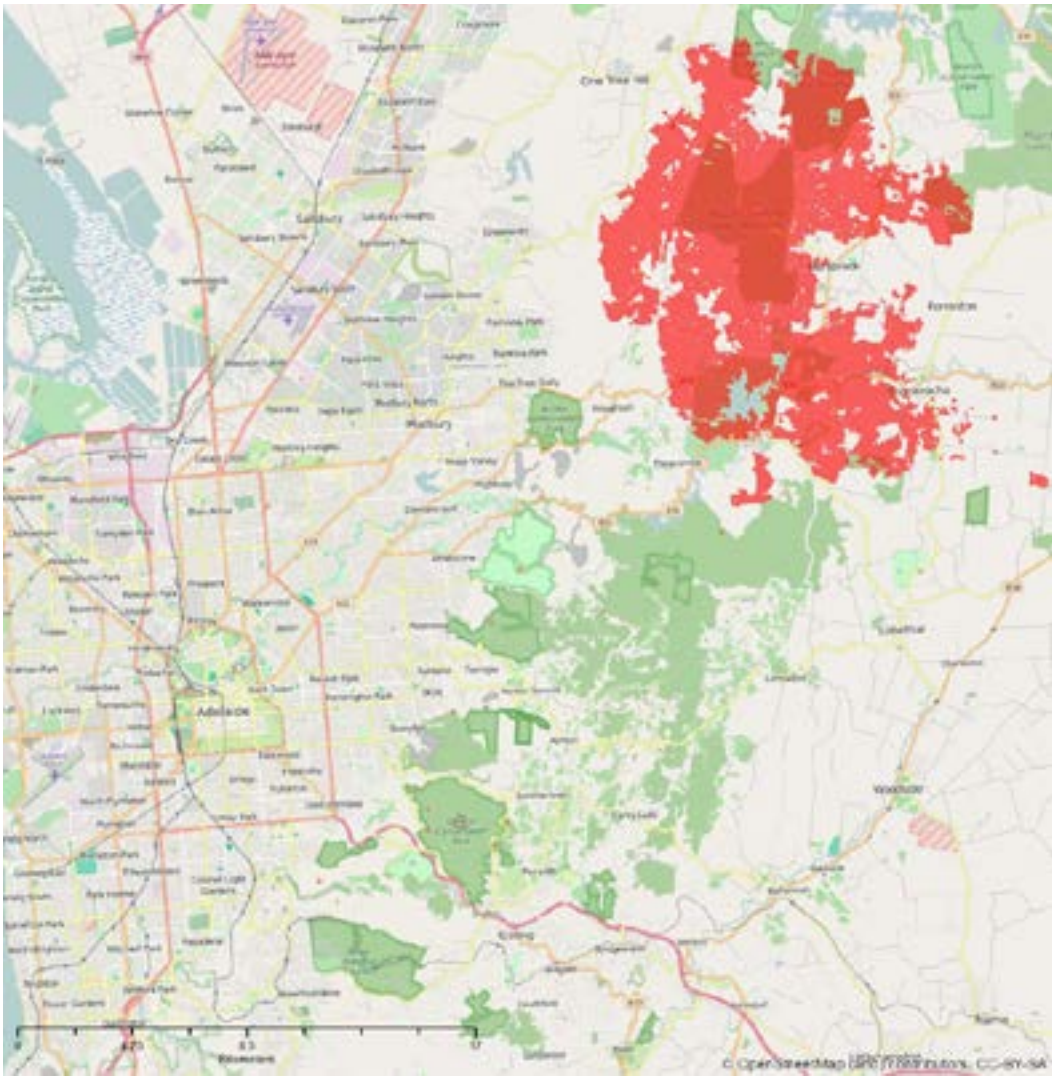
BACKGROUND

The Sampson Flat bushfire started on 2 January 2015, a day of forecast 'catastrophic' fire conditions in the Adelaide Hills. The ignition point was six km from the suburban edge, and 30 km north east of the Adelaide CBD. The fire burnt approximately 12,500 hectares of shrubland, forest and grassland, destroying 24 homes, 146 other structures and five businesses. The fire was declared contained after six days on 7 January. While there was no loss of human life, 142 people (mostly firefighters) were injured and there were significant losses of livestock and pets.

CRC RESEARCH

The research built on previous similar studies and used both qualitative and quantitative methodology. From 30 June until 31 August 2015, 543 people in the fire-affected area answered an online survey or a telephone survey about their bushfire experiences, and 25 people participated in in-depth interviews.

The surveys and interviews collected information around general demographics, awareness of and concern about bushfires, planning and preparation, people's responses on the day of the fire, and their connections with their community. Participants who were members of



Right: THE AREA BURNT BY THE SAMPSON FLAT FIRE IS SHOWN IN RED. THIS MAP SHOWS THE PROXIMITY OF THE FIRE TO SUBURBAN ADELAIDE, WITH THE FIRE COMING WITHIN TWO KILOMETRES OF THE SUBURBAN EDGE. PHOTO: CFS

Community Fire Safe groups also answered questions about changes in key aspects of bushfire safety since becoming a member. Participants living in the rural/urban interface completed questions about the information they accessed and the warning messages they received.

RESEARCH OUTCOMES

Planning and preparedness

While the majority of residents (88.3%) who participated in the study reported having a discussion about what to do in the event of a bushfire, only a quarter of residents had a written bushfire survival plan (25.5%), and/or practiced their plan (23.4%). This is positive in comparison to the national average of 5% in previous post-bushfire studies (McLennan *et al.* 2015). However, two thirds of people had no plan or had made plans that could potentially expose them to late evacuation. That is, 17.9% of residents planned to wait and see how bad the fire was before leaving, or planned to stay but leave with the fire front, while 16.9% reported either not knowing what their bushfire plan was (12%) or not having a plan (4.9%). People living on standard residential blocks (see breakout box above) were less likely than those living rurally to have a plan – 67.9% of those who indicated that they did not have a plan were living on a standard residential block, and only 31.9% of those had a clear mental plan.

DEFINITION: STANDARD RESIDENTIAL BLOCK

A block of land in a township or larger urban centre which is generally less than 2000 square metres in size.

Reflecting these low levels of planning, the research found that people were more likely to prepare for a bushfire than to plan for a bushfire. They were also more likely to undertake lower cost preparations (e.g. buying a hose) than higher cost ones (e.g. installing a sprinkler system). This is consistent with previous CRC research following seven other major bushfires across Australia since 2009 (McLennan *et al.* 2015). This previous research linked a low-cost preference bias with people over-estimating their bushfire preparedness.

However, concern about bushfires increased the likelihood of a person writing and practicing a plan, and also of undertaking higher-cost but more effective bushfire preparations (i.e. installing

sprinklers, having an independent water source for bushfire protection, having a firefighting hose and pump). This indicates that awareness-raising continues to be an important focus for motivating people in at risk areas who have undertaken limited planning and preparation. This is particularly so for those living in the rural/urban interface, where this study shows levels of concern about bushfires were lower than those living rurally.

Physical and emotional preparedness

The research findings also highlighted a significant gap in preparation – an important new insight from these studies. Although the majority of people (75%) felt physically prepared (i.e. they had readied their property and their belongings), only half of all participants felt emotionally prepared (i.e. for the short-term effects of anxiety and fear, and the long-term effects of sadness and anger), as shown in the graph on the right. This was the case for members of Community Fire Safe groups as well, who also indicated lower levels of emotional preparedness. Interviews showed these strong emotions, particularly anxiety and fear, were a factor in people changing their plans at the last minute.

Men were more likely to feel emotionally prepared, although women were as likely to feel unprepared as prepared. One factor that increased emotional preparedness was prior experience of bushfires. Although not everyone can have prior experience of bushfires, the interviews highlighted that sharing the stories and lived emotional experience of bushfires could be a useful method of increasing emotional preparedness.

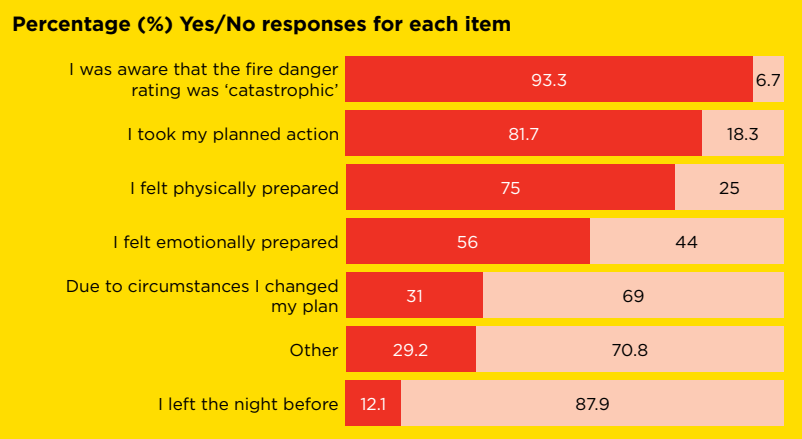
Information and warnings

This aspect of the study specifically considered the awareness and understanding of bushfire warnings, and found residents' awareness of the newer classification of 'catastrophic' fire danger rating was high. However, there was confusion about the meaning of messages classified as an Emergency Warning. Those people who received official CFS warnings did not understand that the message was directing them to "shelter in place", i.e. in their home. Instead they were most likely to understand that the message was requiring them to either evacuate or prepare to evacuate. This may reflect that, prior to the bushfire, people living in the rural/urban interface were less likely to have accessed information relating to bushfire safety, and were therefore less familiar with emergency messaging.

The majority of people were happy with the information that they received during the fire. However, for those who were leaving, many would have liked more details about where to evacuate to, particularly where to evacuate with pets. For those who stayed and defended, more detailed and timely information about the fire's direction and speed was requested.

Community Fire Safe groups

While part of the study was aimed at understanding the contribution of Community Fire Safe groups in the experience of the bushfire, the response rate from Community Fire Safe group members to the research was unfortunately low. Although it is not possible to make generalised conclusions from a small quantitative data set, when combined with interview data from nine different groups,



▲ **Above:** RESIDENTS AWARENESS, ACTIONS AND PREPARATION IN THE IMMEDIATE LEAD UP TO THE FIRE.

END USER STATEMENT

The Country Fire Service worked tirelessly to contain the Sampson Flat fire of January 2015 for almost a week. Despite the fire destroying homes and livestock being lost, the fire claimed no human lives. Affecting a highly populated area, and with smoke visible from the Adelaide CBD, the fire generated much interest from the media and people living in rural/urban areas.

Public information has become as important as firefighting since the devastating 2009 Victorian bushfires. CFS is dedicated to educating the public in how to prepare for bushfire through its Community Fire Safe groups and other engagement activities.

This research reflects how physically well prepared some of the Adelaide Hills community were before this incident. The residents who had prepared their properties should be congratulated on following the advice provided to them by CFS Community Engagement Officers and local brigades.

Despite the bushfire impact on 12,569 hectares of public and private lands with losses including 24 homes, 146 other structures, five businesses and much livestock and fencing, no lives were lost. We believe this is due to the bushfire safety information CFS has delivered to the community over the past decade.

However, it also shows that many in the community were not emotionally prepared, therefore CFS will look at ways to incorporate these learnings into future community engagement activities.

The research shows the preparedness of community members living in rural/urban areas was not as high as those in the more rural areas, which did not come as a surprise to CFS. However, we will continue to educate this community in the future.

This research is an integral part of the CFS's learning process; we need to understand how our communities react to a bushfire event and these lessons will shape the future of CFS's ongoing engagement with our communities, before, during and after bushfire.

Thank you to all community members who were part of this vital research.

– Greg Nettleton, Chief Officer, SA Country Fire Service.

the study provides useful insights on how groups function.

In relation to the people represented in the research, the program had a positive impact on bushfire safety. Group members reported that since joining a group they were more likely to have a bushfire plan, undertake property preparations, and alert their neighbours to fires. Group members were 6.7 times more likely to develop a plan since becoming a member. They were also three times more likely to feel motivated to prepare their property. However, being a member of a group did not increase the likelihood of people undertaking higher-cost preparations. Ninety percent of group members stayed in contact with their group during the fire.

The online survey of Community Fire Safe groups indicated almost all respondents (96.7%), were satisfied with the outcomes of their group, however most rated their group's motivation and ability to work together as moderate. This latter finding is consistent with interviewee comments, which suggested that individual and situational factors such as the need for privacy, time constraints, friendships and disagreements, and different attitudes towards fire risk, made it difficult to organise group meetings and sometimes led to breaks in phone trees.

For the nine groups that participated in the interviews, the leadership style of their coordinator made a difference in the group's outcomes. Coordinators that actively drove information dissemination, meetings and activities in the neighbourhood regardless of response were most effective at overcoming the challenges of privacy, time, disagreements and attitudes. This study showed coordinators with this approach adapted communication methods to include one-on-one meetings, actively recruited new people into the group, focused on the positive and demonstrated an ongoing commitment to bushfire safety.

▲ **Above:** THE SAMPSON FLAT FIRE AFFECTED THE POPULAR ADELAIDE HILLS AREA, ALONG WITH THE URBAN/RURAL FRINGE OF ADELAIDE. PHOTO: CHRIS BASTIAN, CFS

CONCLUSION

In line with previous CRC research on major Australian bushfires (e.g. McLennan *et al.* 2015; Trigg *et al.* 2015), this study found that although people may discuss what to do in a bushfire, far fewer plan for a bushfire, and a significant proportion continue to plan to 'wait and see' when a bushfire threatens, before deciding what to do. Those living in the rural/urban interface were less likely than those in rural areas to know what do in a bushfire, or to plan and prepare their property. This tendency was countered by high concern about bushfires, and by being a member of a Community Fire Safe group. However, one aspect of preparation, that of emotional preparedness, was low, even for those who are members of Community Fire Safe groups. This research suggests that awareness-raising of bushfire risk remains a key focus for bushfire safety campaigns, especially in the rural/urban interface. Education campaigns in the rural/urban interface could focus on de-mystifying emergency messaging, how to prepare for fires in a more urban area, and information on safe relocation with pets. Further, the positive effects of Community Fire Safe groups could be increased by providing training for group coordinators, to assist in developing adaptive and flexible skills for managing these groups. Both for those in groups, and those who were not members, increasing emotional preparedness emerged as a consistent theme throughout the research. Future research could focus on mapping the emotional landscape of bushfire experiences as a basis for developing and trialing emotional preparedness programs.

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HAZARD **NOTE**

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TOPICS IN THIS EDITION | COMMUNICATION | DECISION-MAKING | CHILD-CENTRED | ANIMALS | TSUNAMI

TURNING WARNINGS INTO ACTION

ABOUT THESE PROJECTS

This is an overview of the *Communications and warnings* cluster of Bushfire and Natural Hazards CRC research projects. This cluster has five linked studies:

1. **Connecting communities and resilience** – Professor Vivienne Tippett, Professor Sharon Christensen, Professor Bill Duncan, A/Professor Amanda Stickley, Dr Dominique Greer, Dr Amisha Mehta and Dr Paula Dootson, Queensland University of Technology. For more information contact vivienne.tippett@qut.edu.au
2. **Managing animals in disasters** – Dr Mel Taylor, Megan McCarthy, Macquarie University, Dr Kirrilly Thompson, Dr Bradley Smith, CQUniversity, Dr Penny Burns, Rachel Westcott, Western Sydney University and Greg Eustace, RSPCA Queensland. For more information contact mel.taylor@mq.edu.au
3. **Child-centred disaster risk reduction** – Prof Kevin Ronan, CQUniversity, Dr Briony Towers and Professor John Handmer, RMIT University, Dr Katharine Haynes, Macquarie University, Dr Eva Alisic, Monash University, Nick Ireland, Marla Petal, Susan Davie, Save the Children, Professor David Johnston and Dr Vicki Johnson, Massey University. For more information contact k.ronan@cqu.edu.au
4. **Improving hazard communications** – Dr Ilona McNeill, A/Professor Jennifer Boldero, Dr Paul Dudgeon, Professor Alex Wearing, University of Melbourne, Professor John Handmer, RMIT University and Professor David Johnston, Massey University. For more information contact imcneill@unimelb.edu.au
5. **Understanding tsunami warnings systems** – Professor Douglas Paton, Katelyn Rossiter, Dr Petra Buergelt, Charles Darwin University, Professor David Johnston, Massey University and Sarah Anderson, Surf Life Saving Australia. For more information contact douglas.paton@cdu.edu.au

CONTEXT

This cluster is investigating community resilience to natural hazards. Initial work has previously looked at bushfires, with these projects building on this work and extending it to other hazards, greatly assisting the development of policy and approaches to working with communities on resilience.

CONNECTING COMMUNITIES AND RESILIENCE

BACKGROUND

Community members experiencing natural disasters often do not comply with official government instructions during the response and recovery phases. Consequences of this can include obstructing the emergency response and putting lives at risk. This project is developing and testing emergency warning messages to establish which message framing best achieves compliance.

RESEARCH ACTIVITY

Key activities to date included a social media analysis and community focus groups. The social media analysis examined 50,000 tweets during Queensland's Severe Tropical Cyclone Marcia in February 2015 to explore information processing, decision-making and risk communication in the response phase of the event.

Eight focus groups were conducted in Queensland, Victoria and New South Wales

▲ **Above:** A FLOODED ROAD IN MORAYFIELD, QUEENSLAND, IN THE AFTERMATH OF CYCLONE MARCIA IN FEBRUARY 2015. DECISION-MAKING AND RISK COMMUNICATION WAS EXAMINED AFTER THE CYCLONE. PHOTO: SHUTTERSTOCK.COM

(with two pending in Western Australia) to examine community comprehension of emergency warning messages. A number of workshops have also been conducted.

During the next year, the project will experiment with emergency warning messages to test which message framing best achieves compliance. As major natural disasters have a significant economic impact on society, even small changes in protective behaviours can be valuable. Informed emergency messaging can save lives and reduce the costs associated with disasters.

RESEARCH OUTCOMES

The social media analysis recommends that emergency services add information to their warnings to increase the self-efficacy of community members. Increased precision of instructional messages will further meet this need. In addition, emergency services could integrate phrasing that personalises and visualises risk to enhance community members' ability to take effective action and share knowledge about damage. This could aid community members' understanding of their risk for subsequent emergencies. The community focus groups are ongoing.

END USER STATEMENT

Agencies managing natural disasters have traditionally relied on techniques that deliver information to communities and prescribe actions to avoid in a natural disaster. Such top-down communication can often overlook the complexity of decision making in a crisis, and may even contribute to people ignoring or acting contrary to agency advice. This research is helping to explore new, innovative ways of working with, influencing, motivating and empowering community members, to share the responsibility for managing disasters and build the resilience of communities across Australia.

By keeping utilisation goals front of mind, researchers and agencies are well-positioned to readily adopt the research outputs. An example of these outputs could be effective, timely and targeted warning messages that motivate appropriate actions in an emergency.
– Andrew Richards, Manager, Community Engagement, NSW State Emergency Service.

Above: HOW CAN EMERGENCY SERVICES BETTER WORK WITH ANIMAL OWNERS, WHETHER IT BE LIVESTOCK OR PETS, DURING EMERGENCIES? PHOTO: ASHLEY HOSKING CFS PROMOTIONS UNIT

MANAGING ANIMALS IN DISASTERS

BACKGROUND

Concern for animals can impact on people's decision-making and behaviour during natural disasters – sometimes risking lives. There has been little research in this area to guide policy development and training needs. This project is leveraging current initiatives, programs and research on prevention and preparedness by providing complementary research on the impact of animals on response and recovery, both for the community and responders.

RESEARCH ACTIVITY

Initial scoping identified the challenges and needs of responders and other stakeholders, reviewed plans, policies and initiatives and identified priority areas with end users and other stakeholders.

The project is currently undertaking field work to focus on the issues around the integration of informal volunteers into animal emergency management, using South Australia's Sampson Flat bushfire in early 2015 as a case study.

A second field study will involve developing a multi-stakeholder research project in Tasmania to focus on animal owners in the urban/rural interface. The team is developing a method to collect data in order to map animal ownership distribution and owners' intentions in bushfires. This will support planning for the Tasmania Fire Service, the Department of Primary Industries, Parks, Water and Environment and local government. It is hoped that this proof of concept study can be tested with another end user organisation in a different hazard situation, e.g. flood or cyclone, to assess its applicability in other contexts.

RESEARCH OUTCOMES

Findings to date have been drawn together with other sources to prepare an audit report. This broad review spans the current legislation, plans, policy, community engagement resources, initiatives, needs, and research dissemination in animal emergency management in Australia. Summarised key findings include:

- The emergency management system needs to better integrate and recognise animal emergency management.
- Roles and responsibilities for managing animals during emergencies need to be better clarified and communicated.
- The 'non-core' status of animal emergency management leaves advances in this area more prone to unstable funding and organisational structures.
- The apparent disconnect between initiatives and communities may lead to duplication of activities, with no evidence available about their effectiveness.
- Animal emergency management needs to be reframed as a people issue; a rigid focus on animal welfare leads to discounting and disengagement by emergency response organisations.
- The better use of technology offers opportunities, e.g. for re-unification systems, management of emergent informal volunteers, and better data collection.

CHILD-CENTRED DISASTER RISK REDUCTION

BACKGROUND

Disaster education for children is a key priority in reducing the impacts of natural hazards. The child-centred disaster risk reduction (CC-DRR) approach is becoming increasingly popular, but rigorous empirical research on efficacy and implementation is scarce. This project is developing a research program to chart CC-DRR progress and identify policy-practice-research gaps and challenges. Key project objectives are:

- Understanding if CC-DRR programs are effective.
- Ensuring programs are stakeholder supported and evidence-based.
- Understanding if programs produce cost-effective outcomes and are able to be scaled up sustainably at schools, at the community level and in emergency management policy.

RESEARCH ACTIVITY

The project has focused on the following themes: scoping and review of CC-DRR theory, policy, practice and research; consulting end users to establish a project and implementation road-map; and pilot research seeking views from major stakeholder groups (children, households, schools, emergency management/disaster risk reduction professionals).

A capacity-building workshop in April 2015 provided feedback from stakeholders that shifted the focus to the co-development of a CC-DRR/disaster resilience education practice and evaluation framework. This change was made to more clearly reflect the needs of end users.

Additionally, emergency services agencies have nominated disaster resilience education programs for evaluation. This evaluation looks for key, evidence-based practice elements, such as curriculum, pedagogy, assessment, evaluation and monitoring, and implementation.

RESEARCH OUTCOMES

The team has concluded that a different mindset is needed by emergency services to achieve a large-scale, effective implementation of CC-DRR programs. Moving beyond a project mentality, such programs need to overcome known implementation obstacles to promote risk reduction and resilience, and be taught by well-trained teachers and emergency management professionals. This mindset requires a move from a short-term project-focused mentality to a longer-term, strategic curriculum and implementation mentality. That longer-term view would benefit substantially from research that evaluates the role and benefits of CC-DRR programs and identifies key implementation mechanisms and facilitators.

IMPROVING HAZARD COMMUNICATIONS

BACKGROUND

How effective are existing hazard communications and community engagement strategies in increasing preparedness and planning among residents of hazard-prone areas? This project addresses this question and identifies key barriers and enablers to motivating preparedness and planning by residents in order to improve the effectiveness of these strategies.

▲ **Above:** RESIDENTS WHO USE INFORMATION FROM AGENCIES TO HELP THEM PREPARE FOR A NATURAL HAZARD CARRY OUT MORE PREPARATIONS THAN RESIDENTS WHO DO NOT. PHOTO: QUEENSLAND FIRE AND EMERGENCY SERVICES

RESEARCH ACTIVITY

Two studies conducted over the spring and summer of 2014/2015 investigated the effectiveness of existing communications strategies for bushfire and flood, such as community engagement groups, brochures, websites and advertising campaigns in increasing preparedness and planning by residents of hazard-prone areas. Data was gathered amongst residents of bushfire and flood-prone areas, measuring both active use of information sources such as community-based information meetings, brochures and websites, and passive awareness of TV-based advertising on bushfire and flood preparedness. Also captured was the extent to which these residents had performed a variety of preparatory and planning actions. This allowed a statistical determination of whether residents who had actively used information sources and/or were aware of advertising campaigns ended up preparing more or less than those who did not.

The bushfire study began in October-December 2014 (location depending) with 514 participants from New South Wales, South Australia, Tasmania, Victoria and Western Australia (south of Geraldton). Information was collected at two time points, a month after the fire season began, and then six weeks after the initial survey.

Data for the flood survey were collected in February 2015. This resulted in a total of 286 responses from residents living in flood-prone areas in New South Wales and Queensland.

RESEARCH OUTCOMES

Preliminary findings show that the majority of residents do not use any of the listed information sources to help them prepare (67% for bushfires, 69% for floods). Those who do use at least one of these information sources carry out more preparations than those who do not. These results cannot be fully explained by differences in risk perceptions and personality factors, so other factors must be at play.

Residents who remember seeing an ad on TV that focused on preparing for bushfires or floods do not carry out more preparatory actions than those who did not recall seeing an ad over the past six months. Bushfire-prone residents who go online to find information about preparing, go to information sessions and/or use a brochure have higher risk perceptions than those who do not. Flood-prone residents who report going to meetings and/or using websites have higher risk perceptions than those who do not.

HAZARD **NOTE**

UNDERSTANDING TSUNAMI WARNINGS SYSTEMS

▲ **Above:** RESEARCH IS INVESTIGATING HOW PEOPLE RESPOND TO A TSUNAMI THREAT.

BACKGROUND

The eastern Australian coastline faces some 8000km of active tectonic plate boundary that is capable of generating a tsunami that could reach Australia in two to four hours. This makes it imperative that coastal communities understand and can respond effectively to the Australian Tsunami Warning System. Activation of this warning system could result in warning times ranging from 90 minutes to three hours. Warning times of these durations could leave insufficient time for people to implement their emergency plan (e.g., to prepare their property, plan an evacuation etc.) on receipt of a warning. This project is researching key aspects of community response capability.

RESEARCH ACTIVITY

This project has adopted a qualitative approach to understanding people's tsunami risk and warnings beliefs. Members of coastal communities are being interviewed about their views on causes of tsunamis, origin, tsunami travel times, warning times, warning sources and dissemination, as well as what people will be warned of and the actions warnings should trigger. The project examines how community members and stakeholders can engage in ways that contribute to developing tsunami warning systems that can accommodate community and geographical diversity and facilitate the development of an enduring community capacity to respond in effective and timely ways on receipt of a warning.

The first study interviewed community volunteers from coastal communities around Australia that participate in coastal activities and emergency services in a range of Australian coastal communities. The aim was to identify community perceptions and understanding of tsunami risk and awareness of tsunami warning systems.

In response to consultations with end users, the project has now also incorporated two pilot studies investigating:

1. Tsunami community engagement and education both in schools and in communities.
2. Tsunami knowledge and existing communication processes within select coastal recreation groups and occupations.

RESEARCH OUTCOMES

Initial interviews in communities in New South Wales, Queensland, Tasmania and Western Australia identified diverse views on what people should be warned of, and how to warn them. Views on warning content included long-term issues (e.g. evacuation problems) and immediate actions (e.g. knowing evacuation routes). The interviews identified a need to adapt warnings to specific localities and to enhance community readiness.

Among the insights from the 18 interviews were:

- Only eight acknowledged either the SES or Bureau of Meteorology as official sources of tsunami warning communications; only one acknowledged both.
- Participants were either unsure about the likelihood of a tsunami affecting them and their community, or thought that it was very unlikely, and this reduced their interest in considering their risk.
- People expected warnings to come from a number of sources (including internet/social media, word of mouth and TV) with radio and SMS being the most commonly mentioned. People would check information from several sources for consistency before considering taking action.
- People were more likely to consider preparing when they received a warning. People's beliefs about how long they would have to prepare ranged from 20 minutes to several hours, with a belief that 30 minutes would be sufficient time to prepare.

Following discussions with end users, the project is more clearly refocused on how interaction between community members and emergency service agencies influences tsunami risk and warning beliefs. The results of this work will help to develop and carry out a community engagement strategy to enable end user agencies to develop community warning and response strategies.

The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

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HAZARD **NOTE**

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HOW THREE SOUTH AUSTRALIAN COMMUNITIES RESPONDED TO THE 2014 BUSHFIRES

Above: AN ERICKSON AIRCRANE AND FIRE UNITS BATTLE THE BANGOR FIRE IN JANUARY 2014. PHOTO COURTESY TAIT SCHMALL/NEWSCORP

SUMMARY

This *Hazard Note* summarises results from research commissioned by the South Australia Country Fire Service (CFS) following three very different bushfires in early 2014: a rapid-onset fire, a long-campaign fire, and repeat fire incidents. The study investigated bushfire risk perceptions, decision-making processes and the behaviour of residents affected by these fires. Findings showed regardless of the nature of the fire, many residents may have been dangerously late in leaving their homes. Ten percent of interviewees had a written fire plan to guide their decision making. In each of the three interview sites, the percentage of those who ultimately chose to leave as a whole household was approximately double that for the intention to do so. Regarding communication strategies, the results reinforce similar research from other states in finding that a 'one size fits all' approach to warning and informing the community during fires is not appropriate.

ABOUT THIS PROJECT

This research was conducted for the CFS by the Bushfire and Natural Hazards CRC through the South Australian-based Appleton Institute of CQUniversity. The CFS aims to use the findings to better support communities in preparing for bushfire and understanding its consequences. The study delivers valuable knowledge and builds on previous post-bushfire research in Victoria, Western Australia, Tasmania and New South Wales.

The full report, *Capturing community experiences: South Australian bushfires January 2014*, is available on the Bushfire and Natural Hazards CRC website. Thank you to the affected communities for their participation in the research.

AUTHORS

Josh Trigg, Dr Sophia Rainbird, Dr Kirrilly Thompson and Dr Chris Bearman, (Appleton Institute, CQUniversity), Lyndsey Wright (Bushfire and Natural Hazards CRC) and Dr Jim McLennan (La Trobe University).

CONTEXT

The widespread fires of summer 2013-2014 demanded the highest operational capacity of the CFS since its inception. The research draws on three very different bushfires to provide a greater understanding of community members' experiences, focusing particularly on three themes: 1) community and programs, 2) local bushfire risk perception and preparedness and 3) information, warnings and action.

BACKGROUND

South Australia experienced simultaneous and complex fires over an extended period in summer 2013-2014, with some fires that started in January continuing into February. Lightning from intense thunderstorms ignited hundreds of fires across the state, including fires in the southern Flinders Ranges (Bangor), Eden Valley and Rockleigh. These fires provided a research opportunity to investigate bushfire risk perceptions, decision-making processes and behaviour of residents across three very different events: a rapid-onset fire (Eden Valley); a long-campaign fire (Bangor); and repeat fire incidents (Rockleigh).

CRC RESEARCH

The research used both qualitative and quantitative methodology. During April and May 2014, 171 interviews were conducted with residents of affected communities and 606 people participated in an additional online survey, open to residents across South Australia.

Both the interviews and online survey collected information around general demographics, sense of community, previous experience of bushfires, what happened on the days before the fire threat, what happened on the day, and what, if any changes have been made in bushfire planning and preparedness as a result of that experience.

This *Hazard Note* discusses the 171 interviews. For information about the online survey, please see the full report.

RESEARCH OUTCOMES

Community and programs

Despite interviewees across the three locations perceiving a high degree of community connectedness (e.g. 'could get help from neighbours'), only half of the residents interviewed actually interacted with their neighbours during the fires. Although many interviewees had participated in a CFS community program, most tended to report relying on their own common-sense preparations around the home and property (e.g. clearing gutters), rather than a written, practised bushfire survival plan.

Local bushfire risk perception and preparedness

Nearly two thirds of Rockleigh (68%) and Bangor (61%) interviewees considered their home and family at potential risk of bushfire before the fire occurred and rated their concern about potential risk as moderate. Risk perception was lower in Eden Valley (40%).

Although most interviewees had both house and contents insurance, a notable proportion of residential, lifestyle, and farm/agribusiness properties had no insurance for house (9–16%) and contents (9–18%).

Two thirds of interviewees had a mental bushfire survival plan, however one in 10 reported having a written plan. There was little variation between locations.

One-quarter (26%) of interviewees reported use of CFS materials in the creation of either their written or mental bushfire plan, with 20% having used a Bushfire Survival Plan template and 25% having referred to Your Guide to Bushfire Safety.

The large number of fires in the Rockleigh area did not appear to have led residents to be more likely to have either a mental or written plan. Nor did such experience appear to have led to specific long term preparation activities.

Information, warnings and action

Across the three study areas interviewees reported they were aware of the warnings about bushfire risk, with 63% citing the weather conditions for their awareness. Some took specific action based on the fire danger rating.

Visual clues (e.g. seeing smoke/flames) and calls from family and friends were the most common way interviewees became aware of the fire. In the more rural areas at Bangor and Eden Valley, more than a third of people learnt about the fire threat from the radio, as compared to 8% in Rockleigh. In Eden Valley, where the fire spread extremely rapidly, four in ten of those interviewed identified the Emergency Alert text message/phone call as an important source of fire awareness. This is more than twice the frequency with which this information source was reported in Bangor and Rockleigh.

Once alerted to the fire threat, most (85%) sought further information. Family and friends, radio and the CFS website were the most used sources. Less than 10% checked social media channels. The differing nature of the three fires is reflected in the level of information seeking, with those in Bangor (a long duration fire) far more likely to have sought information through the radio, CFS website or through contact with family and friends.

Intentions versus actions

Despite the previous experience of fire in the area, the initial intention of nearly half those interviewed in the Rockleigh area was to 'wait and see' before deciding on an action. In the rapid-onset Eden Valley fire, those waiting and seeing effectively halved from intention to ultimate action.

One in four of those interviewed in the Bangor area indicated that their initial intention had been to have some members of the household leave early and others stay and defend. This is more than twice the rate of this intention reported in Rockleigh or Eden Valley. In particular, it differs significantly from the intention in the Eden Valley where nearly one in three of those interviewed intended for the whole household to leave.

Detailed findings and discussion from this research can be found in the full report, available on the the CRC website.

FUTHER READING

McLennan J, Wright L, Mackie B (2013) How three communities reacted to bushfire: research findings from the January 2013 bushfires in NSW, Bushfire CRC *Fire Note 119*.

McLennan J (2014), Study captures insights on bushfire risk and responses: research findings from the October 2013 NSW bushfires, Bushfire CRC *Fire Note 131*.

McLennan J (2015) Capturing community bushfire readiness: post-bushfire interview studies 2009-2014, Bushfire and Natural Hazards CRC *Hazard Note 004*.

Trigg J, Rainbird S, Thompson K, Bearman C, Wright L, McLennan J, (2015) Capturing community experiences: South Australian bushfires January 2014, Bushfire and Natural Hazards CRC, Australia.

END USER STATEMENT

These research results will be used by the CFS and other fire agencies to improve support for communities in preparing for bushfires, and in understanding their consequences.

While the land use and lifestyles of the communities interviewed differ, the research shows they share many similarities with respect to bushfire. However, the research also highlights that the demand for information and how it is best communicated varies depending on the degree of independence and resilience of communities.

These findings add to the national body of evidence collected from similar research in other states. Importantly, analysis of the data confirms that fire agencies need to carefully tailor their fire prevention strategies and community engagement programs for specific communities. A 'one size fits all' approach in providing warnings and information to the community during fires is not appropriate.

– Greg Nettleton, Chief Officer, SA Country Fire Service

The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

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HAZARD **NOTE**

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CAPTURING COMMUNITY BUSHFIRE READINESS: POST-BUSHFIRE INTERVIEW STUDIES 2009-2014

Above: THE BUSH MEETS THE URBAN INTERFACE IN THE NSW BLUE MOUNTAINS, WHERE FIRES IMPACTED COMMUNITIES IN OCTOBER 2013. AFTER THE FIRES, CRC RESEARCHERS INTERVIEWED LOCAL RESIDENTS ABOUT THEIR EXPERIENCES. PHOTO: GARY P HAYES, PROVIDED BY NSW RFS

SUMMARY

While governments will continue to fund fire and land management agencies to combat bushfires, there is now an expectation that residents should share responsibility for their safety and property protection. Fire agencies expend considerable resources on community bushfire safety education. One way to review the impact of these endeavours is to interview residents who experienced a serious bushfire threat about their pre-fire bushfire risk perception, their planning and preparation, and their actions when threatened. This *Hazard Note* summarises overall findings from seven post-bushfire interview studies conducted since 2009. A significant percentage of residents interviewed did not believe that they were at-risk and neither planned nor prepared for a possible bushfire. While many reported having a plan, written versions of such plans were rare. An appreciable percentage of residents whose plan was to leave had not prepared adequately to implement their plan safely. Very few residents self-evacuated early on the basis of fire danger weather predictions. New approaches to promoting community bushfire safety need to be developed, trialled and evaluated.

ABOUT THIS PROJECT

The studies described in this *Hazard Note* were conducted by Bushfire and Natural Hazards CRC and Bushfire CRC researchers, and involved interviews with members of communities threatened by destructive bushfires in Victoria, Western Australia, Tasmania and New South Wales from 2009-2014. The studies were conducted at the request of fire agencies in those states, and their purpose was to inform agencies about how residents understood bushfire risk, planned and prepared for a possible bushfire, and responded to a serious bushfire event.

AUTHOR:

Dr Jim McLennan is an adjunct professor in the School of Psychology and Public Health at La Trobe University. He was involved in all the studies discussed, in various roles: field interviewer, research advisor, chief investigator. For more information, contact j.mclennan@latrobe.edu.au

CONTEXT

Most Australian bushfire scientists predict that there will be more frequent severe bushfires threatening life and property, for two reasons: (a) climate change resulting in reduced rainfall and higher temperatures in many regions; and (b) an increase in the number of householders choosing to reside in areas of high bushfire risk. Economic constraints will limit governments' abilities to fund increased agency bushfire suppression capability. Residents will be expected to assume greater responsibility for their bushfire safety in the future.

BACKGROUND

From 2001, the Australian Fire Authorities Council (now the Australasian Fire and Emergency Services Authorities Council) developed position statements on community safety in the face of imminent bushfire threat, culminating in 2005 with what became known as 'Prepare, stay and defend or leave early'. This position guided fire agencies' approaches to community bushfire safety prior to the 2008-2009 bushfire season. On 7 February 2009, 'Black Saturday', the worst bushfires in Australia's post-European settlement history, ravaged communities across Victoria, resulting in 173 deaths and the destruction of more than 2000 homes. Investigations for the 2009 Victorian Bushfires Royal Commission, including interviews with survivors conducted by a Bushfire CRC research task force, identified generally low levels of planning, preparation and safe responding by residents. Subsequently, AFAC developed a new position statement, *Prepare. Act. Survive.* in consultation with fire agencies, with many agencies increasing their community safety resources. After significant bushfires in WA in 2011 and 2014, and in Tasmania and NSW in 2013, the fire agencies in these states requested the

▲ **Above:** RESEARCHERS VISITING A HOUSE IN STRATHEWEN AFTER THE BLACK SATURDAY BUSHFIRES IN 2009.

Bushfire CRC (2011-2013) and the Bushfire and Natural Hazards CRC (2013-2014) to conduct post-bushfire interview studies in order to investigate residents' pre-bushfire risk perceptions, plans and preparations, readiness on the day of the fire, warnings received, and actions taken.

CRC RESEARCH

Table 1 (right) summarises the bushfires studied by CRC interview teams. For each of the fires studied after Black Saturday, the relevant fire agency requested the Bushfire CRC (2011-2013) or the Bushfire and Natural Hazards CRC (2013-2014) to conduct interviews with residents in the fire-affected areas. For each study a semi-structured interview guide was used. Each interview guide was developed jointly by the investigators and agency staff to cover:

- Awareness of bushfire risk before the bushfire.
- Planning and preparation for, and knowledge of, bushfire danger before the bushfire.
- Awareness of official and informal warnings generally immediately prior to and during the bushfire event
- Responses to warnings.
- Experiences during the fire event and any impacts on their property.

Before commencing an interview study, teams were briefed about the bushfire by a fire agency staff member. Team members undertook training in interview procedures, were instructed on their legal and ethical responsibilities, and were briefed on relevant occupational health and safety issues. Team members were reminded of the possibility that some interviews could be stressful and were advised about ways to manage these. In most studies, agencies were able to provide interview teams with fire-scar maps to guide selection of locations for visits to households.

END USER STATEMENT

Understanding how the community prepares for and responds to an emergency is an issue for fire services and emergency management agencies around the world.

The New South Wales Rural Fire Service worked with both CRCs after major fires in 2013, which was one of the most challenging and dangerous years for bushfires in NSW in more than a decade.

These fires presented the NSW RFS with an opportunity to learn and refine our processes, particularly in relation to community preparedness and the delivery of information and warnings. The research has delivered benefits, influencing our approach to community engagement, as well as improving our understanding of how the public uses and responds to information and warnings, and the barriers which may prevent people responding.

The NSW RFS is also proud to contribute to the national research agenda, and contribute to the bank of research and knowledge around bushfire preparation and response.

– Anthony Clark, Group Manager, Corporate Communications, New South Wales Rural Fire Service

TABLE 1: BUSHFIRE EVENTS STUDIED

BUSHFIRE LOCATIONS	FIRE DANGER RATINGS	IMPACTS
Feb 2009, Victoria: Beechworth; Bendigo; Bunyip; Churchill; Horsham; Kilmore East; Murrindindi; Narre Warren	Extreme[a]	173 deaths; 2029 homes destroyed
Jan 2011, WA: Lake Clifton	High	10 homes destroyed
Feb 2011, WA: Roleystone, Kelmscott, Red Hill	High	72 homes destroyed
Jan 2013, Tasmania: Boomer Bay; Connelly's Marsh; Copping; Dunalley; Eaglehawk Neck; Forcett; Primrose Sands; Taranna	Catastrophic[b]	203 homes destroyed
Jan 2013, NSW: Coonabarabran, Yass, Shoalhaven	Extreme	51 homes destroyed
Oct 2013, NSW: Blue Mountains, Port Stephens, Wingecarribee Shire	Very High – Extreme	221 homes destroyed
Jan 2014, WA: Parkerville; Stoneville; Mt Helena	Extreme	57 homes destroyed

a Would now be Code Red/Catastrophic
b Equivalent to Code Red in Victoria

TABLE 2: PRE-BUSHFIRE RISK PERCEPTIONS, PLANS AND ACTIONS

BUSHFIRE EVENTS STUDIED	No. interviewed (no. at home when fire was reported)	% Perceived some level of risk before the fire	% Claimed had a pre-fire bushfire plan (% written plan)	% Planned to leave	% Planned to stay and defend	% Planned to either leave or to stay and defend	% Planned to wait and see	% Had no plan	% Left early, before any fire reported
Feb 2009, Victoria	496 (437)	89%	78% (2%)	24%	48%	72%	6%	22%	2%
Jan 2011, WA	40 (36)	93%	80% (2%)	65%	10%	75%	5%	20%	0
Feb 2011, WA	456 (407)	nr	72% (nr)	28%	20%	48%	28%	24%	0
Jan 2013, Tasmania	245 (217)	92%	88% (4%)	47%	26%	73%	15%	12%	1%
Jan 2013, NSW	238 (212)	85%	92% (9%)	29%	34%	63%	29%	8%	10%
Oct 2013, NSW	194 (150)	67%	68% (7%)	26%	28%	54%	14%	32%	1%
Jan 2014, WA	91 (80)	91%	81% (8%)	49%	25%	74%	7%	19%	0
Total	1760 (1539)								
Unweighted Average		86%	80% (5%)	38%	27%	66%	15%	20%	2%

nr = not recorded

For the first two studies (Black Saturday 2009 and WA January 2011), all interviews were transcribed and analysed for content. This proved a costly and time consuming procedure. In the subsequent studies, a procedure was adopted in which an interview-content checklist was completed by a member of each interview team during the course of the interview and reviewed for accuracy following the interview. Data from the checklists were subsequently entered into spreadsheets allowing rapid quantitative analyses. Samples of interviews (20%-40%) were transcribed and verbatim statements from residents were incorporated in the reports for agencies to illustrate the issues identified through the quantitative compilations of responses to the interview questions.

RESEARCH OUTCOMES

Table 2 (above) summarises residents' responses to interview questions about their pre-bushfire risk perceptions, plans and actions before the fire was reported. Table 3 (right) summarises pre-bushfire levels of preparations for a possible bushfire.

High level findings from all studies include:

- A significant percentage of residents of the bushfire-affected communities had neither planned, nor prepared for, a possible bushfire.
- While many reported having 'a plan' as to what to do in the event of a bushfire, few (5%) had written plans.
- An appreciable percentage of residents whose plan was to leave had not prepared adequately to implement their plan safely.
- Very few people (2%) self-evacuated early on the basis of fire danger weather predictions before reports of a fire.
- Few of those interviewed had participated in organised community bushfire safety activities.
- About one-third of those interviewed in 2013 and 2014 reported reading agency material about bushfire safety.
- Less than 10 per cent reported consulting material on fire agency websites before the fire.
- There is no evidence of dramatic improvement since Black Saturday in overall levels of bushfire safety planning and preparedness based on the accounts given by those interviewed.

Different motivations drove residents' choices of their household bushfire plan, with residents who planned to leave indicating this was because of the perceived danger that would be posed by a bushfire, especially if the household included vulnerable members such as the elderly, the disabled or young children.

Most residents who planned to stay and defend did so in order to protect their valued property – the 'valuing' could be understood as a spectrum: at one end the valuing was financial, when the property was associated with a business and income, at the other end the valuing was an emotional 'attachment to place'. Staying and defending was seldom understood by residents as a bushfire survival plan, rather it was understood by most to be asset-protection involving some level of acceptable risk.

Residents who intended to wait and see

TABLE 3: PERCENTAGE OF RESIDENTS ADEQUATELY PREPARED TO IMPLEMENT THEIR PLAN

BUSHFIRE	PLANNED TO LEAVE[a]	PLANNED TO STAY AND DEFEND[b]
Feb 2009, Victoria	8%	48%
Jan 2011, WA	6%	6%
Oct 2013, NSW	27%	17%
Jan 2014, WA	24%	70%

a Safe destination chosen, route planned, go-kit packed ready to leave
b Self-contained water supply, hoses and pump independent of mains power

IN RESIDENTS' OWN WORDS

"Yeah, I suppose it was a concern. When I first bought (the place) and we saw all these trees and vegetation around, I think it's the first thing you think about is fire. But then again, some of the neighbours tell us we haven't had a fire since Jesus Christ entered Jerusalem. So everything was hunky-dory and we took it on. You get that feeling it'll never happen, it'll never happen. But it did, it did, yeah."
[Lake Clifton resident, 2011]

"I was told by people who had grown up on this property who are now in their 80s that there had never been a fire here and we thought that was pretty good! I now think I should have realised that we were due for a 100-year fire."
[Coonabarabran resident, 2013]

"Resident to the east of our home had prepared and maintained a safe yard. Resident to our west had not removed leaves from their yard for years. They had rubbish and leaves piled up against the front fence and up their yard in the proximity of the fence."
[Roleystone resident, 2011]

"Well, the house is insured and things can be replaced, and our lives come first."
[Port Stephens resident, 2013]

"Obviously we're well set up. I've got equipment, water, pumps, everything. I'm as prepared, even more, than the rural fire brigade – and more passionate because this is my property."
[Winmalee resident, 2013]

what developed before making a final decision typically did this because: (a) they perceived their bushfire risk to be low; (b) they believed that waiting would not add to their risk; (c) they viewed both leaving unnecessarily and having to defend against a serious fire as equally unappealing; and (d) they intended to wait and hope for the best that the fire ultimately would not threaten their property.

Two general methodological weaknesses of all the studies should be noted. Householders aged under 30 were under-represented because they were less likely to be at home during business hours when interview teams visited. Residents whose homes had been destroyed were under-represented because many had left the area. Thus caution should be exercised in generalising the findings.

IMPLICATIONS OF THE RESEARCH FINDINGS

The findings suggest that fire agencies have been only moderately successful in their endeavours so far to raise overall levels of bushfire preparedness in at-risk communities. Impressions reported by interviewers suggest that more residents understand the inherent dangers posed by bushfires than was the case before Black Saturday and more residents view staying and defending as a course of action which involves a degree of risk and is not a choice to be made lightly. However, the findings from six post-Black Saturday interview studies summarised in this *Hazard Note* suggest that overall levels of bushfire threat readiness among residents of at-risk communities remain lower than desired by fire and emergency services agencies.

FUTURE DIRECTIONS

Probably the most pressing need is for new approaches aimed at increasing the numbers of residents in at-risk communities who have planned and prepared appropriately to survive a future serious bushfire threat to be (i) developed, (ii) trialled, and (iii) evaluated. At present many agencies rely heavily on (a) making detailed written (including web-based) information about bushfire safety available and (b) exhorting householders to read this and act upon it. Decades of research into health promotion and injury prevention demonstrate that education-based approaches alone result in limited improvements at best. Success stories such as lowering the road toll and reducing smoking rates involved costly mixes of innovative approaches to motivation and education, engineering solutions, legislation, sanctions, incentives and enforcement. There is no reason to believe that improving community bushfire safety will prove any easier.

FUTHER READING

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The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

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Extreme Weather

HAZARD **NOTE**

bushfire&natural HAZARDSCRC

ISSUE 48 JUNE 2018

TOPICS IN THIS EDITION | FIRE IMPACTS | FIRE SEVERITY | FIRE WEATHER

EXTREME FIRE BEHAVIOUR: RECONSTRUCTING THE WAROONA FIRE PYROCUMULONIMBUS AND EMBER STORMS

ABOUT THIS PROJECT

This research was conducted as part of the *Coupled fire-atmosphere modelling* project.

AUTHORS

Dr Mika Peace and Dr Jeff Kepert, Bureau of Meteorology. For more information contact mika.peace@bom.gov.au

SUMMARY

The Waroona bushfire, 100 km south of Perth, burnt 69,000 ha, destroyed more than 160 homes and caused two fatalities in Yarloop in January 2016. During the first two days of the fire, which hit both the towns of Waroona and Yarloop, there were four periods of extreme fire behaviour: two involving massive pyrocumulonimbus (bushfire thunderstorm clouds) and two major ember showers. Pyrocumulonimbus developed over the fire on the evening of 6 January and around midday on 7 January. Destructive ember showers occurred on two consecutive evenings: at Waroona on 6 January, and then Yarloop on 7 January. The Yarloop ember storm destroyed the town. None of these four episodes matched the time of highest fire danger as measured by fire danger indices. This *Hazard Note* is based on a case study that examined the meteorology and fire reconstruction in parallel, and identified the dynamic processes behind the extreme fire behaviour, providing valuable knowledge to apply during future events.

▲ **Above:** FIREFIGHTERS BATTLING THE WAROONA BLAZE. PHOTO: DEPARTMENT OF FIRE AND EMERGENCY SERVICES WA.

CONTEXT

Extreme fire behaviour can threaten the lives of local residents and firefighters, destroy properties and infrastructure and severely damage natural environments. Pyrocumulonimbus clouds are an indication of extreme fire behaviour, and due to their convective nature they can produce gusty, erratic winds that may result in changeable and very rapid fire spread in any direction. Understanding the triggers and factors that produce extreme fire behaviour will enable predictive tools to be developed that can help mitigate its impacts.

Following the Waroona bushfire, an independent review was completed by Euan Ferguson on the response to the fire. The *Report of the Special Inquiry into the January 2016 Waroona Fire* noted two opportunities for the Department of Fire and Emergency Services WA and Department of Biodiversity, Conservation and Attractions to engage with the CRC and the Bureau of Meteorology to investigate the causes of and effects of pyrocumulus weather occurrences on bushfire behaviour, and the prediction of lightning strikes.

BACKGROUND

During the first two days of the Waroona bushfire, there were four episodes of extreme fire behaviour. Two separate pyrocumulonimbus (pyroCb) events developed; both were associated with unusually fast fire runs given the prevailing surface wind speeds. The first pyroCb on 6 January developed a smoke plume over 14 km high and ignited new fires downwind. The second pyroCb on 7 January occurred earlier than the normal timing of surface-based thunderstorms. Two evening ember storms also occurred: the first impacted Waroona when the incident management team believed the fire to be several kilometres further east, and the second resulted in the destruction of Yarloop and caused two fatalities.

The extreme fire behaviour at the Waroona fire was unexpected and did not coincide with the time of day of highest fire danger, as measured by the Forest Fire Danger Index. Surface conditions of temperature, relative humidity and wind gave no indication that the environment was conducive to extreme fire behaviour.

A collaborative case study on the Waroona bushfire has identified the dynamic interaction processes between the fire, the local topography, local fuels and meteorology that contributed to the observed, extreme fire activity.

HAZARD **NOTE**

BUSHFIRE AND NATURAL HAZARDS CRC RESEARCH

The limitations of surface-based approaches to fire prediction using the McArthur grass and forest fire danger indices are widely recognised in Australian fire management. The emphasis on surface meteorological inputs provides a limited picture of the three-dimensional, time-evolving environment that drives a bushfire. In particular, interactions between the fire, the atmosphere and surrounding topography can drive processes such as wind modification and plume dynamics in the vicinity of a fire. However, these processes are complex and manifest differently at different fires, making them hard to define and difficult to simplify into a predictive process. The team examined case studies to gain insight into the contributing factors and the dynamic processes that drive extreme fire behaviour. The study of the Waroona fire benefited greatly from collaboration across different fields of expertise. This collaboration allowed the overlaps between the fire behaviour and surrounding meteorology to be explored at different stages of the fire.

WHAT IT MEANS

Pyrocumulonimbus (pyroCb) is a cumulonimbus (thunderstorm) cloud that forms over a bushfire. PyroCbs develop in unstable atmospheres and are triggered by the heat energy released by the fire. They can produce lightning, hail and tornadoes. PyroCb are usually associated with large (often crown) fires, high energy release, high flames and indicate extreme fire behaviour. Due to their convective nature they can produce gusty, erratic winds that may result in changeable and very rapid fire spread in any direction.

Density current outflow is the downdraft from the pyroCb. The pyroCb has an updraft and compensating downdraft. Condensation and evaporation processes make the downdraft air denser (heavier) than the surrounding air, so the downdraft accelerates downwards until it hits the surface, where it spreads out as a turbulent flow, producing gusty winds in any direction.

Downslope winds form in the lee slope of mountain ranges in the evening and overnight. They occur when a cooler air mass moves up the windward slope, and is 'squeezed' between the hilltop and a temperature inversion above the ridge. Once on the (warmer) leeward slope, the air accelerates downwards in a highly turbulent, gusty flow. Downslope winds occur regularly in favourable locations during spring and summer and are known colloquially as 'gully winds' in Adelaide and 'scarp winds' in Perth. Downslope winds can produce a hydraulic jump, an atmospheric wave with rapid up and down motion, which, if corresponding with a fire plume, can rapidly lift and deposit many embers (see figure 1, page 3). Even without a hydraulic jump, the turbulence in gully winds can rapidly transport firebrands locally.

RESEARCH FINDINGS

The four extreme fire behaviour episodes at the Waroona fire are detailed here.

Pyrocumulonimbus events

During the late afternoon of 6 January, a pyroCb developed over the fire, with a dense, rotating smoke plume extending to higher than 14 km. The pyroCb produced an extensive cirrus anvil (anvil-shaped thunderstorm cloud), evidence that it had accelerated upwards so powerfully that it had 'punched' into the stratosphere. Lightning from the pyroCb ignited new fires downwind of the main fire front and a density current outflow (a downdraft carrying heavier, cooler air in the compensating downwards column of the pyroCb) was observed at the nearby Wagerup Automatic Weather Station (AWS).

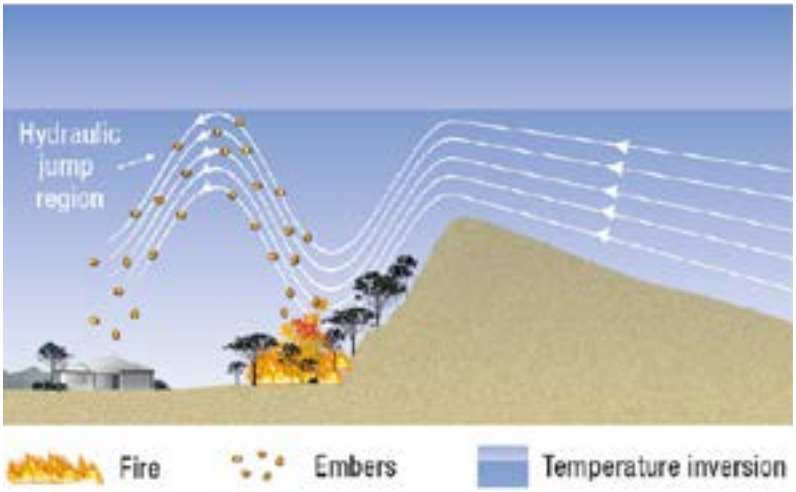
This gust outflow from the pyroCb downdraft recorded at Wagerup AWS on the evening of 6 January shows the potential impact of dry (or hybrid) microburst environments when a fire is burning. Dry microbursts can produce strong, downdraft winds and have been associated with fatalities at other fires; the Waroona pyroCb outflow, seen on radar and AWS observations, illustrate the hazard associated with the phenomenon. Thunderstorm and pyroCb outflow boundaries are regions of enhanced turbulence and are therefore conducive to transporting large quantities of embers, as well as unusually fast and erratic fire spread.

▲ **Above:** EXTREME FIRE BEHAVIOUR DURING THE WAROONA FIRE. PHOTO: DEPARTMENT OF FIRE AND EMERGENCY SERVICES WA.

On 7 January, a pyroCb developed in the late morning, which is unusual timing for surface-driven thunderstorm activity. This study shows that two processes drove the pyroCb. The first was high energy release along a 20 km fire line spreading in heavy vegetation that had been unburnt for 20 years. The second was rapid forward spread driven by the movement of above surface winds down to the surface, via a process called 'momentum entrainment', within the fire plume. This circulation process involved the downward motion of faster, higher energy air from a 'wind maximum' – a fast channel in the atmosphere – located one to three kilometres above the surface. Doppler radar velocity scans showed strong, fire-induced, low-level convergence. This pyroCb featured two short-lived pulses of cloud to the upper levels of the atmosphere when energy release from the fire was sufficient to overcome a weak elevated temperature inversion.

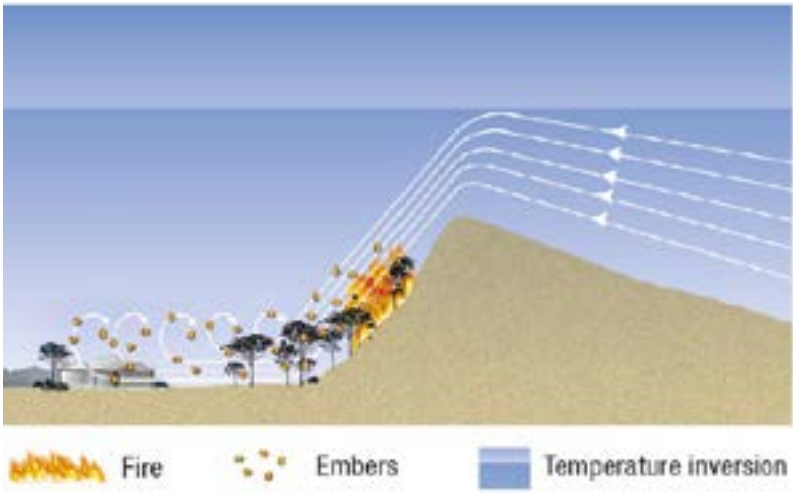
Although pyroCbs occurred on both days

FIGURE 1



▲ **Above:** HOW A HYDRAULIC JUMP CAN SPREAD EMBERS AHEAD OF A FIRE FRONT.

FIGURE 2



▲ **Above:** HOW DOWNSLOPE WINDS SPREAD EMBERS AHEAD OF A FIRE FRONT.

in favourable environments, the triggers and thresholds were different. On 6 January, a sea breeze front triggered the pyroCb, which developed in the late afternoon, at a similar time as non-fire thunderstorms. In contrast, on 7 January, the pyroCb developed in the late morning, against normal daily thunderstorm trends.

On both days, vertical wind shear (changes in wind direction and speed with height) contributed to the coherent structure and rotation of the fire plume, which enabled strong plume updrafts that injected smoke and other pollutants into the stratosphere.

Ember shower in downslope winds

On both evenings, the Wagerup AWS showed an increase in wind speed consistent with downslope winds in the area, which is known to experience gusty 'scarp' winds during the evening and overnight. An important aspect of the dynamics of downslope winds in driving ember showers is their highly turbulent nature near where the base of the hill meets the coastal plain. When co-located with a fire, downslope winds produce an environment that is highly conducive to spotting and ember showers, particularly if vegetation is favourable for firebrand production. High resolution modelling shows the presence of a hydraulic jump adjacent the scarp. The hydraulic jump is an atmospheric wave with rapid up and down motion that can enhance localised lofting and deposition of many firebrands over an area (see figure 1, above). The high velocities in the hydraulic jump mean that embers are more likely to be deposited while still alight (that is, large numbers of embers can be transported significant distances within the ember's burnout time).

On the evening 6 January, Waroona was reported to be under ember attack around 9pm. The ember attack is likely to have been due to lightning ignition of a new fire closer to the town, which was subsequently driven by the density current outflow from the pyroCb. Local downslope winds and a hydraulic jump produced the mechanism for localised lofting, transport, and turbulent dispersion of firebrands, which resulted in the ember attack over Waroona.

The evening ember storm on Yarloop on 7 January was also driven by downslope winds, similar to the ember attack over Waroona. Dense, long-unburnt vegetation just to the east of Yarloop contributed significantly to the intensity of the fire, as well as being a source of firebrands. Doppler radar velocity scans show significant vertical fire plume development and localised convergence at the time Yarloop was destroyed by the ember storm.

END-USER STATEMENT

While our current fire behaviour models perform well under a broad range of conditions, they have been shown to be incapable of representing the complex fire behaviour that can occur when large bushfires interact with the atmosphere. Fires of this type tend to be particularly dangerous and have resulted in extensive damage and loss of life. Having a sound understanding of factors that trigger coupling between a fire and the atmosphere, together with the ability to predict fire behaviour in real time, would better place fire managers to respond to fires of this type and to minimise impacts on the community. This case study is an important step in better understanding extreme fire behaviour.

– Dr Lachlan McCaw, Principal Research Scientist, Department of Biodiversity, Conservation and Attractions Western Australia

HOW IS THE RESEARCH BEING USED?

The case study's findings have helped identify the drivers of the unexpected extreme fire behaviour at the Waroona fire.

▲ **Above:** THE RAPID SPREADING OF THE WAROONA FIRE WAS CAUSED BY UNUSUAL WEATHER PHENOMENA. PHOTO: DEPARTMENT OF FIRE AND EMERGENCY SERVICES WA.

The lessons relating to pyroCb development and impacts and ember transport in downslope winds can be applied to bushfires in many other locations around Australia. This study will help to raise awareness of situations in which extreme fire behaviour may not occur at the same time or place as the maximum observed fire danger index.

This case study has been presented at many forums that included numerous operational personnel, such as fire behaviour analysts, meteorologists embedded with fire and other agencies, fire weather forecasters and fire managers. In reaching this audience, the researchers have shared the study's findings with operational decision-makers, equipping them to better identify potential risks at future fires and mitigate destructive impacts.

This study builds on previous CRC research on mountain waves (see *Hazard Note* 24) and ember transport in plumes, by showing a specific case for downslope winds. The impact of downslope winds at the Waroona fire shows how a highly turbulent low-level wind environment can be conducive to destructive ember showers.

This research could be applied to develop a predictive tool that identifies environments and localities that are favourable for winds conducive to the development of ember showers. This is likely to complement other CRC research, including the project *Improved prediction of severe weather to reduce community impact*, which is developing tools for predicting pyroCb and for ember transport in smoke plumes. Both projects highlight the need to identify environments and situations when normal daily patterns of fire danger are unlikely to apply, in order that risks can be communicated to fire managers and the community.

FURTHER READING

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FUTURE DIRECTIONS

This project will continue until 2020. The next phase of the research, currently in progress, is to run simulations of the Waroona bushfire with the coupled fire-atmosphere model ACCESS-Fire. The project has substantially developed the ACCESS-Fire model, which was originally created by Monash University and the University of Melbourne. This model couples the Australian Community Climate and Earth-System Simulator (ACCESS) Numerical Weather Prediction model and a range of fire spread prediction models, such as the McArthur, Rothermel and CSIRO grass and forest models. ACCESS-Fire can simulate large fires with full coupling to the atmosphere. In the coupling process, fire spread and vegetation burnt is calculated at each time step. The energy released by the fire is passed to the atmospheric model as a heat and moisture flux, which changes the atmosphere, particularly the nearby winds. The model results show how the energy released by a fire can modify the surrounding atmosphere, as well as resolve the complex interactions with local terrain. This develops the understanding of dynamic fire behaviour and enables predictive tools to be developed that can be used to mitigate the impacts of large fires. The project's researchers plan to continue collaborating on ACCESS-Fire with colleagues at the University of Melbourne.

The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

HAZARD **NOTE**

bushfire&natural HAZARDSCRC

ISSUE 24 DECEMBER 2016

TOPICS IN THIS EDITION | FIRE WEATHER | FIRE SEVERITY | FIRE IMPACTS

FIRE ESCALATION BY DOWNSLOPE WINDS

ABOUT THIS PROJECT

This research is part of the *Improved prediction of severe weather to reduce community impact* project, and builds on work described in *Hazard Note* 22.

AUTHORS

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SUMMARY

One of the most challenging situations in fire management is when relatively benign weather conditions are expected, but a severe fire eventuates. These situations can result in significant loss of property or even life. Identifying the cause of such incorrect expectations can help to prevent them from recurring in the future. Analysis of the meteorology of recent bushfires has now uncovered three cases (the State Mine fire, New South Wales, 2013, the Margaret River fire, Western Australia, 2011, and the Aberfeldy fire, Victoria, 2013) where a weather phenomenon known as mountain waves has contributed to the severe fire behaviour. Mountain waves are atmospheric oscillations that occur due to air flowing over hills or mountains. They can arise in several different ways, some more predictable than others. Often they cause strong downslope winds on the lee slope of the hill or mountain. If a fire is present, it may become unexpectedly severe as a result.

▲ **Above:** THE STATE MINE FIRE IN THE BLUE MOUNTAINS, OCTOBER 2013, SPREAD ABNORMALLY FAST FOR THE WEATHER CONDITIONS DUE TO A WEATHER PHENOMENON KNOWN AS A MOUNTAIN WAVE. PHOTO: GARY P HAYES, PROVIDED BY THE NSW RURAL FIRE SERVICE.

CONTEXT

This project has investigated the meteorology of several recent cases where unexpectedly severe fire behaviour has occurred. In the three bushfires discussed, mountain wave activity seems to be at least part of the cause.

BACKGROUND

Mountain waves are oscillations that can occur when the wind blows across a mountain or hill. They are somewhat similar to water flowing over a rock in a stream, but are much more complex because their existence and amplitude is sensitive to the atmospheric temperature structure (stability) and vertical variation of the wind (wind shear). They often lead to strongly accelerated flow attached to the lee slope of the mountain or hill, known as downslope winds, as seen for example in Adelaide's famous gully winds and the analogous scarp winds in Perth. While some have suggested that these strong winds could affect a fire (Sharples, 2009), there has been little direct evidence of this actually happening, either in Australia or overseas.

RESEARCH ACTIVITY

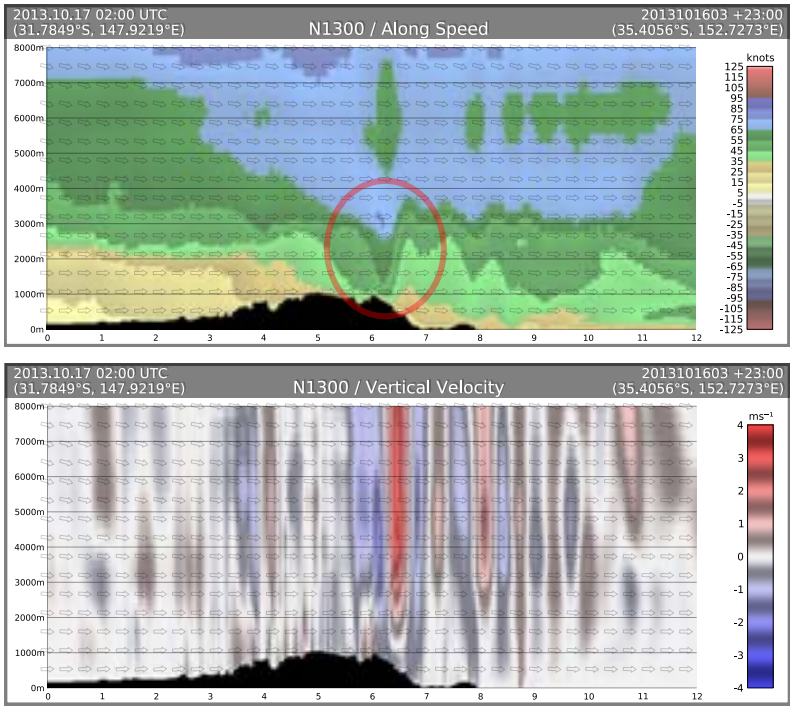
The Bureau of Meteorology's operational numerical weather prediction system, ACCESS, has been used to conduct the case studies into severe fire weather. ACCESS can simulate the weather of the event at very high resolution (a grid spacing of around 440 metres). This compares with the highest operational grid spacing of four kilometres at the time of the case study fires. Sub-kilometre resolutions are currently impractical for operational forecasting because the computer runtime becomes very long (by a factor of up to 1,000 times), although they can be very instructive in research mode. After running the model, the simulation is verified against the observed weather, and

HAZARD **NOTE**

DEFINITIONS

Mountain waves: Atmospheric oscillations that occur due to air flowing over hills or mountains. There are several causes, some more predictable than others. Often mountain waves cause strong downslope winds on the lee slope of the hill or mountain. If a fire is present, it may become unexpectedly severe as a result.

Dry slot: In the context of fire weather, a relatively long narrow band of dry air, often associated with a wind change, which can cause sudden drops in humidity and increases in wind speed if it mixes down to the surface. The onset of dry air can reduce fine-fuel moisture and thereby elevate fire risk.



Above: FIGURE 1: A NORTH WEST – SOUTH EAST CROSS-SECTION THROUGH THE VICINITY OF THE STATE MINE FIRE AT 1PM ON 17 OCTOBER 2013. THE TOP PANEL SHOWS WIND COMPONENT ALONG THE CROSS-SECTION PLANE, WITH STRONG HORIZONTAL DOWN WINDS CIRCLED, AND THE LOWER PANEL SHOWS VERTICAL VELOCITY (RED = UP, BLUE = DOWN). THE FIREGROUND WAS NEAR THE NUMBER 6 ON THE X AXIS. THE FLOW DIRECTION IS LEFT TO RIGHT.

if it proves to be sufficiently accurate, it can be assumed it is a good representation of what actually occurred. In many cases, the team have been able to uncover fine-scale meteorology, too small in scale to be resolved by the operational models or captured by available observations, which would have contributed to more severe fire behaviour. However, these features would either not have been depicted in the traditional fire danger parameters of surface temperature, humidity and wind, or would have been filtered out in a broader-scale depiction of the data.

Such numerical weather prediction-based case studies have been widely used in meteorology and have significant benefits. While observations sample only a few points, the model contains information on the conditions throughout the area of interest, including above the surface. The model data are coherent in space and time, making it easier to interpret what is happening, and less likely to have something of importance fall in the gaps between the observations. These studies also help shape future numerical weather predictions, using high-impact events to test the models under demanding conditions and demonstrate the value of upgraded computers.

In the course of this research, a number of significant bushfires have been analysed. It has been discovered that mountain waves were a factor in three of these fires, enough to suggest that mountain wave impact on fire is a reasonably common problem.

RESEARCH OUTCOMES

Blue Mountains fire

A detailed case study of the Blue Mountains (NSW) fires of October 2013 was undertaken, focusing on 17 October when some 200 houses were destroyed. On this day, the State Mine fire, one of several fires in the Blue Mountains, grew from 1,036 to 12,436 hectares in around 10 hours. While antecedent conditions had been dry, this was severe fire behaviour by any definition, especially occurring so early in the fire season.

Figure 1 (above) shows a cross-section of the horizontal wind speed and vertical motion along a section passing north west – south east through the fireground. Notice the region of strong horizontal winds (circled) extending downwards towards the surface in the vicinity of the fire. Elsewhere, much weaker winds prevailed at these levels. Notice also the oscillations downwind of this feature. Looking at vertical motion along the same cross-section, alternating bands of ascent and descent are apparent. Together, these bands are the characteristic features of mountain waves.

The modelling also showed that a marked 'dry slot' of drier air passed over the fireground during the day (see definitions box, above left), further contributing to the fire danger.

Margaret River fire

The Margaret River fire in November 2011 was a prescribed burn that escaped overnight. Strong winds the following day drove it south into the communities of Prevelly and Gnarabup, where 39 houses were lost. While the fire activity was reasonably consistent with the fuels and weather on the day, the behaviour overnight was not. For the days preceding the escape, the fuels had been reluctant to burn, to the extent that it was decided to leave the fire overnight. Early the following morning, crews returned to find the fire had dramatically intensified and was in the process of crossing the control lines. They were unable to contain it and it proceeded through inaccessible terrain to impact those communities.

The prescribed burn area included the southern slopes of a small hill about 200m in height. Modelling has shown that overnight, as the wind tended northerly, strong downslope winds developed on this slope, reinvigorating the fire and pushing it towards the containment line. In this particular case, and in contrast to the State Mine fire, strong near-surface atmospheric stability due to a nocturnal temperature inversion was important for the development of the mountain waves. In fact, the meteorology appears similar to Adelaide's gully winds,

END USER STATEMENT

This research has drawn attention to an important but hitherto neglected weather phenomenon that can cause bushfires to behave with unexpected severity on downslope terrain in the lee of a mountain range. An interesting finding from the work is that, under some conditions, mountain wave phenomena may occur in areas where the local relief is as small as one or two hundred metres. High resolution numerical weather modelling has contributed to improved understanding of the factors associated with strong downslope winds. Having the ability to identify situations where strong downslope winds are likely to occur would allow better planning of fire suppression operations, reducing risks to firefighters and the community in affected areas. Further work is required to develop weather products that can convey information about the location of areas prone to downslope winds and the likelihood of wind speeds exceeding specified thresholds.

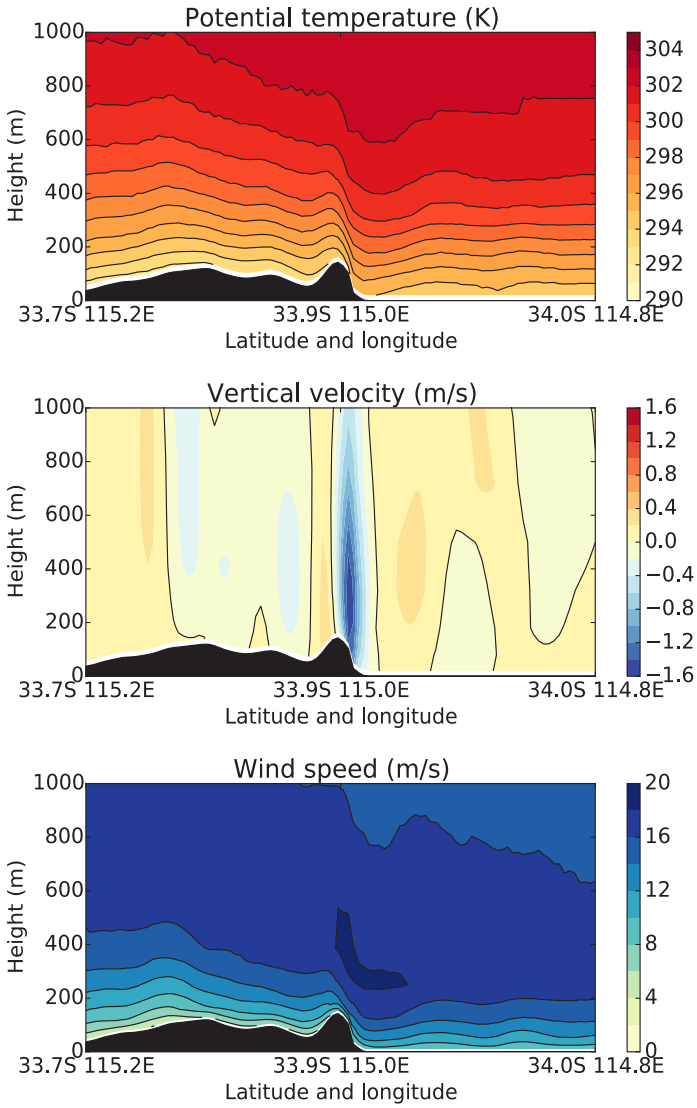
– Lachlan McCaw, Principal Research Scientist, Department of Parks and Wildlife Western Australia

or the similar scarp winds that occur off the Darling Escarpment east and south of Perth. Figure 2 (right) shows a cross-section through the fireground, aligned along the wind direction. The strong low-level inversion, marked descent and wind acceleration on the lee slope are all clearly visible.

A further meteorological contributor to the unexpected fire behaviour in this case was that dry continental air moved over the fire earlier in the night, making the fuels more flammable. For further details on this case study see Kepert and Fawcett, 2013.

Aberfeldy fire

In the Aberfeldy fire, the unexpected fire activity occurred on the night of 17 January 2013. Like the Margaret River fire, this was against the usual diurnal trend. The main difference with the Margaret River fire was that the fireground was much more elevated, being on the southern slopes of the Great Divide overlooking the Latrobe Valley. Modelling has shown clear evidence that mountain waves and strong downslope winds developed overnight. These winds would have directly increased the fire intensity and spread, as well as contributed to firebrand transport. However, it is likely that other factors also contributed. One influence was the steep and rugged topography, while another was that the fireground, being elevated, was in the warm dry air above the nocturnal inversion, which would have limited overnight recovery of the fuel moisture. More details on this analysis can be found in Wells *et al.* (2014).



Above: FIGURE 2: CROSS-SECTIONS OF POTENTIAL TEMPERATURE (TOP), VERTICAL VELOCITY (MIDDLE, BLUE IS DOWN) AND WIND SPEED (BOTTOM) THROUGH THE FIREGROUND OF THE MARGARET RIVER FIRE. THE OVERNIGHT INTENSIFICATION AND ESCAPE OF THE FIRE OCCURRED ON THE LEE OF THE SMALL HILL NEAR THE CENTRE OF THE DOMAIN. THE FLOW DIRECTION IS LEFT TO RIGHT.

HOW COULD THE RESEARCH BE USED?

This research has found strong evidence in three cases of mountain waves and downslope winds contributing to unexpectedly severe fire behaviour. So what does this mean for fire management?

Obviously, it would help to be able to forecast such activity. In cases such as the Margaret River fire, the ingredients that led to similar events such as the Adelaide gully winds and its Perth counterpart are well known (nocturnal cooling, reasonable strong synoptic flow, gentle upwind slope and steeper downwind). Other mountain wave forecasting cases are more difficult – forecasters could be reasonably confident of some activity, but is it strong enough to cause a serious problem?

Mountain wave activity is sensitive to the atmospheric wind and temperature

structure, to the shape of the particular hill, and to all the hills upwind of that. Theory helps in some cases, but attempts to fit the Blue Mountains case study into one of the existing theoretical paradigms were not successful. On the other hand, sufficiently high resolution modelling is well established as being capable of capturing at least some of these events, and the Bureau of Meteorology's new 'city domain' versions of ACCESS have a grid spacing of 1.5 km, which should suffice in many circumstances. However, these are only available in those regions covered by those models (in most cases, a roughly 1,000 km square centred on the state capitals). They have been enabled by the new supercomputer, and will be operational in 2017.

A further problem is that the area affected by mountain waves is often comparatively small – only a few kilometres across in the case of the Margaret River fire. District-level forecasts may be too broad-scale to capture the effect, as will forecasts based on anything but the finest resolution numerical weather prediction.

Even if numerical weather prediction that reasonably correctly resolves the occurrence and amplitude of the mountain waves is available, it is still necessary to get the information to the fire manager. A request for a spot forecast from the fire manager, mentioning the precise location and perhaps the possible concern regarding mountain waves, might be necessary. But this approach could rapidly become impractical when there are many fires, and fire managers might be reluctant to request a spot forecast when they expect the fire behaviour to be benign. It may be necessary to train both meteorologists and fire managers in the potential impacts of mountain waves on fires.

These studies show the utility of high-resolution numerical weather prediction in diagnosing the cause of unexpectedly severe bushfires, and this utility should translate into skill in the forecast situation. But high-resolution numerical weather prediction contains a wealth of fine-scale three-dimensional detail, only a small part of which will be relevant to a particular situation. Teasing out the useful information, and avoiding swamping the user with unnecessary detail, are challenges that will become harder as forecast capabilities increase.

▲ **Above:** A MOUNTAIN WAVE CAUSED THE ESCAPE OF THE PRESCRIBED BURN NEAR MARGARET RIVER IN NOVEMBER 2011, EVEN THOUGH THE HILL THAT RESULTED IN THE DOWNSLOPE WINDS WAS ONLY AROUND 200M HIGH. 39 HOUSES WERE LOST. PHOTO: DEPARTMENT OF FIRE AND EMERGENCY SERVICES, WESTERN AUSTRALIA.

FUTURE DIRECTIONS

Mountain waves are also a hazard through wind damage and to aviation, and so a substantial body of research exists. Their formation and amplitude is sensitive to the topography, and to upwind conditions through the depth of the troposphere, and accurate forecasting of strong events is known to be a difficult problem. Where there is sufficient model resolution to resolve them, better means of detecting mountain wave occurrence in the model will help. But downscaling methods need to be improved for use with coarser resolution models.

The three events that have been identified to date are each quite different. It would be optimistic to assume that these cover the full range of the phenomenon. Further case studies will likely reveal other examples of mountain waves adversely affecting fires, perhaps in quite different situations to those discussed here.

FURTHER READING

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Sharples JJ (2009). An overview of mountain meteorological effects relevant to fire behaviour and bushfire risk, *International Journal of Wildland Fire*, **18**, 737–754.

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The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

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HAZARD **NOTE**

bushfire&natural HAZARDSCRC

ISSUE 22 NOVEMBER 2016

TOPICS IN THIS EDITION | FORECASTING | MODELLING | SEVERE WEATHER | REMOTE SENSING

MONITORING AND PREDICTING NATURAL HAZARDS

ABOUT THESE PROJECTS

This is an overview of the *Monitoring and prediction* cluster of Bushfire and Natural Hazards CRC research projects. This cluster has five linked studies:

1. **Improved predictions of severe weather to reduce community impact** – Dr Jeff Kepert, Dr Kevin Tory, Dr Will Thurston, Simon Ching, Dr Robert Fawcett, Dr Dragana Zovko-Rajak, Bureau of Meteorology. Contact jeff.kepert@bom.gov.au
2. **Disaster landscape attribution** – Prof Simon Jones, Dr Karin Reinke, Dr Luke Wallace, Dr Sofia Oliveira, Vaibhav Gupta, Bryan Hally and Chathura Wickramasinghe, RMIT University. Contact karin.reinke@rmit.edu.au
3. **Mapping bushfire hazard and impacts** – Dr Marta Yebra, Prof Albert van Dijk, A/Prof Geoff Cary, The Australian National University. Contact marta.yebra@anu.edu.au
4. **Mitigating the effects of severe fires, floods and heatwaves through improvements to land dryness measures and forecasts** – Dr Imtiaz Dharssi, Dr Vinod Kumar, Claire Yeo, Dr Jeff Kepert, Dr Peter Steinle, Dr Adam Smith, Dr Ian Grant, Bureau of Meteorology; Prof Jeffery Walker, Monash University. Contact i.dharssi@bom.gov.au
5. **Improving flood forecast skill using remote sensing** – A/Prof Valentijn Pauwels, Prof Jeffery Walker, Dr Stefania Grimaldi, Dr Yuan Li, Monash University. Contact valentijn.pauwels@monash.edu.au

CONTEXT

The ability to understand, predict, forecast and monitor natural hazards is fundamental to improving resilience through better planning, preparedness, risk management and response. The focus of the *Monitoring and prediction* cluster is to improve present predictive capabilities through expanding the underpinning data as well as the range of monitoring and modelling techniques.

Above: RESEARCH IS IMPROVING MODELLING FOR EAST COAST LOWS – HERE IS DAMAGE AT JIMMY'S BEACH IN NSW FROM THE APRIL 2015 EAST COAST LOW. PHOTO: OFFICE OF ENVIRONMENT AND HERITAGE NSW.

IMPROVED PREDICTIONS OF SEVERE WEATHER TO REDUCE COMMUNITY IMPACT

BACKGROUND

This project uses high-resolution modelling and a range of meteorological observations to better understand and predict important meteorological phenomena such as fire weather, East Coast Lows and tropical cyclones. Outcomes will contribute to reducing the impact and cost of these hazards on people, infrastructure, the economy and the environment.

RESEARCH ACTIVITY

Ember transport

The study has been developing understanding of how fire embers generated during bushfires can be lifted into the atmosphere and carried by winds ahead of a fire front, potentially starting new fires downwind. The team has undertaken simulations for ember transport for a wide range of wind speeds and ember fall speeds. It is important to consider a range of fall speeds, since different types of embers have different densities and aerodynamic properties which affect how far they are carried.

2013 Blue Mountains fires

Although the Blue Mountains fires of October 2013 persisted for several weeks, much of the fire spread occurred on 17 October. This day was expected to be a day of high fire risk, but the extreme fire spread was not anticipated and the causes were unknown. The State Mine fire grew from 1,036 hectares at 11:56am to 12,436 hectares by 9:46pm, an increase in area of over 11,000 hectares in about 11 hours. There was a period of unusually strong winds and a very marked reduction in humidity, both of which approximately coincided with the major fire run. Subsequent analysis focused on determining the meteorological processes that caused these factors.

Pyrocumulonimbus

Plume modelling has also been utilised to study pyrocumulonimbus clouds (PyroCb). Intense fire plumes in suitably moist environments can lead to PyroCb development, with the possibility of strong downbursts which can exacerbate already extreme fire conditions. A survey of current understanding and forecast techniques has been completed, and the team will be working towards developing improved techniques in the coming year.

April 2015 East Coast Low

East Coast Lows are intense low-pressure systems that form adjacent to the east coast of Australia, most commonly along the New South Wales coast. Research has analysed the April 2015 low, which resulted in flooding and three fatalities in the NSW town of Dungog, using, for the first time, an ensemble of 24 simulations rather than just a single forecast.

RESEARCH OUTCOMES

Ember transport

Research has confirmed that the mean travel distance of firebrands for a given fire intensity depends mainly on wind speed. However, the spread in the landing positions shifts from being substantially cross-wind at light winds, to dominantly along-wind at high winds. This spread is greatly increased by the turbulence in the plume, and the maximum spotting distance can be more than double the mean for this reason. This aspect of the project is complete. These sophisticated and computationally intensive calculations will now be used to inform the development of physically realistic and computationally cheap parameterisations of ember transport for use in fire models, and inform fire behavior analysts of the potential downwind distances that spotfires may occur.

2013 Blue Mountains fires

High resolution simulations have shown that the downward extension of high upper-level winds to the vicinity of the fire ground, caused by mountain wave activity (wind oscillations that can occur when the wind blows across a mountain or hill), were a factor in the extreme fire spread experienced. In addition, the marked wind change on that day was associated with a dry slot, a relatively long narrow band of dry air, often associated with a wind change, and that can cause sudden drops in humidity. However, the underlying cause of the dry slot seems to be different to previously documented cases. This will be documented in further detail in a future *Hazard Note*. The research phase of this component of the project is now complete.

PYROCUMULONIMBUS

The team has analysed the processes that lead to PyroCb clouds, with special attention on the relative importance of moisture from the atmosphere and combustion. Findings show that the influence of moisture from combustion is close to negligible. This knowledge will be used to develop a forecast tool for PyroCb formation.

April 2015 East Coast Low

Collectively, the ensemble simulations accurately predicted the position and intensity of the low, the strong winds and the rainfall. The differences between them give insight as to the forecast uncertainty, the overall envelope of areas at some risk, and the areas at highest risk. The ensemble also enables insight into the processes that lead to the rapid intensification of these systems. The team is continuing to learn from ensemble simulations about predictability of East Coast Lows and how to use this information to benefit both forecasters and the emergency services.

DISASTER LANDSCAPE ATTRIBUTION

BACKGROUND

Earth observation technologies are rapidly evolving, creating new opportunities for remotely detecting and tracking fires. Fire and land management agencies need to understand the potential application of these new data products, as well as their limitations. This project seeks to develop active fire mapping and detection capabilities from these new satellite-based data sources.

▲ **Above:** RESEARCH IS IMPROVING SATELLITE-BASED MAPPING OF BUSHFIRES AND PRESCRIBED BURNS. PHOTO: KARIN REINKE.

RESEARCH ACTIVITY

The project is evaluating and validating current satellite-based remote sensing options for active fire detection and surveillance. Using simulations and experiments, the team is determining the accuracy with which fires can be detected, along with their temperature and shape.

The project is also creating new techniques and protocols for the rapid attribution of fire landscapes (pre- and post-fire). Past work focused on the Moderate Resolution Imaging Spectrometer (MODIS) sensor, which is soon to be decommissioned. Current work is focusing on:

- TET-1, a polar-orbiting satellite providing high-resolution imagery every three to four days.
- Himawari-8, a geostationary satellite providing lower resolution imagery than TET-1, but every 10 minutes.

In addition to satellite imagery analysis, the project is also creating new ground-based techniques and protocols for the rapid quantification of fuel loads in fire landscapes (pre- and post-fire). In consultation with end-users, the landscapes identified as a priority are peri-urban areas, desert/mallee and closed (multiple canopy) forests. These techniques seek to add quantitative rigour to existing fuel hazard estimation practices.

RESEARCH OUTCOMES

TET-1 has been evaluated using fire simulations. The results indicate that TET-1 can detect fires that range in size from 1 m^2 through to 100,000 m^2 depending on fire temperature. Simulations show that TET-1 may detect small, hot fires or larger, low temperature fires under ideal conditions, as well as being able to detect spotfires ahead of the main fire body. The ability of TET-1 to detect large areas at low temperatures suggests it may be useful in mapping recently burnt areas.

Using a new algorithm and computer scripting, Himawari-8 has been used to track three fires in Western Australia. Results showed that the fires were able to be continuously tracked during the day, at a resolution of 500m. While the spatial resolution is lower than available from TET-1, the ability to process imagery every 10 minutes may enable almost real-time fire detection, a capability that cannot be achieved from other satellites.

To help land managers quickly and more accurately assess fuel loads before and after prescribed burns, a beta smartphone application, Fuels3D, is being developed. Using a computer vision technique, called Structure from Motion (SFM), the phone's camera takes a series of photos which are then analysed to create a point cloud. A point cloud represents the external surface of an object. SFM allows for the extraction of information about the structure, which results in a 3D model of the fuels. A number of different technologies were reviewed by the team to assess which could underpin a low-cost, high quality service. Trials with end-users are ongoing.

MAPPING BUSHFIRE HAZARD AND IMPACTS

BACKGROUND

This project uses cutting edge technology and imagery to produce spatial information on fire hazard and impacts needed by planners, land managers and emergency services to effectively manage fire at landscape scales.

RESEARCH ACTIVITY

The project is focused on two related activities:

1. Fire hazard mapping and monitoring – this focuses on spatial information of fuel load, structure and moisture properties that can assist fire preparedness through better fire danger ratings and fire behaviour predictions. The information supports logistics and resources planning by emergency services, and can also improve fire management by helping guide activities such as scheduling and implementing prescribed burning. Discussions between researchers and end-users indicate that the greatest and most urgent information gap is spatial information on forest fuel load, structure and moisture.
2. Fire impacts on landscape values – land managers need spatial information on the expected fire impacts on landscape values, such as water resources, carbon storage, habitat and remaining fuel load. Relevant issues include the impact of unplanned or prescribed fires and subsequent recovery on catchment water yield and the carbon lost due to fire and then subsequently taken up during regeneration. Current prediction methods are crude and make bold assumptions (for example, about the similarity of the water use patterns between (well-studied) recovering mountain ash forests and (unstudied) other forest types.

▲ **Above:** RESEARCHER DR MARTA YEBRA MEASURING THE SPECTRAL RESPONSE OF GRASSLANDS AT AN EXPERIMENTAL BURN SITE. PHOTO: CAROLINA LUIZ.

RESEARCH OUTCOMES

The team has developed the Bushfire Information System, the first Australia-wide system with potential for operational estimation of live fuel moisture content (one of the primary variables affecting bushfire ignition) and flammability using satellite data. Evaluation is ongoing and improvements expected, but current outputs are already useful for fire managers to monitor spatial and temporal dynamics in fuel moisture, providing insights into risk of unplanned fire and optimal scheduling of prescribed burning.

The team has also developed, tested and published software to classify a dense point cloud derived from a mobile laser scanner into different vegetation components: ground returns, near-surface vegetation, elevated understory vegetation (shrubs), tree trunks and tree canopy. The resulting classified point cloud is used to automatically derive information on the different fuel components that are important for fire hazard assessment such as total biomass, fractional cover and height. These results open a pathway of automatically deriving detailed vegetation structure information from ground-based LiDAR.

MITIGATING THE EFFECTS OF SEVERE FIRES, FLOODS AND HEATWAVES THROUGH IMPROVEMENTS TO LAND DRYNESS MEASURES AND FORECASTS

BACKGROUND

Accurate soil moisture information is critical for the management and warning of fires, floods and other natural hazards. Fire ignition, intensity and spread rate are strongly influenced by soil moisture content – the occurrence of large destructive fires corresponds to very large soil moisture deficit values. Many studies suggest that soil moisture significantly influences rainfall as well as temperatures and heatwave development.

RESEARCH ACTIVITY

This project is developing a high resolution, state of the art soil moisture analysis system that makes use of surface and remotely sensed observations, land surface modelling and data assimilation. The Joint UK Land Environment Simulator-based Australian Soil Moisture Information (JASMIN) system is a more accurate alternative to the Keetch-Byram Drought Index (KBDI) and Mount's Soil Dryness Index (MSDI) that are currently used for operational fire danger prediction.

This new system uses the Joint UK Land Environment Simulator land surface model, which is used by the Bureau of Meteorology numerical weather prediction systems and also used at many other international weather prediction centres. The JASMIN outputs are calibrated to have the same dynamic range and statistical properties as KBDI and MSDI. This retains the accuracy, temporal and spatial resolution of JASMIN products and will allow much easier incorporation of calibrated JASMIN products into operational fire danger

prediction systems. Downscaling methods will be implemented to provide soil moisture information at about 1 km resolution.

RESEARCH OUTCOMES

The study has produced a 40-year historical dataset at 5 km resolution of KBDI and MSDI using observation-based analyses of rainfall and maximum temperature. This new gridded dataset of KBDI and MSDI can be compared with the much used, lower 25 km resolution, Finkele-Mills dataset, and will be a valuable resource for researchers working on fire climatologies, ecological and flooding studies across Australia.

KBDI, MSDI and JASMIN outputs have been verified against soil moisture observations from around Australia. The soil moisture observations are located in many different land types including forests, savanna, croplands and grasslands. Verification shows that JASMIN soil moisture analyses are significantly more accurate than KBDI and MSDI, and that KBDI has a significant wet bias. A case study has been undertaken using the 2013 Blue Mountains State Mine fire, with results showing that JASMIN would have provided more accurate guidance than KBDI.

END USER STATEMENT

Managing our response to natural hazards demands we understand the current situation and are able to predict its likely development. Projects in this cluster are tackling some of the biggest situational awareness challenges for fire and flood response: understanding the arrangement, amount, and moisture content of fuels, along with monitoring of soil dryness and fire detection. The modelling work in the cluster is developing cutting edge methods which will help to improve predictions of severe storms, floods and bushfires. Utilisation of research outcomes from the cluster will make a difference to how we prepare for and respond to natural hazards in the future.

– Dr Stuart Matthews, Senior Fire Behaviour Analyst, NSW Rural Fire Service

▲ **Above:** THE CLARENCE RIVER HAS FLOODED AREAS AROUND GRAFTON, NSW, FOUR TIMES SINCE 2009, SIGNIFICANTLY AFFECTING MANY RURAL PROPERTIES SUCH AS THIS ONE IN FEBRUARY 2013. PHOTO: NSW STATE EMERGENCY SERVICE, CLARENCE NAMBUCCA REGION.

IMPROVING FLOOD FORECAST SKILL USING REMOTE SENSING

BACKGROUND

Flood forecasting systems aim at predicting the arrival time, water depth and velocity of a flood and are relied upon heavily by water and emergency managers. These systems consist of a hydrologic and a hydraulic model, using observed and predicted rainfall as primary inputs. The hydrologic model calculates the amount of water that is flowing through the river network, while the hydraulic model converts this flow volume into river water levels/velocities and floodplain extents. The accuracy and reliability of these flood forecasting systems has significantly improved, but due to errors and/or uncertainties in the models and model parameters, it is still difficult to provide accurate flood warnings. This study is using remote sensing to improve modelled flood forecasts.

RESEARCH ACTIVITY

The project has two test sites – the Clarence River in northern New South Wales, and the Condamine River in southern Queensland. Field work has been conducted in both locations to gather missing data, which is expected to improve the existing models.

RESEARCH OUTCOMES

Improving the hydraulic model at both test sites is underway, based on a combination of field data, in-situ collected data, and remote sensing data. The comparison of the model results with remote sensing-derived observations of flood extent and levels will allow the validation of the model protocol, which will lead to calibration of the numerical model.

A joint calibration experiment using both streamflow and remote sensing soil moisture data has also been conducted in the Clarence River. Four scenarios were tested, with results indicating that remote sensing soil moisture has the potential to improve streamflow estimation, with improvements likely to be better where river gauges do not exist. It was also found that the impact remote sensing soil moisture data decreases when the density of calibration sites increases. The same calibration strategies are being implemented in the Condamine River, and a comparative study of the two locations will be conducted.

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Fire Predictive Services

HAZARD **NOTE**

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ISSUE 91 FEBRUARY 2021

TOPICS IN THIS EDITION | FIRE IMPACTS | FIRE SEVERITY | FIRE WEATHER

AUSTRALIAN SEASONAL BUSHFIRE OUTLOOK: MARCH – MAY 2021

OVERVIEW

The influence of La Niña on Australia's climate has had a pronounced effect on fire potential. Spring and summer have seen average to above average rainfall across much of the country, with the exceptions of south east Queensland, south west Tasmania and parts southern Western Australia.

For autumn, below normal fire potential can be expected in parts of Victoria and far northern Queensland due to wet conditions and damp vegetation and soils. In contrast, dry conditions mean that parts of central and southern Queensland inland from the coast have been assessed as above normal fire potential.

Elsewhere, where the rain has fallen in southern Australia, the risk of grass and crop fires continues into autumn due to strong vegetation growth. These types of fires are fast moving and spread rapidly during strong winds.

Prescribed burning during this *Outlook* period is an important tool to reduce bushfire risk. In many areas, prescribed burning opportunities may arise under appropriate weather conditions and with enough local resources.

The *Australian Seasonal Bushfire Outlook: March – May 2021* covers all states and territories. Fire management is a year-round process and the *Outlook* reflects the priorities in each state and territory for the coming months given the expected climate conditions. It provides information to assist fire authorities in making strategic decisions such as resource planning and prescribed fire management to reduce the negative impacts of bushfire.

Fire potential can vary greatly, even at the smaller scale, between bordering states and territories. Each state and territory's assessment takes into account different land use types (such as agriculture, forestry, public land) and vegetation types (forests, grasslands, deserts). This in turn is influenced by different forecasts for temperature and rainfall over these regions. It is important to remember that areas designated as normal or below normal fire potential may experience fire – normal or below normal risk does not mean there is no risk.

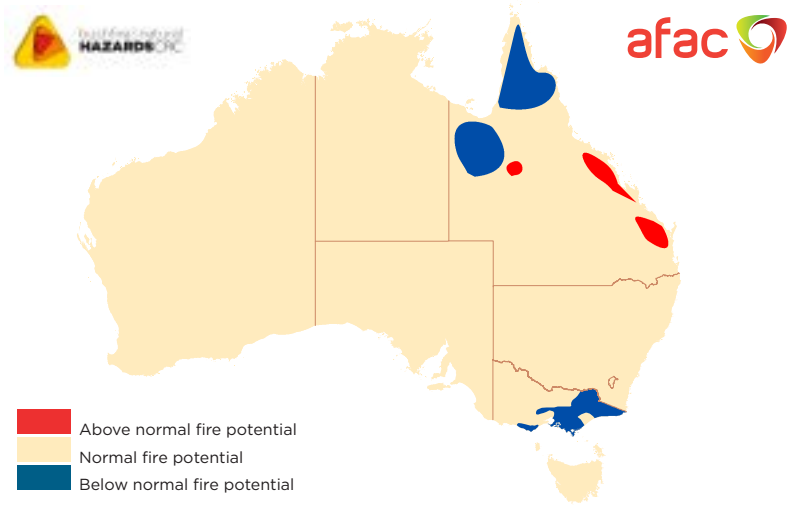


Figure 1: AUSTRALIAN SEASONAL BUSHFIRE OUTLOOK: MARCH – MAY 2021. AREAS ARE BASED ON THE INTERIM BIOGEOGRAPHIC REGIONALISATION FOR AUSTRALIA AND OTHER GEOGRAPHICAL FEATURES.

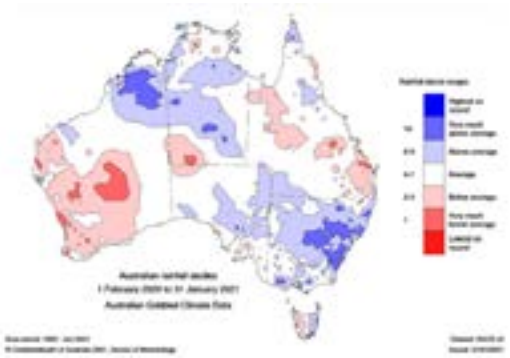
The *Australian Seasonal Bushfire Outlook: March – May 2021* is developed by the Bushfire and Natural Hazards CRC, AFAC, the Bureau of Meteorology, Queensland Fire and Emergency Services, the New South Wales Rural Fire Service, ACT Emergency Services Agency, ACT Parks and Conservation Service, Country Fire Authority, Department of Environment, Land, Water and Planning Victoria, Tasmania Fire Service, Country Fire Service, Department of Fire and Emergency Services and Department of Biodiversity, Conservation and Attractions Western Australia, and Bushfires NT.

OUTLOOK – AUTUMN 2021

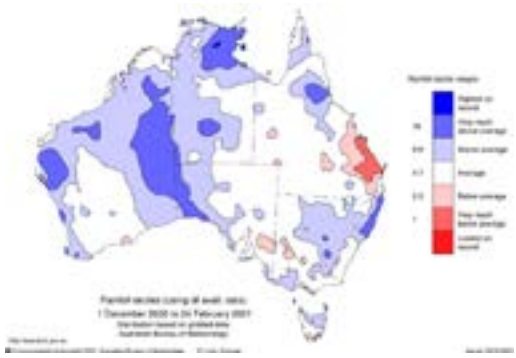
Bushfire potential depends on many factors. The volume, location and timing of rainfall are critically important when estimating vegetation (fuel) volumes and growth. The climate outlook for the next few months is also a crucial factor. Of particular interest are the future tendencies of Pacific sea surface temperature associated with the El Niño-Southern Oscillation, as well as the Indian Ocean Dipole – major climate drivers over Australia. Other less quantifiable factors, such as the distribution and readiness of firefighting resources, are also considered.

DEFINITION

Fire potential: The chance of a fire or number of fires occurring of such size, complexity or other impact that requires resources (from both a pre-emptive management and suppression capability) beyond the area in which it or they originate. Fire potential depends on many factors including weather and climate, fuel abundance and availability, recent fire history and firefighting resources available in an area.



▲ **Figure 2:** RAINFALL DECILES FEBRUARY 2020 TO JANUARY 2021.



▲ **Figure 3:** RAINFALL DECILES DECEMBER 2020 TO 24 FEBRUARY 2021.

Although La Niña has reached its peak, it is still expected to influence Australia's climate into autumn, with above average rainfall likely over much of the country.

For future updates on fire potential during autumn, visit your rural fire agency website.

RECENT CONDITIONS

Seasonal fire conditions are a function of fuel (vegetation) amount and dryness, and recent rainfall and temperature patterns. Australia's climate in spring and summer 2020/21 has been markedly different to 2019. Since February 2020, rainfall has generally been average to above average across much of the south east and north west of the country (see Figure 2, above). Rainfall during summer 2020/21 was above average across parts of the south east, central, north and west of the country (see Figure 3, above right). In contrast, 2019 was Australia's warmest and driest year on record.

La Niña has been underway in the tropical Pacific since September 2020 but is expected to return to neutral (neither El Niño nor La Niña) in autumn. La Niña events typically increase the likelihood of above-average rainfall across much of Australia during spring, and across much of eastern Australia during summer and early autumn. Above average rainfall since August 2020 over some areas of eastern Australia has eased rainfall deficiencies. However, south west and southern Western Australia, and some of the southern agricultural areas of South Australia, have received near- to below-average rainfall in the last 12 months. As a result, south west WA continues to experience long-term rainfall deficiencies.

The long-term warming trend means that above-average temperatures now dominate most years, and recent months have generally followed this pattern, despite La Niña. Spring 2020 was the warmest spring nationally on record. However, December 2020 and January 2021 were only slightly warmer than average, with above average rainfall, especially in December (Australia's third wettest December on record), keeping daytime temperatures cooler.

Rainfall so far in spring and summer 2020/21 has eased the fire risk for large parts of eastern Australia, however southern South Australia and south west WA have generally seen drier and warmer conditions in recent months. Areas such as south west WA have seen reduced rainfall over the multi-year timescale and did not see the extended average to above average rainfall that some regions in eastern Australia saw in 2020. More rainfall is needed across many areas to fully recover from the extreme dry of spring and summer 2019/20.

The tendency towards fire seasons with more frequently elevated fire dangers and for elevated fire danger to occur earlier and later in the season is a clear trend in Australia's climate, reflecting reduced and/or less reliable cool season (April to October) rainfall in southern parts and rising temperatures. Fire season length and severity is increasing across much of Australia as measured by annual (July to June) indices of the Forest Fire Danger Index, with increases tending to be greatest across inland eastern Australia and coastal WA. For more details on the changes being observed, see the recently updated State of the Climate 2020 report from the Bureau of Meteorology and CSIRO.

CLIMATE OUTLOOK

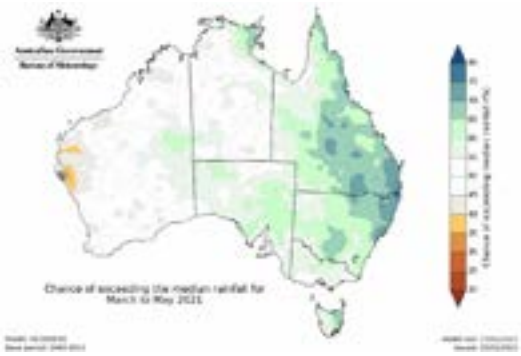
The Bureau of Meteorology's climate outlooks are based on the physics of the oceans, atmosphere, land and ice. They implicitly include all current climate drivers, including long-term trends.

The climate influences of 2020/21 are very different to those that led to the extreme dry conditions in 2019. A La Niña event has been active in the tropical Pacific Ocean since September 2020. La Niña typically results in above average spring, summer and early autumn rainfall over much of eastern and northern Australia. Combined with other drivers that enhance rainfall, including warmer than average waters to the north and west of Australia, parts of eastern Australia are expected to experience wetter than average conditions during autumn.

The rainfall outlook for March to May (Figure 4, page 3) shows that wetter than average conditions are likely for eastern parts of Queensland, New South Wales and Tasmania, with roughly an equal chance of wetter or drier conditions elsewhere. Historical outlook accuracy for March to May is high across much of Australia, but generally moderate to low around far south west WA, near the New South Wales-Queensland border and parts of south east NSW.

Average maximum temperatures for March to May are likely to be above average for Tasmania, parts of northern Australia and near-coastal parts of WA and Victoria. There is no shift towards either above or below average temperatures for the remainder of the country (Figure 5, page 4). Average minimum temperatures for the same period are very likely to be above the long-term average across much of the country (Figure 6, page 4). Historical accuracy for March to May maximum temperature outlooks is high to very high across the north of Australia. Elsewhere it is moderate, apart from much of SA and inland southern WA, where it is low. Historical minimum temperature outlook accuracy is moderate to high across much of northern Australia, SA and the south east, including Tasmania, and low across much of southern Queensland and WA.

The tropical cyclone season, which officially started in November 2020 and runs until the end of April 2021, has to date been relatively subdued, though there have been



▲ **Figure 4:** CHANCE OF EXCEEDING THE MEDIAN RAINFALL FOR MARCH TO MAY 2021.

a number of tropical lows that have brought rainfall to some parts of northern Australia. However, March is historically the most active month for tropical cyclone occurrence across the Australian region. While this may increase the chance of rainfall across northern Australia, including inland regions, areas of increased wind could potentially interact with any fires in the south of the country.

Updates to climate forecasts, including forecasts of monthly, fortnightly and weekly outlooks and the outlook for the Indian Ocean Dipole and the El Niño–Southern Oscillation will continue to be published at www.bom.gov.au/climate/ahead.

REGIONAL SUMMARIES

QUEENSLAND

Recent rainfall, particularly across northern Queensland continues to improve fire risk conditions. With the continued rainfall in the northern parts of the state, an increase in growth in biomass is expected and is likely to lead to lower than normal fire potential.

Lower than normal rainfall over the coastal areas from Rockhampton to south of Townsville may increase fire potential through March to early April. Conditions are likely to return to normal by May.

For this autumn outlook period, fire potential across most of Queensland is expected to return to normal or below normal conditions. The exception to this is some areas of the interior, to west and central coastal areas, with above normal fire potential expected. Fire mitigation activities may be challenging and affected by the positive moisture outlook throughout Queensland. These activities will be dependent upon local weather conditions.

NEW SOUTH WALES

The expected increase to grass fuel loads across the central west of the state eventuated during the last outlook period. Although a number of hot and dry periods occurred over summer, more recently the usual pattern of curing or drying of the grass that normally causes fire danger to increase has been interrupted by the frequency and amount of rain.

This rain has also led to continued growth. Although the rainfall outlook for the coming months suggests higher than average rainfall is possible for much of the state, depending on local conditions these high grass fuel loads may pose a risk during autumn.

The rainfall outlook, in combination with warmer than average minimum temperatures outlooks, may extend growing conditions for grassland areas. This could lead to higher fuel loads heading into next fire season and poses a particular risk to an early start to next season in grassland areas especially if frosts occur during winter as this could result in high fuel loads more susceptible to fire.

Whilst the fire outlook on the balance of the forecast appears normal, there is a need to monitor for unusual weather events (particularly windy conditions) that occasionally present during this period.

Traditionally in NSW the period March to May sees a shift from the fire danger period to a focus on hazard reduction burning. Conditions for the current outlook period appear variable, with soil moisture conditions for large areas in the eastern half of the state area wetter than average.

The grassland fuel state reflects this situation with reports of grass growth and low levels of curing (green grass). As conditions allow, NSW fire and land management agencies will undertake hazard reduction burning.

ACT

Due to the influence of La Niña, good rainfall has been received across the ACT during summer. The forecast return to neutral El Niño–Southern Oscillation conditions (neither El Niño nor La Niña) is expected to bring near average rainfall and daytime temperatures during March to May, however above average minimum temperatures are expected. Normal fire potential for autumn is expected as a result of these conditions.

Given the return to neutral climate conditions, fire agencies and land managers will undertake prescribed burning when conditions allow. Given the amount of recent rainfall, grassland areas are likely to allow for prescribed burning sooner than forest areas. ACT residents can monitor prescribed burns that are being planned and undertaken through either the ACT Emergency Services Agency and ACT Parks and Conservation Service websites or Fires Near Me App.

VICTORIA

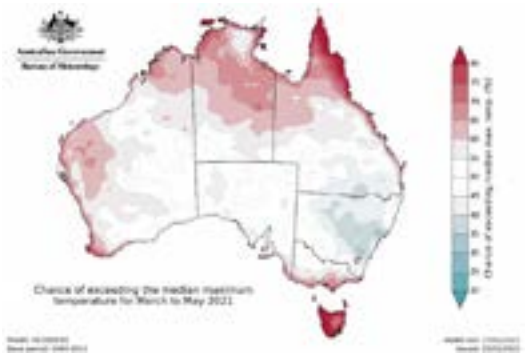
Above average rainfall has occurred over much of Victoria during summer and daily maximum temperatures were below average across the south, but average across the north of the state. These conditions led to reduced fire activity in both grasslands and forests, with a cumulative area burnt of 6,800 ha to date compared to the 10 year annual average burnt per year of 252,026 ha.

These conditions and the climate outlook indicate lower bushfire potential for many parts of Victoria than is normal during autumn. Below normal fire potential is expected in wet forests and many foothill forests due to higher than normal soil moisture levels limiting the flammability of vegetation (fuels). These soil moisture levels will likely persist due to no strong changes to drier conditions.

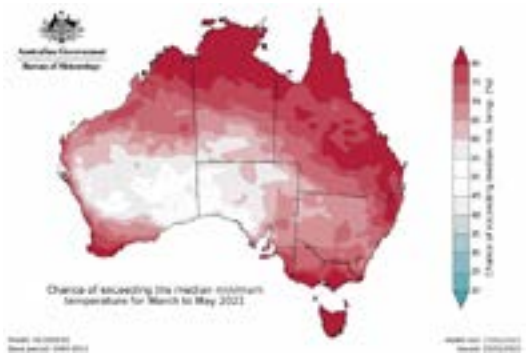
Opportunities for planned burning may be currently limited in foothill forests due to high soil moisture levels. However drier forests, woodlands, heathlands and grassy woodlands may be more receptive to planned burning compared to previous seasons. A return to drier patterns would see planned burning opportunities in foothill forests open up. Warmer than average nights during autumn may also expand windows for planned burning. District staff and planned burn teams will monitor fuel conditions to safely and effectively conduct planned burn operations.

TASMANIA

The influence of La Niña during spring and summer has seen above normal rainfall across northern Tasmania, and below normal bushfire activity across the state. The south west was consistently drier than normal from July 2020 to January 2021 but large amounts of rain during February have returned the soil dryness



▲ **Figure 5:** CHANCE OF EXCEEDING THE MEDIAN MAXIMUM TEMPERATURE FOR MARCH TO MAY 2021.



▲ **Figure 6:** CHANCE OF EXCEEDING THE MEDIAN MINIMUM TEMPERATURE FOR MARCH TO MAY 2021.

index to normal across large areas. Grassland curing is proceeding across the state, with most areas now over 80% cured. These conditions mean that there is little likelihood of sufficient drying occurring to allow landscape scale fires during autumn, although the grass fire risk remains in areas where the pasture has not been harvested or grazed. Normal fire potential is expected across the state for the outlook period. Conditions for planned burning during autumn are very promising, with planned burning projected to start in March.

SOUTH AUSTRALIA

Whilst some parts of South Australia have received above average rainfall so far this bushfire season, this rainfall has not been widespread or significant enough to negate a sustained risk of fire for most of the state. Furthermore, long-term rainfall deficiencies persist across most of the state, adding to the overall threat.

This risk is in line with conditions typically experienced during autumn and is characterised by short periods of heightened fire danger at regular intervals that can support intense fire behaviour. Such spikes in fire danger created the conditions experienced during summer at the Blackford fire at Lucindale and the Cherry Gardens fire in the Adelaide Hills.

While the current climate forecast indicates an increased chance of exceeding the median rainfall over the coming months, early autumn is a nevertheless a climatologically dry time of year for SA. Until sufficient rainfall is broadly received, which typically will not occur until later in autumn, this risk will persist and an extension to the dates of the fire season in some fire ban districts may be required. This potentially extended fire season would be fairly typical of recent years and as such normal fire potential has been assessed for autumn.

WESTERN AUSTRALIA

Northern Western Australia has received a good amount of summer rainfall and this is reflected in the above average soil moisture content of the root zone. Consequently, soil moisture may cause a delay in planned burning activities for the Victoria Bonaparte, Ord Victoria Plain, Central Kimberley, Northern Kimberley and Dampierland bioregions.

Summer 2020/21 saw WA affected by a number of severe bushfires in the south of the state. However the south west received significant rainfall along the west coast from a tropical low in early February which has elevated soil and live woody vegetation moisture contents, particularly for the Geraldton sandplains, Swan Coastal Plain, Jarrah Forest and Warren bioregions. This above average summer rainfall, together with a neutral climate outlook, has resulted in an expectation of normal fire potential for the outlook period.

NORTHERN TERRITORY

With an active monsoon, root zone soil moisture is above average for most of the northern Top End including the Arnhem Coast, Darwin Coastal, Gulf Fall and Uplands, Gulf Coastal and Tiwi Coburg regions. As a result, grass fuel growth continues with increasing moisture content. Above average soil moisture levels extend through most of the central belt from the Sturt Plateau to the Tanami, Great Sandy Desert, Burt Plain, Davenport Murchison and MacDonnell Ranges regions and grass fuel curing has been marginally lowered as a result. While La Niña has passed its peak, rainfall is forecast to persist into the early dry season for parts of the Top End. Normal fire potential has been assessed for the whole of the Top End. Planned burning activities may be challenging until late May due to increased soil moisture levels and lower than average curing.

For central Australian regions, the fire danger period commenced in mid-December 2020 and was revoked on 29 January 2021 following widespread rain. This rain increased soil and fuel moisture content levels which reduced the fire risk. All regions in central Australia have been identified as having normal fire potential through to May 2021.

The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

HAZARD **NOTE**

bushfire&natural HAZARDSCRC

ISSUE 88 JANUARY 2021

TOPICS IN THIS EDITION | FIRE | FIRE IMPACTS | REMOTE SENSING

THE AUSTRALIAN FLAMMABILITY MONITORING SYSTEM: PROVIDING A CLEAR PICTURE OF LANDSCAPE DRYNESS

Above: THE AUSTRALIAN FLAMMABILITY MONITORING SYSTEM SHOWS FIRE INCIDENTS (AS SEEN ON 22 DECEMBER 2021) AND LIVE FUEL MOISTURE CONTENT, WITH DARKER BLUE INDICATING MORE THAN 136% MOISTURE (VERY DAMP) AND DARKER RED INDICATING BETWEEN 0 AND 17% MOISTURE (VERY DRY).

ABOUT THIS PROJECT

This *Hazard Note* summarises the research from the Bushfire and Natural Hazards CRC's *Mapping bushfire hazard and impacts* project. The research produced the Australian Flammability Monitoring System (AFMS), which provides a clear interactive map showing vegetation and soil dryness across the Australian landscape.

AUTHORS

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SUMMARY

This project developed the first near real-time web application in the world that uses satellite data to provide a clear picture of live fuel moisture and soil moisture content at a continental scale, to improve the understanding of the flammability of trees, shrubs and grass. The Australian Flammability Monitoring System (AFMS) is a website that allows users to see where there are high levels of vegetation and soil dryness, which are the perfect conditions for a severe bushfire. It makes spatial information on fuel moisture content and flammability easier and faster to access for fire behaviour analysts, land managers, prescribed burning planners and fire behaviour analysts to manage fire at landscape scales. The AFMS is the first national-scale, pre-operational fuel and soil moisture content and flammability monitoring system in Australia, delivering accurate spatial information in near-real time. Access the AFMS at http://anuwald.science/afms.

CONTEXT

Understanding and predicting fire danger and behaviour is a priority for fire agencies, land managers, and sometimes individual businesses and residents. This is an enormous scientific challenge given the complexity of bushfires, with fire behaviour and severity driven by complicated interactions involving vegetation, topography and weather conditions. A good understanding of bushfire danger across the landscape depends on accurate spatial information about fire hazards, in order to prevent, avoid and manage impacts.

The amount of vegetation in an area, also known as fuel load, is one of the main drivers of the rate of spread of a fire. Therefore, an accurate assessment of the quantity and flammability of fuel loads in any given area, coupled with an assessment of how those fuel loads vary over time, may improve wildland vegetation management and help design more efficient fire management strategies. A key determinant of flammability of fuel and fire spread is the condition of the vegetation (fuel), for example, the moisture content, continuity, structure and quantity/load of the fuels.

Prior to this research, there has been limited emphasis on routinely providing and using spatial information on landscape-related hazard factors, such as fuel load or condition, in determining fire danger. This is partly because of a lack of timely, reliable, consistent,

The Australian Flammability Monitoring System was recognised with the Outstanding Achievement in Research Utilisation Award from the CRC in 2019.

accurate and long-term information. This project developed, tested and refined different methods to produce accurate spatial information on fuel condition and fire danger. The resulting technology is crucial for planners, land managers and emergency services. It supports a wide range of fire risk management and response activities, such as prescribed burning, pre-positioning firefighting resources and, in the long-term, informing enhancements to the new Australian Fire Danger Rating System.

BUSHFIRE AND NATURAL HAZARDS CRC RESEARCH

Phase One: testing the methods

In the first phase of the research, between 2014 and 2017, researchers investigated several different methods of mapping flammability. These methods were categorised as either 'in-field' or 'national-scale':

- 'In-field' mapping methods included on-ground networks of field sensors and ground-based Light Detection and Ranging (LiDAR) laser scanning. These data sources provide detailed information about the height, cover and density of different overstorey and understorey plant layers, at a plot scale of metres to hectares. While these data are often more accurate and spatially concentrated, this approach is costly to develop and maintain.
- 'National-scale' methods are generally derived from existing satellite imagery and other spatial data, and measure things like fuel moisture content and soil moisture content. Although these sources provide slightly less accurate data than the in-field methods, they are often much cheaper to implement and use in near-real time. Researchers developed two national-scale methods for the purposes of this project – the AFMS and the High-resolution Fire Risk and Impact (HiFRI) framework. The HiFRI produces an unprecedented level of detail and accuracy when estimating fuel condition.

Researchers then compared the relevance and value of all these methods for their practical feasibility and costs of use – depending on spatial resolution, accuracy, operational availability, and resources required for data acquisition, processing and interpretation. Where appropriate, the information was developed so it could be used as an input into the current Fire Danger Rating system or fuel classification systems suitable for end-users.

National-scale methods were found to represent the best return on investment and generated greater interest among end-users, therefore having greater utilisation potential. This became the focus of the second phase of the project.

Phase Two: refining the Australian Flammability Monitoring System

The second phase of this research, between 2017 and 2020, focused on ensuring that the AFMS – the preferred national-scale method – was refined and adopted by end-users. Together with end-users, researchers identified improvements that could be made to the AFMS that would help overcome any constraints.

The AFMS provides the first Australia-wide product of flammability from satellite estimates of live fuel moisture content (Yebra et al. 2018). The flammability index was adjusted using a continuous logistic probability model between fire occurrence and live fuel moisture content. Researchers evaluated the feasibility and relative benefits of using different satellite sources, and worked with Geoscience Australia to develop high-resolution datasets and a proof-of-concept code that computes products using satellite data at a grid resolution of 20 metres giving detailed information of topography driven fuel moisture content (FMC) differentials.

While live fuel moisture content is important when assessing flammability, this research also considers the roles of other important factors, such as fire weather, dead fuel moisture content, fuel load and ignition. The result is a comprehensive characterisation of flammability, providing a more observation-based assessment (van Dijk et al 2019).

RESEARCH FINDINGS

The Australian Flammability Monitoring System

In response to the needs expressed by end-users, researchers developed and refined the AFMS – an experimental, operational, near-real-time flammability data service. The AFMS can be accessed at http://anuwald.science/afms.

The prototype system is the first web application in the world that uses satellite data to provide a clear picture of fuel and soil moisture content and flammability at a continental scale. See the figure on page 1 for an example of the system map. It shows where there are high levels of vegetation and soil dryness, which are the perfect conditions for a severe bushfire. It makes spatial information on fuel moisture content and flammability easier and faster to access.

Specifically, the AFMS provides easier and faster access to spatial information on:

- live fuel moisture content, in kg water per kg dry matter
- uncertainty in the fuel moisture content values, in the same units
- a flammability index, providing a relative measure of fuel flammability between 0 (low flammability) and 1 (maximum flammability)
- soil moisture content near the surface (0-10cm), in m3 water per m3 soil volume
- soil moisture content in shallow soil (10-35cm), in the same units.

When using the AFMS, different filters and settings give users (such as emergency services and land management agencies) a new way to evaluate the risk of a bushfire occurring in certain areas, based on the dryness of the soil and fuels, and the flammability of vegetation. It also offers flexibility to incorporate other relevant spatial information that might be currently available, for example, fire weather or grassland curing or predicting the likely state of fuels in the near future (fuel loads, dead FMC).

Light Detection and Ranging (LiDAR) technology

LiDAR technology, although a mature product that is readily available, was found to be insufficient for fuel mapping as it lacks standardised data specifications and processing methods. Researchers reviewed the technology and developed a specification for deriving analogues of the overall fuel hazard from LiDAR. This was applied to an ACT LiDAR dataset to produce spatially explicit fuel maps at resolutions of 2m, 5m and 25m – the 25m maps were found to be easiest to use, with resolutions suitable for operational use.

Researchers also identified several priority areas for research and development of LiDAR, to achieve more cost-effective and successful use for fire management, including the development of standardised methods for fuel mapping, validation of these methods using field measurements, and investigation of full-waveform LiDAR as a promising alternative to current LiDAR methods.

A High-resolution Fire Risk and Impact (HiFRI) framework

Researchers developed a framework (model-data fusion) to provide estimates on

historic fire impacts on landscape, as well as real-time estimates of current fuel loads and flammability. They applied this framework to a case study of data for the western ACT between 2000 and 2010 (including native forests, plantations and grasslands), to analyse the value of different airborne and remote sensing observations. Results showed that the framework is capable of producing accurate estimates of the impacts of fire on water and carbon balance variables (such as transpiration, evaporation, photosynthesis etc), and that these balances are impacted by solar irradiance and vegetation regrowth.

In pursuit of more comprehensive fire danger ratings

Researchers developed an objective and observation-based approach to fire danger assessment that considers spatial data on the occurrence of actual fires, as well as of fire factors that are already produced every day in Australia. This project's methodology could be used to incorporate new fire danger predictors into the current system. Evidence was provided that suggests the current Forest Fire Danger Index could be improved by the use of either a model-based precipitation index or a soil moisture satellite measurement – both of which would more accurately estimate soil moisture than the current method (Keetch-Bryam Drought Index).

HOW IS THIS RESEARCH BEING USED?

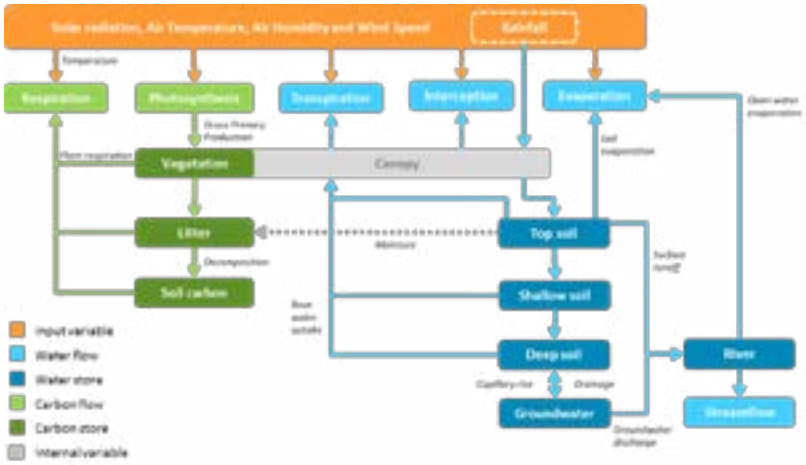
The AFMS is currently in its test-use phase and has gained a lot of national and international interest. Several key emergency services and land management agencies have been using the AFMS to make informed decisions about where a fire may ignite and spread, and what areas should be prioritised when sending resources and equipment to fight fires. These include the NSW Rural Fire Service, the NSW National Parks and Wildlife Service, the ACT Parks and Conservation Service, the Department of Defence, South Australia's Department for Environment and Water, Queensland Fire and Emergency Services and the Tasmania Parks and Wildlife Service. A/Prof Marta Yebra worked alongside the NSW RFS at their headquarters in November 2019 during a peak fire danger period, providing data to assist the RFS make informed decisions about where fires may spread, and what areas should be prioritised when sending resources and equipment.

Fire managers are using the system to understand when parts of the Australian landscape are either not going to burn, burn in a way that will allow them to control a fire, or are so dry that if a fire starts it will become very dangerous and difficult to control.

During the 2019/20 bushfire season (between November 2019 and February 2020), the AFMS received around 1,500 visits from users in nearly all states, which averages around 15 sessions per day during that time, with sessions averaging six minutes. Key users were the NSW Rural Fire Service and NSW National Parks and Wildlife Service, highlighting how beneficial this tool is for both fire agencies and land management agencies.

The AFMS is now being used as part of preseason planning, when fire agencies and land management departments formulate their seasonal outlook for fire and map at-risk areas. It is also being used in prescribed burn planning, particularly in mountainous locations where flammability changes depending on the terrain.

The AFMS and its algorithms have also been used in Europe, South Africa, Argentina, the United States and China, including being implemented in the emissions assessment and smoke-dispersion module of the European Commission's Forest Fire Information System. This provides the Commission and the European Parliament with updated and reliable information about bushfires.

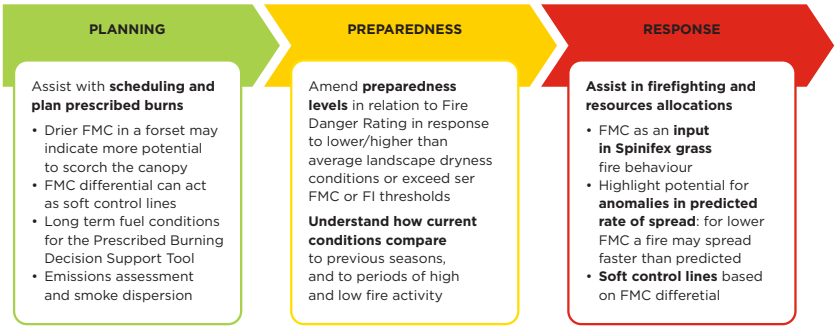


▲ **Figure 1:** ILLUSTRATION OF THE HIFRI FRAMEWORK. THE GREEN COMPONENTS WERE NOT INTEGRATED INTO THE OPERATIONAL MODEL.

FUTURE DIRECTIONS

In the future, the AFMS website will be hosted by Geoscience Australia, as well as integrating near-real-time soil moisture information through the JULES-based Australian Soil Moisture Information System (JASMIN). JASMIN estimates soil moisture on four soil layers over the top three meters of soil, and takes into account the effect of different vegetation types, root depth, stomatal resistance and spatially varying soil texture.

The research team are conducting ongoing tests of the AFMS to identify where it can be further used by fire managers and the community. The findings are being



▲ **Figure 2:** CURRENT AND POTENTIAL USES OF THE AFMS IN FIRE MANAGEMENT.

shared with key stakeholders through education events, and researchers invite end-users to provide comments and suggestions about what can be improved to make the website more useful.

While the AFMS is in its prototype form, researchers are focused on developing specific, operational applications and integrating the information into agencies' current and future decision-making processes and tools. Future use of AFMS could expand to individual community members and private landowners, such as farmers. Those on the land could use the mapping to assess the dryness of their land when managing their agricultural productivity, and when preparing for the fire season.

The constant expansion of satellite-based imagery provides opportunities to develop more sophisticated multi-sensor system(s) that could display daily information on flammability and fuel condition from whatever satellite sensor has collected an image over Australia, including high-resolution satellite imagery. The use of high-resolution satellite imagery will provide an unprecedented level of detail and accuracy when estimating fuel condition bringing the system closer to use in operations. However, the data volumes and large computing resources currently required to store and generate these high-resolution products remains a challenge. Future approaches should also focus on developing methodologies for computing fuel condition that can provide up to date estimations that require reduced data storage and computing resources, for example, using state-of-the-art artificial intelligence algorithms.

In the longer term, there is a need for a bespoke high-resolution space-based fuel monitoring sensor tuned to the Australian landscape, with spectral wavelengths designed specifically to look at live FMC and fuel load, thus informing at the highest possible accuracy, when and where forests are approaching critical dryness levels and fuel loads. This is because all the data explored in this project to retrieve fuel condition is collected by sensors onboard satellites that are not fully fit-for-purpose in terms of readiness, spatial resolution and signal sensitivity in Australia's eucalypt-dominant forests.

END-USER STATEMENTS

"The Australian Flammability Monitoring System has been useful not only in sharing research outputs with operational users, but also allowed users to provide feedback during the project, leading to an improved interface to the data. These efforts are building an integrated suite of observational and modelling tools that will enable users to better understand and predict potential fire occurrence and behaviour."
Dr Stuart Matthews, Principal Project Officer – Operations/ Predictive Services, NSW Rural Fire Service.

"The *Mapping bushfire hazards and impact* project has significantly advanced knowledge and operational capability of fuels and fuel condition. The main research effort aimed at deriving continent-wide spatially explicit estimates of live FMC at near real-time has been achieved. The estimates returned at a resolution of 500m × 500m have been consistent with observed fire behaviour during bushfires and prescribed burns. Besides, the system has succeeded in capturing terrain-driven differences in fuel moisture content relevant to prescribed burning operations.

The project has delivered significant advancements in the operational capability to capture spatially explicit information about the distribution of fuels and the effects of fire. The project developed a specification for deriving analogues of the Overall Fuel Hazard from LiDAR and then applied the method to an Australian Capital Territory-wide LiDAR dataset to produce spatially explicit fuel maps at resolutions of 2m, 5m and 25m.

The overall outcome from the project has been to significantly advance knowledge and operational capability for fire managers in understanding the distribution of fuels and their condition. The bushfire sector is well-placed to rapidly take up these advances and deliver better advances for communities across Australia."
Dr Adam Leavesley, Bushfire Research Utilisation Manager, ACT Parks and Conservation Service

FURTHER READING

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HAZARD **NOTE**

ISSUE 85 NOVEMBER 2020
TOPICS IN THIS EDITION | FIRE IMPACTS | FIRE SEVERITY | FIRE WEATHER

AUSTRALIAN SEASONAL BUSHFIRE OUTLOOK: DECEMBER 2020 – FEBRUARY 2021

OVERVIEW

Australia's climate is now under the influence of La Niña, and as a result the landscape and weather conditions continue to be vastly different to the previous two years. The year to date has seen average to above average rainfall across much of the south east and north west of the country. This rainfall continued through spring, resulting in prolific grass growth in south eastern and central areas. Grass and crop fires are the main concern in these locations for the summer months as the growth dries out in the warmer weather. Grass and crop fires are fast moving and can spread rapidly when fanned by strong winds.

These conditions mean that large parts of New South Wales west of the Great Dividing Range face above normal fire conditions, as well as grassland areas of the ACT and into north eastern Victoria. Western Australia has largely missed out on the rainfall in 2020 and conditions are very dry, with parts of the south and south west coasts expecting above normal fire conditions through summer.

Although large parts of the east coast were affected by bushfires last season, and wetter than average conditions are expected over this summer, normal fire conditions are still expected for much of these forested areas due to the long-term dryness that still persists and the significant amount of area that was not burnt.

The *Australian Seasonal Bushfire Outlook: December 2020 – February 2021* covers all states and territories. It reflects the priorities in each state and territory for the coming months given the expected climate conditions, and provides information to assist fire authorities in making strategic decisions such as resource planning and prescribed fire management to reduce the negative impacts of bushfire.

Fire potential can vary greatly, even at the smaller scale, between bordering states and territories. Each state and territory's assessment takes into account different land use types (such as agriculture, forestry, public land) and vegetation types (forests, grasslands, deserts). This in turn is influenced by different forecasts for temperature and rainfall over these regions.

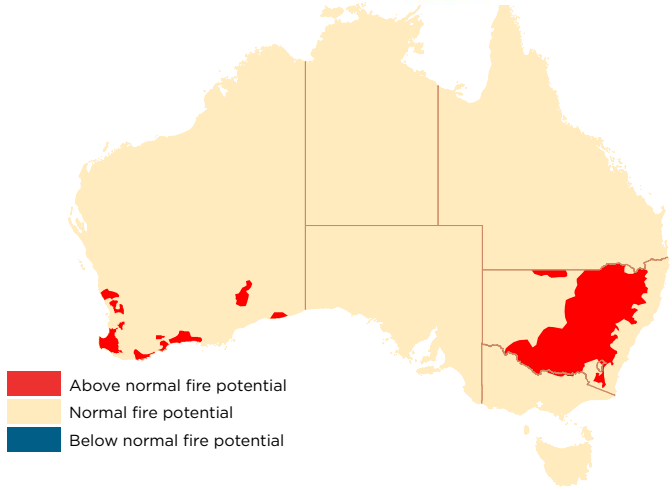


Figure 1: AUSTRALIAN SEASONAL BUSHFIRE OUTLOOK: DECEMBER 2020 – FEBRUARY 2021. AREAS ARE BASED ON THE INTERIM BIOGEOGRAPHIC REGIONALISATION FOR AUSTRALIA AND OTHER GEOGRAPHICAL FEATURES.

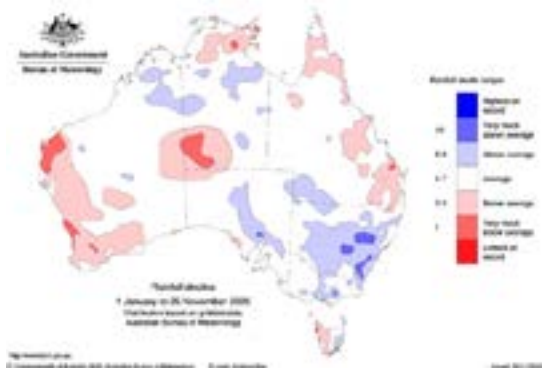
The *Australian Seasonal Bushfire Outlook: December 2020 – February 2021* is developed by the Bushfire and Natural Hazards CRC, AFAC, the Bureau of Meteorology, Queensland Fire and Emergency Services, the New South Wales Rural Fire Service, ACT Emergency Services Agency, ACT Parks and Conservation Service, Country Fire Authority, Department of Environment, Land, Water and Planning Victoria, Tasmania Fire Service, Country Fire Service, Department of Fire and Emergency Services and Department of Biodiversity, Conservation and Attractions Western Australia, and Bushfires NT.

OUTLOOK – SUMMER 2020/21

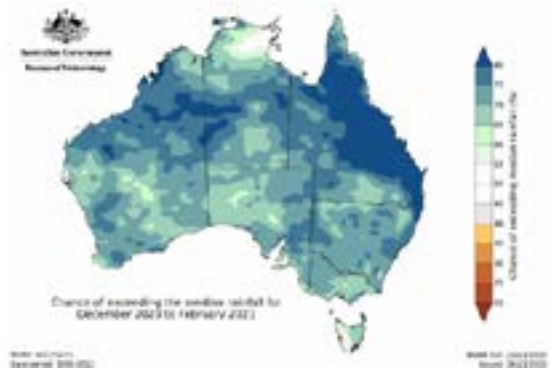
Fire management is a year-round process, and bushfire potential depends on many factors. The volume, location and timing of rainfall are critically important when estimating vegetation (fuel) volumes and growth. The climate outlook for the next few months is also a crucial factor. Of particular interest are the future tendencies of Pacific sea surface temperature associated with the El Niño-Southern Oscillation, as well as the Indian Ocean Dipole – major climate drivers over

DEFINITION

Bushfire potential: The chance of a bushfire or number of bushfires occurring of such size, complexity or other impact that requires resources (from both a pre-emptive management and suppression capability) beyond the area in which it or they originate. Bushfire potential depends on many factors including weather and climate, fuel abundance and availability, recent fire history and firefighting resources available in an area.



▲ **Figure 2:** RAINFALL DECILES 1 JANUARY TO 25 NOVEMBER 2020.



▲ **Figure 3:** CHANCE OF EXCEEDING THE MEDIAN RAINFALL FOR DECEMBER 2020 TO FEBRUARY 2021.

Australia. Other less quantifiable factors, such as the distribution and readiness of firefighting resources, are also considered.

With La Niña climate conditions reached in mid-September, the rainfall outlook through to the end of summer suggests above average rainfall is likely over much of the country. However, these months are a drier time of the year for much of southern Australia. Some southern parts of South Australia and Western Australia have largely missed out on recent rainfall and are very dry.

For future updates on fire potential during summer 2020/21, visit your rural fire agency website.

RECENT CONDITIONS

Seasonal fire conditions are a function of fuel (vegetation) amount and dryness, and seasonal weather conditions. Australia's weather and climate in 2020 has been markedly different to 2019. In 2020, rainfall has been average to above average across much of the south east and north west of the country (see Figure 2, above), whereas 2019 was Australia's warmest and driest year on record.

A La Niña is now well established in the tropical Pacific and is likely to persist until at least the end of summer, potentially peaking in December or January. La Niña events typically increase the likelihood of above average rainfall across much of Australia during spring, and across much of eastern Australia during summer. Above average rainfall since August over some areas of eastern Australia has eased rainfall deficiencies. However, south west and southern Western Australia, and some of the southern agricultural areas of South Australia, have not received above average rainfall. As a result, south west Western Australia has seen an increase in the area in drought over recent months.

Satellite monitoring of vegetation health suggests some areas that have experienced above average rainfall in recent months are now observing a significant increase in grass vegetation growth. This includes large areas of New South Wales to the west of the ranges, parts of western Victoria, and south east South Australia. A period of dry weather in summer can rapidly dry out this type of vegetation, creating fuel for grass fires.

The long-term warming trend means that above average temperatures now dominate most years, and recent months have generally followed this pattern. September 2020 was Australia's second warmest September since national records began in 1910. Preliminary data indicates that November 2020 may also be one of the warmest November's on record. High temperatures add to the impact of reduced rainfall by increasing evaporation. Despite high temperatures in the north and west of the country lifting the national average, cooler than average days have been experienced across large parts of inland south east Australia.

Rainfall so far in 2020 has eased the fire risk for parts of eastern Australia, however southern South Australia and Western Australia have seen drier and warmer conditions persist this year. More rainfall is needed across many areas to fully recover from the extreme dry of 2019/20.

The tendency for fire seasons to become more intense and for fire danger to occur earlier in the season is a clear trend in Australia's climate, reflecting reduced and/or less reliable cool season (April to October) rainfall and rising temperatures. Fire season severity is increasing across much of Australia as measured by annual (July to June) indices of the Forest Fire Danger Index, with increases tending to be greatest across inland eastern Australia and coastal Western Australia. For more details on the changes observed, see the recently updated State of the Climate 2020 report from the Bureau of Meteorology and CSIRO.

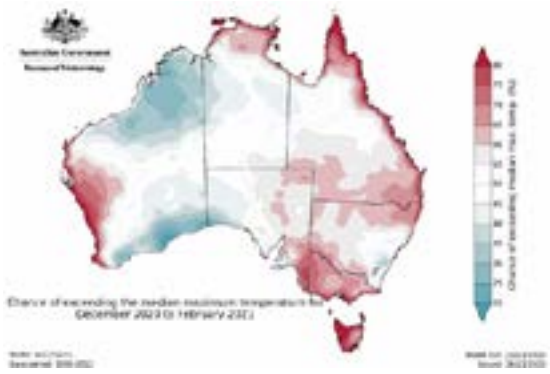
CLIMATE OUTLOOK

The Bureau of Meteorology's climate outlooks are based on the physics of the oceans, atmosphere, land and ice. They implicitly include all current climate drivers, including long-term trends.

The climate influences of 2020 are very different to those that led to the extreme dry conditions in 2019. A La Niña event is currently active in the tropical Pacific Ocean. La Niña typically results in above average spring and summer rainfall over much of eastern and northern Australia. Combined with other drivers that enhance rainfall, including warmer than average waters to the north of Australia and a positive Southern Annular Mode that is forecast to persist until late 2020, much of Australia is expected to see wetter than average conditions over summer.

The rainfall outlook for December to February (Figure 3, above) shows that wetter than average conditions are very likely for nearly all of Australia except western Tasmania, where there is an increased chance of drier than average conditions. Historical outlook accuracy for December to February is very high across much of Australia, but generally moderate to low around central and southern parts of the Northern Territory and the Queensland border, and some parts of north eastern New South Wales.

Average maximum temperatures for December to February are likely to be higher than the long-term average for Victoria, Tasmania, the far west of WA, the northern coastlines of NT and Queensland, parts of eastern SA, southern Queensland, and western NSW. However, the average maximum temperature is likely to be below the long-term average for south coast WA,



▲ **Figure 4:** CHANCE OF EXCEEDING THE MEDIAN MAXIMUM TEMPERATURE FOR DECEMBER 2020 TO FEBRUARY 2021.

▲ **Figure 5:** CHANCE OF EXCEEDING THE MEDIAN MINIMUM TEMPERATURE FOR DECEMBER 2020 TO FEBRUARY 2021.

north east WA, and north west NT. (Figure 4, above). Elsewhere, temperatures are likely to be close to the long-term average. Average minimum temperature for the same period is very likely to be above the long-term average across Australia (Figure 5, above right). Historical accuracy for December to February maximum temperature outlooks is moderate to high across all of Australia except the NT. Historical minimum temperature outlook accuracy is moderate to high across much of Australia, very high in Victoria and Tasmania, and low around central NT and central parts of Queensland.

The tropical cyclone season, which typically starts in November, is likely to be more active this season than in recent years for Queensland, the NT and WA due to the influence of La Niña. While this may increase the chance of rainfall, areas of increased wind could potentially interact with any fires in the south of the country.

Updates to climate forecasts, including forecasts of monthly, fortnightly and weekly outlooks and the outlook for the Indian Ocean Dipole and the El Niño–Southern Oscillation, will continue to be published at www.bom.gov.au/climate/ahead.

REGIONAL SUMMARIES

QUEENSLAND

Recent rainfall, particularly across south eastern Queensland, has seen an improvement in fire risk conditions. Despite this recent rain, large parts of the state are carrying very low to average grass fuel loads relative to long-term records. Long-term rainfall deficits still persist across large parts of the state and significant additional rainfall is needed to overcome this underlying sub soil dryness.

The current La Niña conditions favour above average rainfall across much of Queensland. This rainfall is likely to trigger good grass growth, particularly along coastal areas. The forecast rainfall and maximum temperatures indicate that it will be unlikely that this new grass growth will cure off during summer. This has resulted in an assessment of normal fire risk, however the grass fire risk will continue to be monitored over the coming months.

NEW SOUTH WALES

With a La Niña underway in the tropical Pacific, the summer rainfall outlook appears favourable for above average rain for much of NSW.

The fire outlook for forested areas that were not affected by last season's fires remains at a normal level for this fire season. Like most seasons, there is always a risk that if fires occur, particularly around the interface of high population centres of Sydney, Illawarra and the Hunter, they could quickly impact on houses and infrastructure. In these areas there is a need to monitor for escalation to fire danger associated with prolonged heatwaves that can occur during La Niña years as a result of more heat being retained in the atmosphere.

The rain received through spring has resulted in prolific grass growth west of the Great Dividing Range. These ideal growing conditions for cropping and grassland areas are expected to continue in coming months with the combination of above average rainfall and warmer than average minimum temperatures forecast. This growth has already increased the grass and crop fuel loads, and this is expected to continue throughout summer. Reports of lower stocking levels after the drought means that reduction of fuel loads by grazing may not be as high as what would normally be expected. The risk for this period will be dependent on grass curing or drying rates. For the majority of areas, this is expected to be highest from mid to late summer. Hot and windy days will increase the fire risk and this will continue to be monitored closely. Higher grass fuel loads can increase fire danger by increasing the intensity of grass fires. All other factors being equal, this increase of the intensity makes the fires hotter, more dangerous, and harder to put out. As a result, above normal fire potential is expected for the predominantly grassland areas on and west of the Divide. In these areas, there is a high risk of high intensity grass fires that could impact communities this season.

ACT

The ACT has received significant rainfall in recent months which has resulted in vigorous grass growth. While abundant in amount, this grass is currently seeding and is predominately uncured and too damp to burn in a high-risk way. This is expected to change over summer, as while November and December is the normal time for annual grasses to set seed and then die-off, this season may instead see a second round of flowering, increasing the growth and therefore grass fire risk once the grass dries. As a result, there is above normal risk of fires in these grassland areas and this will be closely monitored by the ACT Emergency Service Agency.

Due to the amount of rain received, forest vegetation is too damp to support fast running or large bushfires. It is expected that these conditions will continue for some time. Should drying conditions emerge during the coming months in these forested areas, the community will be advised by the ACT Emergency Services Agency.

ACT residents need to review their bushfire plans with a particular focus on grass fire risk, and to manage grasses near their property to prevent potential impacts

of fast-running grass fires. It is important to clear around fences. Rural residents are advised to place and maintain strategic breaks to check fire runs. Fire services and land managers will also be implementing plans to further mitigate that risk.

VICTORIA

Victoria experienced below average rainfall for most of the state during winter except for East Gippsland, which received above average rain. Spring has resulted in average rainfall for most of the state, with areas of above average rainfall in the west and south west. As a result, the entire state is currently experiencing average to above average soil moisture conditions.

With the outlook for summer indicating above-average rainfall across Victoria due to the influence of La Niña, it is likely this soil moisture will persist in many areas and will lead to normal fire potential across the state, with the exception of the far north east.

With significant grass growth, 2020/21 has potential to be more of a grass fire-dominated season. There is some potential for above normal grass fire potential in north east border areas, due to the heavy grass and crop fuels prior to harvest.

Bushfire risk in the eastern parts of the state – particularly in areas that burnt last season – has reduced, thereby reducing the risk of prolonged fires. Elsewhere in the state, shorter-duration fires are still likely to occur in drier forests and woodland/heath fuels on hotter and windier days.

TASMANIA

Planned burning is now underway in all areas with suitable vegetation, while annual grasslands are still growing strongly. Tasmania has been assessed as normal fire potential for the outlook period. Above average rainfall in the eastern half of the state has provided significant moisture recharge in the east and south east. In the west, below normal rainfall has been received, resulting in a slowly increasing area of moisture deficit. It should be noted that even reduced rain is still a significant amount of rain in a historically wet area. With the current climate drivers, it is likely this somewhat unusual rainfall pattern will persist and possibly intensify. Therefore, eastern Tasmania may have a quiet fire season, while the fire potential in the south west may increase in late summer due to the availability of peat soils, moist scrubs and forests to burn.

SOUTH AUSTRALIA

The benefits of the early spring rainfall, which has resulted in increased grass fuel growth in many areas, has now been offset by the return of warm and dry weather across South Australia. Despite this, the current Soil Dryness Index figures are below the five year average at the majority of monitoring sites, which is an improved position compared to the previous fire season. The current outlook for SA includes the potential for above average rainfall in broad areas over the next three months, however much of this is reliant on the influence of La Niña, which typically has less of an effect on SA. Average summer rainfall in SA is historically low, so above average rainfall, if it eventuates, may not be enough to bring substantial relief to the fire season. Recent fires across the state highlight that the very real risk of fire remains, particularly grass fires, with dangerous conditions and fires observed on the Eyre Peninsula, Yorke Peninsula, Murraylands and in the Riverlands. An elevated risk of thunderstorm and dry lightning has also been observed, which could increase the number of fires experienced during the rest of the fire season. As a result of the recent conditions and increased risks associated with thunderstorms, SA can expect a normal fire season. Normal fire seasons in SA are still characterised by dozens of high risk fire days. The fire threat is still substantial and significant fires have occurred under similar conditions.

WESTERN AUSTRALIA

Southern parts of Western Australia have been experiencing dry conditions for a number of years, and winter rain has not sufficiently improved the soil moisture content in the root zone this year. This has increased the fire potential to above normal for parts of the Nullarbor and Eucla bioregions. In addition, although planned burning and past bushfires have reduced fuel loads across some forested areas of the South West, there are still areas of forest and shrubland vegetation that have experienced a prolonged rainfall deficit and are carrying significant surface fuel loads with relatively low fuel moisture contents. Moving into summer, parts of the Swan Coastal Plain, Avon Wheatbelt, Jarrah Forest, Warren, Mallee and Esperance Plains bioregions have been identified as having above normal fire potential.

The wet season is now underway in the north, with wetter than average conditions expected for the coming months, resulting in normal fire potential.

NORTHERN TERRITORY

Curing rates in the Darwin Coastal, Pine Creek, Tiwi Cobourg and Daly Basin regions have been reduced as a result of earlier than normal and relatively widespread rainfall in the north west Top End. This has reduced the ongoing bushfire risk in these areas. Areas of the Victoria Bonaparte, Sturt Plateau and Gulf regions continue to have low soil moisture and fully cured surface fuels, resulting in continuing bushfire risk in those regions. With the predicted wetter conditions for the coming months, normal fire potential has been assessed for the whole of the Top End.

For central Australian regions, the fire danger period will commence in mid-December, with surface fuels fully cured. There are some areas throughout central Australia that have experienced a prolonged rainfall deficit and are carrying less than normal surface fuel loads. Minimal landscape scale planned burning has occurred during the past 12 months, with many pastoral enterprises destocking and securing remaining grassy vegetation for pastoral production. All bioregions in central Australia have been identified as having normal bushfire potential through to February 2021.

The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

HAZARD **NOTE**

ISSUE 77 AUGUST 2020
TOPICS IN THIS EDITION | FIRE IMPACTS | FIRE SEVERITY | FIRE WEATHER

AUSTRALIAN SEASONAL BUSHFIRE OUTLOOK: SEPTEMBER – NOVEMBER 2020

OVERVIEW

The 2020/21 fire season will be driven by vastly different climate drivers than the previous two fire seasons. With a La Niña ALERT now active, large areas of eastern and northern Australia are expecting wetter than average conditions through spring. Despite the wetter climate signals, parts of Queensland face above normal fire potential in the south east and central coast, extending to the north.

While these wetter conditions in eastern Australia will help in the short-term, they may lead to an increase in the risk of fast running fires in grasslands and cropping areas over summer. These conditions will be monitored closely over the coming months.

In contrast to the wetter conditions for the east, dry conditions persist in Western Australia, with above normal fire potential continuing to be expected in parts of the north.

The *Australian Seasonal Bushfire Outlook: September - November 2020* covers all states and territories. It reflects the priorities in each state and territory for the coming months given the expected climate conditions, and provides information to assist fire authorities in making strategic decisions such as resource planning and prescribed fire management to reduce the negative impacts of bushfire.

The *Australian Seasonal Bushfire Outlook: September - November 2020* is developed by the Bushfire and Natural Hazards CRC, AFAC, the Bureau of Meteorology, Queensland Fire and Emergency Services, the New South Wales Rural Fire Service, ACT Emergency Services Agency, ACT Parks and Conservation Service, Country Fire Authority, Department of Environment, Land, Water and Planning Victoria, Tasmania Fire Service, Country Fire Service, Department of Fire and Emergency Services and Department of Biodiversity, Conservation and Attractions Western Australia, and Bushfires NT.

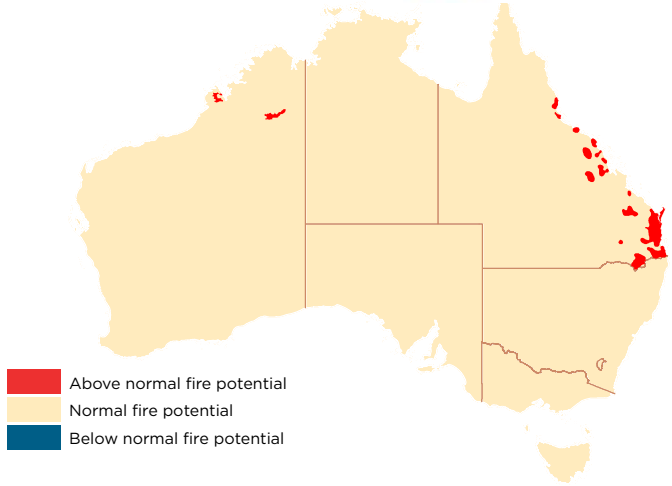


Figure 1: AUSTRALIAN SEASONAL BUSHFIRE OUTLOOK: SEPTEMBER – NOVEMBER 2020. AREAS ARE BASED ON THE INTERIM BIOGEOGRAPHIC REGIONALISATION FOR AUSTRALIA AND OTHER GEOGRAPHICAL FEATURES.

OUTLOOK – SPRING 2020

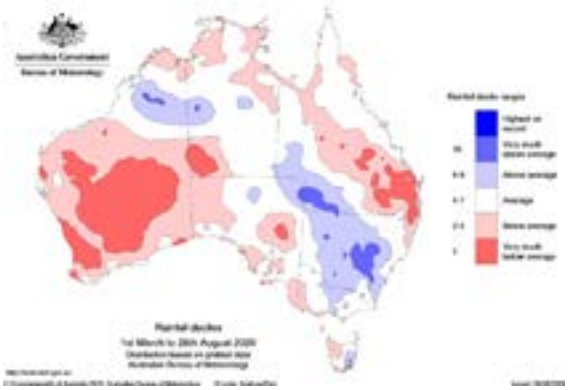
Fire management is a year-round process, and bushfire potential depends on many factors. The volume, location and timing of rainfall are critically important when estimating vegetation (fuel) volumes and growth. The climate outlook for the next few months is also a crucial factor. Of particular interest are the future tendencies of Pacific sea surface temperature associated with the El Niño-Southern Oscillation, as well as the Indian Ocean Dipole, major climate drivers over Australia. Other less quantifiable factors, such as the distribution and readiness of firefighting resources, are also considered.

Both the El Niño-Southern Oscillation and the Indian Ocean Dipole are expected to influence the weather, and therefore fire conditions, during spring. In the Pacific, a La Niña ALERT was issued in mid-August by the Bureau of Meteorology. La Niña typically sees above average spring and summer rainfall over much of eastern and northern Australia. A negative Indian Ocean Dipole may develop during spring, which would further increase the likelihood of wetter conditions in eastern Australia.

Across the country, autumn and winter presented opportunities to conduct prescribed burning where appropriate weather conditions allowed. In some states and territories, this will continue through spring when possible.

DEFINITION

Fire potential: The chance of a fire or number of fires occurring of such size, complexity or other impact (such as biodiversity or global emissions) that requires resources (from both a pre-emptive management and suppression capability) beyond the area in which it or they originate. Fire potential depends on many factors including weather and climate, fuel abundance and availability, recent fire history and firefighting resources available in an area.



▲ **Figure 2:** RAINFALL DECILES 1 MARCH TO 28 AUGUST.

RECENT CONDITIONS

Seasonal fire conditions are a function of fuel (vegetation) amount and state, and seasonal weather conditions. 2019 was warmest and driest year on record for Australia, with many records set. To date, 2020 has seen a shift away from these drier conditions to closer to average rainfall patterns for large parts of the country. However, the last six months has seen drier than average conditions over central and south east Queensland and parts of southern Australia, including large parts of Western Australia (see Figure 2, above).

Rainfall deficiencies over large parts of drought affected New South Wales and Victoria have reduced significantly compared to this time last year, and soil moisture has returned to average in many areas. However, multiple years of below average rainfall means that much of the northern Murray–Darling Basin, eastern South Australia and south west Western Australia require a much longer period of above average rainfall for the wider environment to fully recover. For instance, while water levels in storages across the northern Murray Darling Basin have increased in recent months, they remain at only 21% of their capacity.

Despite above average rainfall across large parts of the country since the start of the year, June and July were largely drier than average nationally, especially in the south west. In contrast, some regions such as the south coast of New South Wales have recorded above average rainfall, largely from the impact of multiple coastal lows.

South west and southern Western Australia is notable in that it has seen much drier than average conditions in autumn and winter – normally the wettest time of year for these regions. These regions have seen an increase in the area in drought this winter.

The long-term warming trend means that above average temperatures now occur in most years, and recent months have followed this pattern. The exception to this was May 2020, which saw the first cooler than average month nationally since October 2016. Temperatures in Australia for 2019 were the warmest in 110 years of record (+1.52°C above the 1961–1990 average, see Annual Climate Statement 2019, Bureau of Meteorology).

To date, 2020 has continued to bring warmer than average conditions for much of the north and west of Australia. Western Australia recorded its second warmest July on record in 2020, second only to July 2019, while June 2020 was warmest on record. High temperatures add to the impact of reduced rainfall by increasing evaporation. Cooler than average conditions have been experienced around large parts of the south east away from mainland eastern coastal areas.

The combined very hot and dry conditions of 2019 saw Australia experience one of its most devasting southern fire seasons in 2019/20. Rainfall so far in 2020 has eased the fire risk for large parts of eastern Australia, however southern South Australia and Western Australia have seen drier and warmer conditions persist this year. More rainfall is needed across many areas to fully recover from the extreme season of 2019/20.

CLIMATE OUTLOOK

Climate outlooks are influenced by current climate drivers, together with other factors including long-term trends.

The climate influences in 2020 are very different to those that led to the extreme dry conditions in 2019. Both the El Niño–Southern Oscillation (ENSO) and the Indian Ocean Dipole are currently neutral. However, the Bureau of Meteorology's *ENSO Outlook* was raised to La Niña WATCH in late June, then to La Niña ALERT in mid-August. This means there is now around a 70% chance of La Niña forming in 2020, roughly triple the normal likelihood. La Niña typically sees above average spring and summer rainfall over much of eastern and northern Australia. Combined with warmer than average waters in the eastern Indian Ocean, this is helping to increase the likelihood of wetter than average conditions across the eastern two-thirds of Australia in the coming months.

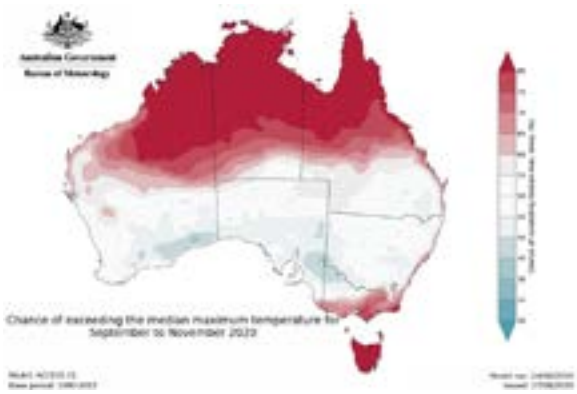
Furthermore, half of the models surveyed by the Bureau indicate a negative Indian Ocean Dipole may develop during spring. A negative Indian Ocean Dipole would act to further increase the likelihood of wetter than average conditions across eastern Australia.

The rainfall outlook for September to November (Figure 3, page 3) shows wetter than average conditions are very likely for most of the eastern two-thirds of mainland Australia, while conditions are likely to be drier than average around the Kimberley and Pilbara regions of Western Australia, as well as south western Tasmania. Most of the remainder of the country has roughly equal chances of wetter or drier than average conditions. Historical outlook accuracy for September to November is very high across much of Australia, but generally moderate to low around the Western Australia and Northern Territory border.

Maximum temperatures during September to November are very likely to be warmer than average across the northern tropics and most of Tasmania, while cooler than average conditions are likely over most of New South Wales and South Australia, southern Queensland, northern Victoria and the south east coast of Western Australia (Figure 4, page 3). Elsewhere, temperatures are closer to average. Minimum temperatures (not shown) are very likely to be warmer than average across the eastern two-thirds of Australia, while the outlook is for closer to average temperatures towards south western Western Australia. Historical accuracy for September to November maximum temperatures is high across all of Australia. Minimum temperature accuracy is moderate to high across much of Australia, very high in Victoria and Tasmania, and low around central parts of Queensland.

The tropical cyclone season, which typically starts in November, is likely to be more active this season than in recent years for both Queensland and Western Australia due to the influence of La Niña. While this may increase the chance of rainfall, areas

▲ **Figure 3:** CHANCE OF EXCEEDING THE MEDIAN RAINFALL FOR SEPTEMBER TO NOVEMBER 2020.



▲ **Figure 4:** CHANCE OF EXCEEDING THE MEDIAN MAXIMUM TEMPERATURE FOR SEPTEMBER TO NOVEMBER 2020.

of increased wind could potentially interact with any fires in the south of the country.

Updates to climate forecasts, including forecasts of monthly, fortnightly and weekly outlooks and the outlook for the Indian Ocean Dipole and the El Niño–Southern Oscillation will continue to be published at www.bom.gov.au/climate/ahead.

REGIONAL SUMMARIES

QUEENSLAND

The major climate drivers are favouring a wetter than normal spring across most of Queensland. If this rainfall eventuates there is potential for the bushfire season to be milder than the previous two seasons. However, if widespread rain does not eventuate, above normal bushfire potential in forested areas in South East Queensland and some central coast areas extending north is likely.

The South East, bounded by Rockhampton to the NSW border south of Cunnumulla, and extending to the coast, has seen significantly below average rainfall over the past 12 to 24 months. As a result, most of this area is experiencing significant drought. Twelve-month rainfall deficiencies have also persisted along much of the state's east coast.

August has seen above average rainfall in some coastal areas between Mackay and Cairns, and from Maryborough to the NSW border. However significant rainfall is still needed to return these areas to average conditions.

Across the remainder of the state very large areas have very low to no grass cover relative to long-term records. With a La Niña ALERT current, Queensland is likely to experience above median rainfall during the outlook period. As a result it is very unlikely this will translate into an elevated grass fire risk before December. Therefore, with around 60% of the state comprising grass and woodland with grassy understory fuels, normal fire potential has been assessed.

NEW SOUTH WALES

Large parts of NSW have experienced welcome rain over the last six months, reducing soil moisture deficits for much of the state. However, long-term rainfall deficiencies are still significant in the north and west. In particular, dry sub soil conditions on the northern ranges are of concern. These areas are being monitored closely.

With a La Niña ALERT current, the rainfall outlook appears favourable for much of the state. Whilst the bushfire outlook on the balance of the forecast is normal for NSW for the outlook period, there is a need to monitor for escalation to fire danger associated with windy weather events that can often present during this period. These windy conditions can be a risk regardless of the temperature where grass has been cured by frosts.

The grass fire risk will continue to be monitored on and west of the Divide over coming months. Recent and forecast rain, combined with warmer than average minimum temperatures, may provide ideal growing conditions for cropping and grassland areas. This spring growth has the potential to increase grass and crop fuel loads as it dries through summer, and this will be monitored closely.

Higher grass fuel loads can increase fire danger by increasing the intensity of grass fires. All other factors being equal, this increase of the intensity makes the grass fires hotter, more dangerous and harder to extinguish.

Where weather permits, NSW fire and land management agencies will continue to undertake hazard reduction activities in the coming months.

ACT

In early August the ACT received sufficient rainfall to remove the residual drought that was posing a raised forest fire threat for the coming fire season. As a result of this rain, and the expectation of further rainfall in spring with a La Niña ALERT current, it is anticipated that forest flammability will remain low over the coming months. The effect of the rains on grass fire risk may not become clear until the end of spring or early summer. These conditions will be monitored over the coming months. For the outlook period, normal fire conditions are expected.

The ACT Emergency Services Agency (ESA) advises that rural residents, and those on the urban edge of Canberra, need to review their bushfire preparedness plans and prepare their property with a focus on potential impacts from fast moving grass fires over summer. Further advice will be provided to the community by ESA as the spring grass growth concludes. Government agencies will continue to implement plans to mitigate grass fire risks.

VICTORIA

The above average rainfall experienced during winter has substantially reduced the risk of campaign bushfires in Victoria's east for the outlook period. Elsewhere, much of Victoria has experienced average to below average rainfall during winter. Parts of the Mallee, Wimmera and Far South West are drier than normal, however the current climatic signals indicate that there is a high chance of above median rainfall across Victoria during spring. The strength of this signal is higher north of the Divide compared to the south of the Divide.

As a result, greater uncertainty exists for the bushfire outlook in western Victoria. It is possible that occurrences of hot,

dry periods may be enough to offset the wetter signal associated with possible La Niña conditions during spring.

Overall, the influence of a possible La Niña is expected to reduce the risk of prolonged fire activity across most of Victoria, leading to an assessment of normal fire potential for the outlook period for the entire state. Short duration fires in grasslands and drier forests/woodlands are still likely to occur by late spring, depending on fire weather conditions and grassland curing.

TASMANIA

After a dry start to winter, the eastern half of Tasmania now has high moisture levels and the Soil Dryness Index is close to zero. Follow up rains during spring will provide valuable moisture recharge for lower soil levels and increased fuel moisture in coarse and heavy fuels. Forested areas are very wet and will take time to become available as fuel. It is anticipated that the start of the fire season will be delayed on the east coast and in the south east.

During spring pasture growth is likely to be significant in the Midlands, South East and East Coast districts. These areas have been assessed as normal fire potential for the outlook period, but will be monitored closely.

The western half of Tasmania has closer to normal moisture conditions for winter. With a La Niña ALERT current, the far south west may become significantly drier than normal, which can occur during a La Niña. This area will be monitored closely and has been assessed as normal fire potential for the outlook period.

SOUTH AUSTRALIA

South Australia has experienced the third driest June and July on record, and as a result prolonged moisture deficits persist.

While the La Niña ALERT that is now active indicates that the forecast models favour wetter than average conditions for spring across South Australia, historically La Niña has had less of an impact on increased rain for southern South Australia than for the east coast. A number of variables have to line up for these wetter conditions to occur in southern South Australia. Increased rainfall for the state is more often influenced by a negative Indian Ocean Dipole, and while climate models indicate this may occur, the signals would only support wetter conditions for a brief period in early spring, rather than an indication of prolonged wetter conditions. Spring rainfall could also encourage grass growth which may raise fuel loads in areas where they are currently reduced. The current rainfall outlook is unlikely to overcome the current soil dryness and long-term rainfall deficiencies. The Fire Danger Season may start later than the previous two seasons, however any benefits from spring rain will quickly be marginalised once warmer weather occurs. In addition, spring rainfall is often accompanied by thunderstorm activity which could see an increase in lightning and new ignitions occurring.

Western South Australia (including much of the Eyre Peninsula), the Flinders Ranges, and the Riverland are currently experiencing drought-like conditions which is likely to limit grass and crop growth. These regions will be monitored closely, especially in areas of native vegetation and scrub, which could present challenges later. Without good rainfall during spring, this pattern of potentially reduced grass fire risk and elevated scrub and forest fire risk is likely to persist over much of the state come summer.

WESTERN AUSTRALIA

The climate outlook indicates normal weather conditions for Western Australia from August through October, with the possibility of below-normal rainfall in parts of the South West Land Division. Seasonal rainfall deficiencies have continued, which is preventing the recovery of root zone soil moisture in much of the eastern Wheatbelt and the eastern South Coast and leading to persistent moisture stress in woody vegetation. Despite overall below normal rainfall, recent rain has helped, leading to an assessment of normal fire potential for the outlook period.

In contrast, some areas in northern WA are experiencing higher moisture content in the root zone in comparison to this time last year, and this is reflected in the lower seasonal grassland curing for some areas of the Kimberley and Pilbara regions. These conditions have delayed the onset of the northern WA bushfire season. For the start of the late dry season, higher than normal fuel loads continue to persist for parts of the Dampierland, Central Kimberley and Ord Victoria bioregions, resulting in a continued assessment of above normal fire potential for these areas as per July's *Australian Seasonal Bushfire Outlook*.

NORTHERN TERRITORY

Wet season rainfall totals in most areas across the Northern Territory were well below average for 2019/20, and as a result many areas are now experiencing drier soil moisture and earlier vegetation curing. As noted in the *Australian Seasonal Bushfire Outlook: July* 2020, the Fire Danger Period for the northern half of the Territory was declared earlier than normal. In some areas of the savanna region, vegetative fuel loads remain lower than average. Planned burning in the north was predominately limited to strategic corridors, carbon burning projects, and fine scale properties. For the top half of the Territory, the duration and extent of the fire weather to date has been slightly less than what was experienced in the 2019 fire season, with the western Top End experiencing higher than average humidity during August. The Bureau of Meteorology's weather modelling indicates a negative Indian Ocean Dipole is possible in coming months. This may increase the chances of an early onset to the wet season and the possibility of exceeding October and November median rainfall. A review of fire season activity to date, completed fire mitigation and overall fuel loads indicates normal fire potential for all regions of the Territory for the outlook period.

The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

HAZARD **NOTE**

bushfire&natural HAZARDSCRC

ISSUE 75 JULY 2020

TOPICS IN THIS EDITION | FIRE IMPACTS | FIRE SEVERITY | FIRE WEATHER

AUSTRALIAN SEASONAL BUSHFIRE OUTLOOK: JULY 2020

OVERVIEW

The winter period coincides with the dry season in northern Australia, and sees this part of the country enter its fire season. The *Australian Seasonal Bushfire Outlook: July 2020* covers all states and territories for the period of July until September, but is particularly relevant to the areas now in their fire season, or due to begin their fire season in the coming months – Queensland, the Northern Territory and northern Western Australia.

In Western Australia, rainfall from tropical cyclones has led to above normal fire conditions in parts of the Kimberley. For Queensland, normal fire potential is expected, however there is a risk of grass fires due to good grass growth in some areas. Normal fire potential is forecast for the Northern Territory. Given the long-term dry conditions in the area, the south coast of New South Wales has above normal fire potential for the time of year for areas that did not burn during the 2019/20 season.

Elsewhere across the country, normal fire potential is expected for the time of year. With a La Niña WATCH current, most states and territories are watching the grass fire risk for coming months, as increased rainfall could see this risk increase when the weather warms. It is important to remember that areas designated as normal fire potential may experience fire. Normal risk does not mean there is no risk.

The *Australian Seasonal Bushfire Outlook: July 2020* is developed by the Bushfire and Natural Hazards CRC, AFAC, the Bureau of Meteorology, Queensland Fire and Emergency Services, the New South Wales Rural Fire Service, ACT Emergency Services Agency, ACT Parks and Conservation Service, Country Fire Authority, Department of Environment, Land, Water and Planning Victoria, Tasmania Fire Service, Country Fire Service, Department of Fire and Emergency Services and Department of Biodiversity, Conservation and Attractions Western Australia, and Bushfires NT.

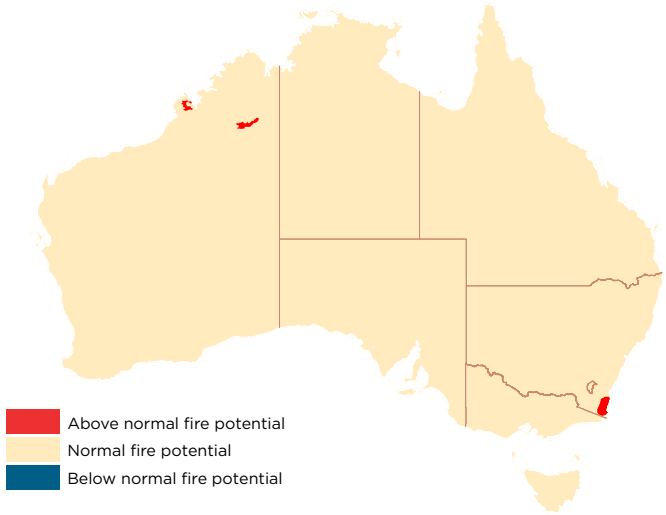


Figure 1: AUSTRALIAN SEASONAL BUSHFIRE OUTLOOK JULY 2020. AREAS ARE BASED ON THE INTERIM BIOGEOGRAPHIC REGIONALISATION FOR AUSTRALIA AND OTHER GEOGRAPHICAL FEATURES.

OUTLOOK – WINTER 2020

Fire management is a year-round process, and bushfire potential depends on many factors. For northern Australia, where the fire season occurs at this time of year, conditions are determined by the nature of the previous wet season. The volume, location and timing of rainfall are critically important when estimating vegetation (fuel) volumes and growth. The climate outlook for the next few months is also a crucial factor.

The *Australian Seasonal Bushfire Outlook: July 2020* covers all states and territories through to September 2020. It reflects the priorities in each state and territory for the coming months given the expected climate conditions, and provides information to assist fire authorities in making strategic decisions such as resource planning and prescribed fire management to reduce the negative impacts of bushfire.

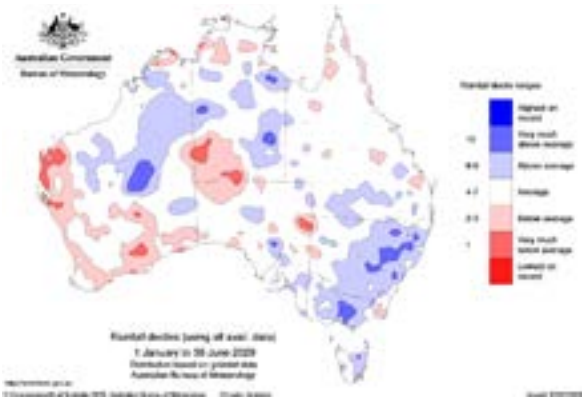
Across the country, autumn presented an opportunity to conduct prescribed burning where appropriate weather conditions allowed. In some states and territories, this will continue through winter when possible.

DEFINITION

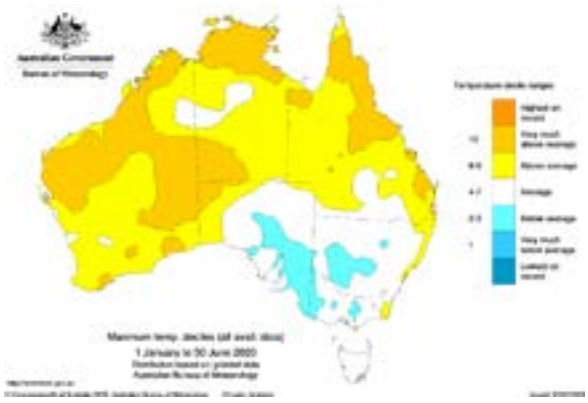
Bushfire potential: The chance of a bushfire or number of bushfires occurring of such size, complexity or other impact (such as biodiversity or global emissions) that requires resources (from both a pre-emptive management and suppression capability) beyond the area in which it or they originate. Bushfire potential depends on many factors including weather and climate, fuel abundance and availability, recent fire history and firefighting resources available in an area.

RECENT CONDITIONS

Seasonal fire conditions are a function of fuel (vegetation) amount and state, and seasonal



▲ Figure 2: RAINFALL DECILES FOR JANUARY TO JUNE 2020.



▲ Figure 3: TEMPERATURE DECILES FOR JANUARY TO JUNE 2020.

weather conditions. 2019 was the warmest and driest year on record for Australia, with many records set. However, the first half of 2020 has seen a shift to more normal rain patterns for a number of areas. This start to the year has been wetter than in the previous two years, and contrasts with prolonged drought in some, but not all, locations, over that period.

January to June 2020 saw more normal rain patterns return to much of southern and eastern Australia (Figure 2, above), with a number of tropical incursions bringing rainfall to drought-affected parts of eastern Australia. This rainfall has eased short-term deficiencies in many areas, especially in the south east of the country. However, years of below average rainfall means that water storages remain low—especially in the northern Murray-Darling Basin—and many months of above average rainfall is needed for the wider environment to fully recover. In the last three months, some areas such as east of the Great Dividing Range, have seen drier than average conditions. A positive Southern Annular Mode through late May and June has resulted in below average rainfall over much of the country, especially in south west Western Australia, adding to rainfall deficiencies in this area.

Some areas of the country did not see any widespread relief from long-term dry conditions. This includes south west Western Australia, which despite seeing some above average rainfall in February, has seen drier than average conditions in autumn and early winter, a wetter period of the year climatologically. Additionally, the northern wet season (October 2019 to April 2020) saw low rainfall across parts of northern Australia, and much of the south. This is the second successive dry wet season, with 2018/19 also below average. Some factors contributing to the drier conditions seen in the 2019/20 wet season included a late monsoon onset in January, three weeks later than average in the Northern Territory, and below average tropical low/cyclone activity. In addition, a strong positive Indian Ocean Dipole was in place until the end of 2019, likely helping to suppress the start of the northern wet season.

The long-term warming trend means that above average temperatures now tend to occur in most years, and recent months have generally followed this pattern. The exception to this was May 2020, which saw the first cooler than average month nationally since October 2016. Temperatures in Australia for 2019 were the warmest in 110 years of record (1.52 °C above the 1961–1990 average, see Annual Climate Statement 2019, Bureau of Meteorology). Early 2020 has continued to see warmer days for much of the north and west. High temperatures add to the impact of reduced rainfall by increasing evaporation.

The combined very hot and dry conditions saw Australia experience one of its most devasting southern fire seasons in 2019/20. The rainfall in early 2020 has eased the fire risk for most of eastern Australia, however, South Australia and Western Australia have seen drier conditions persist into winter.

The tendency for fire seasons to become more intense and fire danger to occur earlier is a clear trend in Australia's climate, reflecting reduced and/or less reliable cool season rainfall and rising temperatures (see State of the Climate 2018, CSIRO and Bureau of Meteorology). Fire season severity is increasing across much of Australia as measured by annual (July to June) indices of the Forest Fire Danger Index, with the increases tending to be greatest in inland eastern Australia and coastal Western Australia.

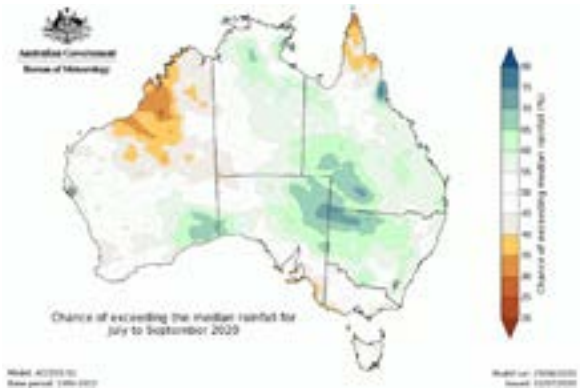
CLIMATE OUTLOOK

Climate outlooks are influenced by active climate drivers, together with other factors including long-term trends.

The influences of the climate in 2020 are very different to those that led to the extreme dry conditions in 2019. Both the El Niño-Southern Oscillation (ENSO) and the Indian Ocean Dipole are currently neutral. However, the Bureau of Meteorology's *ENSO Outlook* has shifted to La Niña WATCH. This means there is around a 50% chance of La Niña forming in 2020, roughly double the normal likelihood. La Niña typically sees above average rainfall over much of Australia. Combined with warmer than average water in the eastern Indian Ocean, this is helping to increase the likelihood of wetter than average conditions across the eastern two-thirds of Australia in the coming months.

The rainfall outlook for July to September (Figure 4, page 3) shows an above average likelihood of wetter than average conditions for parts of central and eastern Australia, extending from north eastern South Australia through New South Wales, as well as central parts of the Queensland coast. Most of the remainder of the country has roughly equal chances of wetter or drier than average conditions, but drier than average for parts of the north west and Cape York Peninsula. Historical outlook accuracy for July to September is very high across much of Australia, but generally moderate to low for western Western Australia, northern Queensland, and in the south east of the country.

Maximum and minimum temperatures during July to September are very likely to be warmer than average across most of Australia (Figure 4 and Figure 5, page 4). Historical accuracy for July to September maximum temperatures is moderate to high across most of Australia, but low in the central Northern Territory to western Queensland. Minimum



▲ Figure 4: CHANCE OF EXCEEDING THE MEDIAN RAINFALL FOR JULY TO SEPTEMBER 2020.

temperature accuracy is moderate to high for much of Australia—very high for northern Australia and north east New South Wales, but low to very low for much of central and southern Western Australia.

While the outlook is favouring good rainfall for the coming months, recent low rainfall in May and June mean a close watch will be kept on where the rainfall does and does not fall leading into the 2020/21 southern fire season.

Updates to climate forecasts, including forecasts of monthly, fortnightly and weekly outlooks and the outlook for the Indian Ocean Dipole and the El Niño-Southern Oscillation will continue to be published at www.bom.gov.au/climate/ahead.

REGIONAL SUMMARIES

WESTERN AUSTRALIA

As noted in April's *Australian Seasonal Bushfire Outlook*, rainfall from Tropical Cyclones *Blake* (early January), *Damien* (early February) and *Esther* (mid February) has resulted in above average root zone soil moisture content for most of the Kimberley and parts of the East Pilbara. Good vegetation growth for tropical grasses and spinifex is visible across the landscape, suggesting potential increases in fuel loads and a delay in grass curing. Planned burning and grazing have been undertaken in these areas, and despite a delayed start to the dry season, the Dampierland, Central Kimberley and Ord Victoria Plain bioregions have been identified as having above normal fire potential due to higher than normal fuel loads.

Soil moisture has decreased across the southern half of Western Australia compared to monthly averages. Woody vegetation in the south western third of the state continues to experience long-term soil moisture deficits, increasing their relative flammability. However, the climate outlook suggests cooler and wetter weather conditions in the coming months, and this should restore root-zone soil moisture, resulting in normal fire potential for this part of the state over the outlook period.

NORTHERN TERRITORY

Wet season rainfall totals in most areas across the Northern Territory were well below average for 2019/20. Two areas were exceptions - the Arnhem East and Gregory North West Fire Weather Forecast Areas - which both received average rainfall. For most of the Northern Territory, it was the second consecutive wet season of below average rainfall. Apart from these two areas, grassy vegetation (fuels) are all but cured. Prescribed burning in the north went ahead as planned, however as a result of the well below average wet season rain, fuel mitigation was limited to strategic corridors and fine scale properties. The Fire Danger Period has been declared earlier because of the drier than usual conditions including grassy fuel curing, and covers the northern half of the Northern Territory. To date, fire season activity, fire mitigation efforts and fuel loads suggest normal fire potential for all regions through to September. Weather modelling by the Bureau of Meteorology suggest that there is an increased chance of an earlier start to the northern Australia wet season.

QUEENSLAND

Late summer rainfall has triggered increased grass growth through parts of Queensland. This growth is in contrast to that seen across areas that were heavily affected by drought in recent seasons. Reduced livestock stocking rates have increased the likelihood that these grass fuel loads may be carried over into the start of the fire season in some areas.

Forested areas, particularly in south east Queensland, remained dry through May due to below average rainfall. Relative soil moisture levels in these areas have now largely returned to normal. There is however significant long-term underlying soil dryness across much of southern Queensland.

The climate outlook through to October is supporting above average rainfall across most of the eastern half of Australia.

As a result, Queensland is expecting a different fire season to what has been experienced in the last two years. There is normal fire potential for the state, however if the projected above average rainfall does not eventuate in coming months, forested areas may become readily available due to the long-term underlying dryness. Areas carrying significant grass fuel loads may see an increased risk of grass fires, particularly during the start of the season, though projected rainfall and warmer temperatures may also lead to rapid greening up of these areas in late winter and early spring.

NEW SOUTH WALES

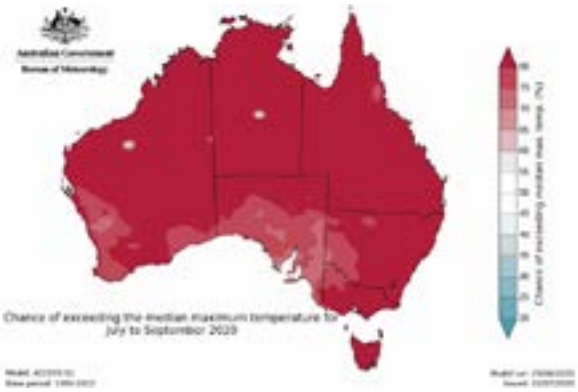
Large parts of NSW west of the Great Dividing Range have experienced welcome rain since March, which has increased soil moisture in these areas. However, long-term rainfall deficiencies remain right across the state. In particular, dry sub soil conditions on the northern ranges, far north coast and south coast are of concern. These areas are being monitored closely.

Due to ongoing dry conditions and a reduced chance of above median rainfall, above normal fire potential is expected for the south coast for this time of year in areas unburnt after last season's fires. However, should a significant rain event, which has been forecast for mid-July, affect the south coast, this is likely to decrease the fire potential for the outlook period.

In spite of dry conditions, normal fire potential is expected for the northern ranges and far north coast due to an increased chance of above median rainfall in these areas.

With a La Niña WATCH current, the rainfall outlook appears favourable for much of the state. Whilst the bushfire outlook on the balance of the forecast is normal for most of NSW for the winter period, there is a need to monitor for unusual weather events (particularly windy conditions) that occasionally present during this period.

The grass fire risk will continue to be monitored west of the Divide over coming months. Recent and forecast rain, combined with warmer than average temperatures, may provide ideal growing conditions for grassland areas. Whilst this is potentially good news, this spring growth has the potential to increase



▲ Figure 5: CHANCE OF EXCEEDING THE MEDIAN MAXIMUM TEMPERATURE FOR JULY TO SEPTEMBER 2020.

▲ Figure 6: CHANCE OF EXCEEDING THE MEDIAN MINIMUM TEMPERATURE FOR JULY TO SEPTEMBER 2020.

grassland fuel loads as it dries through summer.

Since April, fire management in NSW has focused on hazard reduction. Where weather permits, NSW fire and land management agencies will continue to undertake hazard reduction burning in the coming months.

ACT

With some useful rain over autumn, the ACT has had some relief from the ongoing severe drought. Bushfire risk managers will be monitoring conditions over winter and spring to see how the bushfire risk develops ahead of the next fire season. At present the landscape is damp and there is minimal bushfire risk, which is normal for winter. Bushfire risk mitigation actions, under the ACT Government's Strategic Bushfire Management Plan, continue. Community members need to continue to keep their property bushfire safe, and should take the opportunity over winter to review their bushfire survival plans.

VICTORIA

Throughout autumn large parts of Victoria have seen above average rainfall, with the exception of East Gippsland. As a result, there are still areas in Gippsland with unburnt vegetation – particularly in the north, west and along coastal strips. These areas have experienced three years of drought. In the last two seasons, the fire danger period in East Gippsland has commenced earlier than usual and it is anticipated that an early season start is likely for the coming season given the dry conditions. If this drying trend continues in East Gippsland, it is possible that fires in the scale of a thousand hectares may develop under prolonged warm and windy conditions in late winter or early spring. For the remainder of the state, normal fire conditions are expected during winter.

With the increased rainfall, there are good prospects for spring pasture and crop growth in the north and west of the state. A La Niña WATCH is current, and if a La Niña eventuates there is a higher than normal chance of above average rainfall during spring. As a result, fire risk in pastoral and agricultural areas will be monitored closely come spring. Planned burning activity in Victoria is typically reduced during winter due to unsuitable weather conditions.

SOUTH AUSTRALIA

South Australia has experienced average rainfall since March, with exceptions being parts of the south east and north east, which have seen slightly above average rainfall, and the APY Lands in the north west, which has experienced below average rainfall. Variability associated with the path of significant weather systems has meant soil dryness seen across observation points is extremely variable. For example, in the Flinders and Mount Lofty Ranges, soils are very wet, whilst in the Riverland and parts of the Eyre Peninsular, soils are quite dry.

In partnership with the Department of Environment and Water, prescribed burning has been undertaken where conditions have allowed, however opportunities in the foreseeable future will be limited due to fuel conditions, with vegetation currently too wet to burn.

There is low potential for fire activity across South Australia for the winter period, which is considered normal for the time of year. The current climate outlook shows an increased chance of above normal rainfall through to September, which may increase fuel loads in grassland and cropping areas into spring.

TASMANIA

Autumn rains significantly eased moisture deficits in the northern and eastern parts of the state, while good progress was made with planned burning until the program was ended by early winter rain. Planning is underway to take advantage of suitable weather windows during late winter and early spring for further planned burning and other bushfire mitigation. Deep soil moisture levels are still low in the eastern half of the state but will be improved with further rain. Fire threat levels are normally low in Tasmania until spring unless there are significant drought conditions, and as a result, normal fire potential is expected for this winter.

The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

HAZARD **NOTE**

bushfire&natural HAZARDSCRC

ISSUE 71 APRIL 2020
TOPICS IN THIS EDITION | FIRE IMPACTS | FIRE SEVERITY | FIRE WEATHER

AUSTRALIAN SEASONAL BUSHFIRE OUTLOOK: APRIL 2020

OVERVIEW

The fire season of 2019/20 was one of the most devastating Australia has experienced. Large and destructive bushfires occurred in most states and territories, beginning in the north and extending to the south. There were prolonged periods of smoke exposure to many cities and regional areas, reducing the air quality. The challenging conditions continued until widespread rain occurred across large parts of the east coast in early February 2020. In total, 17.4 million hectares were burnt, resulting in 33 human fatalities and 3,094 homes destroyed (AFAC National Resource Sharing Centre). There was widespread environmental damage and wildlife death.

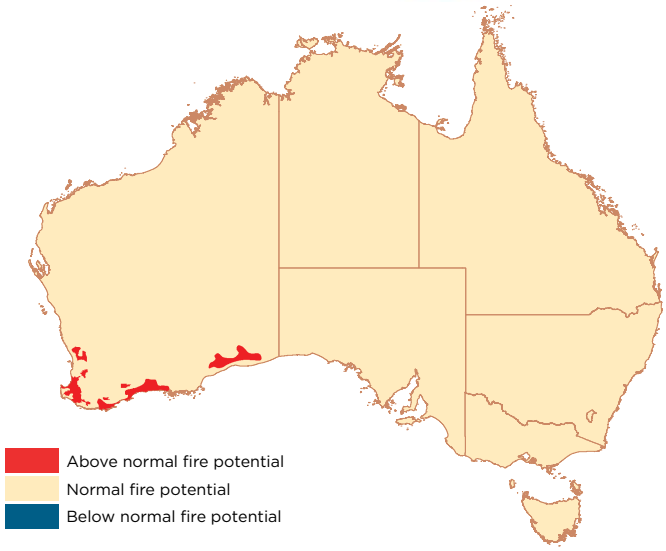
2019 was warmest and driest on record for Australia, with many records set. Temperatures were 1.52°C above the 1961–1990 average (see Annual Climate Statement 2019, Bureau of Meteorology). However, the early months of 2020 have seen a shift to more normal rain patterns for a number of areas.

The *Australian Seasonal Bushfire Outlook: April 2020* is developed by the Bushfire and Natural Hazards CRC, AFAC, the Bureau of Meteorology, Queensland Fire and Emergency Services, the New South Wales Rural Fire Service, ACT Emergency Services Agency, ACT Parks and Conservation Service, Country Fire Authority, Department of Environment, Land, Water and Planning Victoria, Tasmania Fire Service, Country Fire Service, Department of Fire and Emergency Services and Department of Biodiversity, Conservation and Attractions Western Australia, and Bushfires NT.

OUTLOOK – AUTUMN 2020

Bushfire potential depends on many factors. The volume, location and timing of rainfall are critically important when estimating vegetation (fuel) volumes and growth. The climate outlook for the next few months is also a crucial factor. The *Australian Seasonal Bushfire Outlook: April 2020* covers all states and territories through to July 2020. It provides information to assist fire authorities in making strategic decisions such as resource planning and prescribed fire management to reduce the negative impacts of bushfire.

Fire management is a year-round process, and this Outlook reflects the priorities in each state and territory over the next three months given the 2019/20 fire season, and the weather conditions expected in coming months. Although the risk of uncontrolled bushfire is lower in most areas, the fire potential remains high in some specific regions due to the long-term low rainfall. It is important to remember that areas designated as normal or below normal fire potential may experience bushfire – normal or below normal risk does not mean there is no risk.

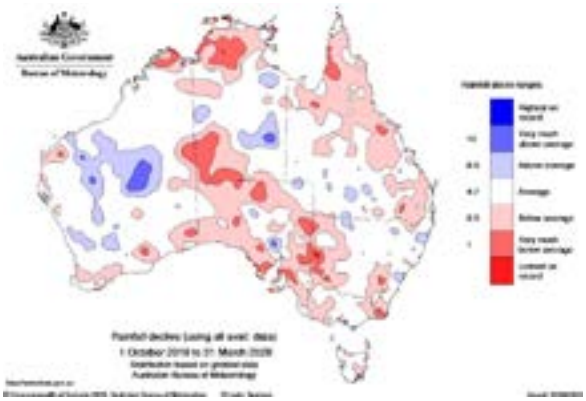


▲ Figure 1: AUSTRALIAN SEASONAL BUSHFIRE OUTLOOK APRIL 2020. AREAS ARE BASED ON THE INTERIM BIOGEOGRAPHIC REGIONALISATION FOR AUSTRALIA AND OTHER GEOGRAPHICAL FEATURES.

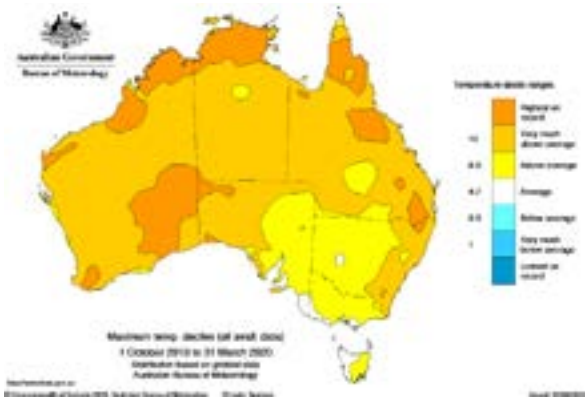
DEFINITION

Bushfire potential: The chance of a bushfire or number of bushfires occurring of such size, complexity or other impact (such as biodiversity or global emissions) that requires resources (from both a pre-emptive management and suppression capability) beyond the area in which it or they originate. Bushfire potential depends on many factors including weather and climate, fuel abundance and availability, recent fire history and firefighting resources available in an area.

Prescribed burning during this Outlook period is an important tool to reduce bushfire risk. In many areas, prescribed burning opportunities may arise under appropriate



▲ Figure 2: RAINFALL DECILES FOR OCTOBER 2019 TO MARCH 2020.



▲ Figure 3: MAXIMUM TEMPERATURE DECILES FOR OCTOBER 2019 TO MARCH 2020.

weather conditions and with enough local resources. It is unclear at this point what effect COVID-19 will have on the ability of agencies and land management departments to conduct prescribed burning, but it is anticipated that there will be impacts. Prior to the COVID-19 restrictions, post-fire season burning programs had already begun in many regions.

RECENT CONDITIONS

Seasonal fire conditions are a function of fuel amount and state, and seasonal weather conditions. 2019 was warmest and driest on record for Australia, with many records set. However, the early months of 2020 saw a shift to more normal rain patterns for a number of areas.

For January to December 2019, rainfall was very much below average over most of Australia. It was the driest year in 120 years of records and was especially dry over eastern and southern Australia. For some areas, such as New South Wales extending into south eastern Queensland, 2019 marked the third year of dry conditions.

The early months of 2020 saw a return to more normal rain patterns, with a number of tropical weather systems bringing rainfall to drought-affected parts of the country. This rainfall, while welcome, was still well short of clearing rainfall deficiencies at a longer time scale. Additionally, the northern wet season to date (October 2019 to March 2020, Figure 2, above) has seen low rainfall across parts of northern Australia, and much of the south.

The long-term warming trend means that above average temperatures now tend to occur in most years, and recent months have followed this pattern. Temperatures in Australia for 2019 were the warmest in 110 years of records (1.52°C above the 1961–1990 average, see Annual Climate Statement 2019, Bureau of Meteorology). Early 2020 has continued to see warmer days for much of the north. High temperatures add to the impact of reduced rainfall by increasing evaporation.

The combined very hot (Figure 3, above) and dry conditions contributed to the extreme nature of the 2019/20 southern fire season. The rainfall in early 2020 has eased the fire risk for much of Australia. At extended timescales of greater than six months, many areas across southern Australia remain drier than average. The late and poor northern wet season rainfall-to-date for many areas of northern Australia may mean less vegetation growth over the season.

The tendency for fire seasons to become more intense, and fire danger to occur earlier in the season, is a clear trend in Australia's climate, reflecting reduced and/or less reliable cool season rainfall and rising temperatures (see State of the Climate 2018). Fire season severity is increasing across much of Australia as measured by annual (July to June) indices of the Forest Fire Danger Index, with the increases tending to be greatest in inland eastern Australia and coastal Western Australia.

CLIMATE OUTLOOK

Climate outlooks are influenced by active climate drivers, together with other factors including long-term trends.

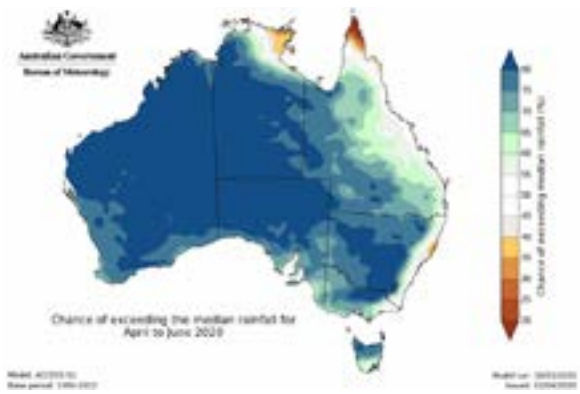
The influences on climate in the second half of 2019 are very different to the current conditions in place now and those forecast for the coming months.

A strong positive Indian Ocean Dipole brought dry conditions to much of Australia in the second half of 2019. Additionally, this was combined with an unusually persistent negative phase of the Southern Annular Mode in the last three months of 2019. A negative Southern Annular Mode means Australia's weather systems are further north than usual, which in late spring to early summer typically means stronger westerly winds for Tasmania and the southern mainland. In areas where those winds are coming off the ocean, it's typically cooler and wetter, but in parts where westerlies blow across long fetches of land, this air becomes dry and hot with reduced rainfall.

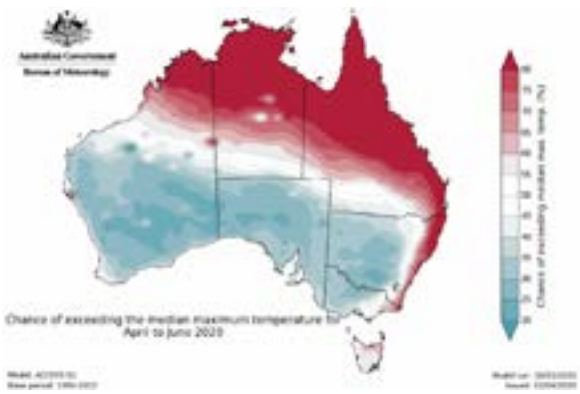
Both of these dry climate drivers had decayed by early January, with the main Australian climate drivers all back at a neutral state. Forecasts suggest both the El Niño-Southern Oscillation and the Indian Ocean Dipole are likely to remain neutral at least until mid-year.

This has allowed more localised influences on the outlook for April to June. The outlook indicates a stronger north to south temperature gradient in the eastern Indian Ocean. This, combined with south westerly winds, increases the likelihood of north west cloudbands and subsequently, wetter than average conditions for much of central and southern Australia.

The outlook for April to June (Figure 4, page 3) suggests that rainfall is likely to be above average across most of Australia. There is an increased likelihood of below average rainfall across small parts of the far north, with the northern and eastern coasts mostly favouring roughly equal chances of



▲ Figure 4: CHANCE OF EXCEEDING THE MEDIAN RAINFALL FOR APRIL TO JUNE 2020.



▲ Figure 5: CHANCE OF EXCEEDING THE MEDIAN MAXIMUM TEMPERATURE FOR APRIL TO JUNE 2020.

wetter or drier conditions. Historical outlook accuracy for April to June is moderate across western and northern Australia, as well as patchy areas of south east Australia. Elsewhere, accuracy is low to very low.

The outlook for April to June maximum temperatures (Figure 5, above right) favours above average daytime temperatures across northern and eastern Australia, while cooler than average days are likely for southern Western Australia, South Australia, western and central New South Wales and western and central Victoria. The outlook for minimum temperatures (not shown) also strongly favours above average temperatures across the country. Historical accuracy for April to June maximum temperatures is moderate to high across Australia, and very high in northern parts. Minimum temperature accuracy is moderate to high for western, central and northern Australia as well as Tasmania. Elsewhere, accuracy is low to very low.

Updates to climate forecasts, including forecasts of monthly, fortnightly and weekly outlooks and the outlook for the Indian Ocean Dipole and the El Niño-Southern Oscillation will continue to be published at www.bom.gov.au/climate/ahead

REGIONAL SUMMARIES

QUEENSLAND

Following a very dry December 2019, a tropical low and a monsoon trough at the end of January 2020 produced moderate to heavy falls from the northern tropics to the Burdekin coasts. Summer rainfall totals were mixed across the state. Areas around the Cape York Peninsula and the north tropical coast, the far south west and the central interior reported below average rainfall. In contrast, parts of the southern interior and south east, and small areas through the central and southern interior and Gulf Country, recorded above average rainfall. Early autumn weather systems have delivered moisture to most of Queensland, significantly reducing the risk of uncontrolled fires. The moisture delivered from these systems is currently promoting regeneration and growth and improving the overall health of vegetation across the state.

Stable conditions with lower than average rainfall are forecast for the coming weeks, however Queensland is within the cyclone season and the chance of weather systems forming cannot be ruled out.

Currently the Bureau of Meteorology's forecast is for Queensland to experience above average rainfall for the coming months in south, west and central areas of the state. As the vegetation responds, opportunities for planned burning activity will commence. These activities will be heavily dependent on any changes in weather systems.

NEW SOUTH WALES

The frequency, size and consequence of bushfires during the 2019/20 fire season was of extraordinary significance in recent NSW fire history. Two successive periods of significant rain during February brought a reprieve to the situation, with the last emergency declaration revoked on 4 March.

Traditionally in NSW the period from April to June sees a shift from the bushfire danger period to a focus on hazard reduction burning. Conditions for the current outlook period appear variable, with soil moisture conditions for large areas in the eastern half of the state area wetter than average. Fuel state reflects this situation, with reports of grass growth and low levels of curing (green grass). However, soil moisture in parts of the Central and Far West and Far South Coast still remain drier than average.

The rainfall outlook appears positive for much of the state. Whilst the bushfire outlook on the balance of the forecast appears normal, there is a need to monitor for unusual weather events (particularly windy conditions) that occasionally present during this period.

Where weather permits, NSW fire and land management agencies will undertake hazard reduction burning.

ACT

Early in 2020 the southern ACT was severely impacted by the Orroral Valley bushfire, while areas to the north, including Canberra, were not affected. The burnt area included 75 per cent of the Namadgi National Park, which equates to 36 per cent of the ACT. Recent rains have mitigated the extended drought effects and have reduced the fire threat to the community to normal levels for this time of year. Grasslands have greened up rapidly with the rain, removing any grassfire risks for the coming months. Some forest fire potential remains, but autumn moisture should keep threats to normal levels. Autumn is traditionally a time for hazard reduction burns. Should the right conditions eventuate this activity will commence. A primary goal for the coming months is to continue to prepare the community for the next fire season as unburnt forest areas remain in the north and west, close to Canberra. That

threat will be closely monitored.

VICTORIA

During autumn, bushfire activity in Victoria generally declines due to seasonal changes and moisture recovery in soils and vegetation. While bushfire potential is normal for this time of year, it is important to note that elevated fire danger under windy conditions in grasslands in the west of the state during April is a possibility. Planned burning activity in Victoria has been ongoing since late summer in the west of the state, under suitable weather conditions. The planned burning program is likely to continue in the west, and as landscape conditions meet operational requirements, this program may contract or expand to the east. There is low confidence and high uncertainty in the success of the planned program in general, based on the potential of high rainfall weather systems during April. In general, planned burn opportunities will depend on rainfall, drying conditions and conducive weather, as well as balancing resource requirements.

TASMANIA

The bushfire season had fires which were exceedingly difficult to suppress due to the underlying drought conditions, especially in the Midlands and eastern Tasmania. Fingal, St Marys, Bicheno and Swansea were all threatened for several weeks by major fires. Widespread rain in March was sufficient enough for the state to be regarded as having normal fire season potential for the time of year. Planned burning has commenced in all areas during suitable burning windows, taking advantage of the different requirements for moorlands and scrubs compared to the dry forests. Given the climate outlook, a normal autumn-early winter planned burning season is expected for all fuel types, with small weather windows becoming available between the passage of frontal systems. Forest fuels in eastern Tasmania may yet be too dry for low intensity burning without further rains.

SOUTH AUSTRALIA

South Australia has not experienced the large rainfall that has fallen across broad areas of the east coast in recent months. As a result, soil dryness is average. However, the rainfall that occurred at the end of January over broad parts of the state was sufficient enough to extinguish the fires that had occurred since November. This rain improved conditions and provided a brief respite, but the effects have been temporary.

Bush and grass fires remain a threat across South Australia. Previous fire seasons have demonstrated that elevated fire weather conditions and major fires have occurred through April and May, and as a result, normal fire potential is expected across South Australia.

WESTERN AUSTRALIA

Rainfall from Tropical Cyclones *Damien* (early February) and *Esther* (mid February) have resulted in significant vegetation growth for the grasslands of the Kimberley and spinifex areas of the Pilbara. With weather conditions becoming cooler and more stable, the northern parts of Western Australia will soon commence their planned burning activities, including the Kimberley's annual aerial and roadside burning programs. These burning programs are a collaboration between the Department of Fire and Emergency Services, the Department of Biodiversity, Conservation and Attractions, Main Roads WA, Traditional Owners, the Kimberley Land Council, the Australian Wildlife Conservancy and the Pastoralists and Graziers Association of WA.

For the southern parts of Western Australia, ongoing hot and dry conditions are reflected in below average root zone soil moisture, particularly in areas with woody vegetation. Above normal fire potential continues for parts of the Swan Coastal Plain, Jarrah Forest, Warren, Mallee, Esperance Plains, Nullarbor and Hampton Biogeographic Regions. In the past two years, the south west has experienced unusually strong and dry pre-frontal winds associated with cold fronts in late autumn, highlighting the need for good burn security and situational awareness in the conduct of prescribed burning operations.

NORTHERN TERRITORY

The northern regions of the Northern Territory are still experiencing significant rain, in part due to ex-Tropical Cyclone *Esther* which occurred in mid February, followed by early March monsoon activity. As a result, grassy fuel growth is strong. Accumulated rainfall totals in most centres of the north are currently below average (by up to 30 per cent) to almost average. Significant curing of these grassy fuels is not evident at present. The current rainfall totals and range suggests normal fire potential for the coming months, leading into the northern Australian fire season. Prescribed burning activity is expected to concentrate during the next three months in the north, and will include broad scale strategic aerial prescribed and roadside fuel hazard reduction burning with landholders, as well as finer scale property planned burning activity.

In central and southern regions of the Northern Territory, recent and quite widespread rainfall has eased the fire danger. In the coming months there will likely be opportunities for fire mitigation programs to be undertaken, including broad and fine scale prescribed burning activity. The recent rainfall, fire season activity, and fire mitigation efforts suggest normal fire potential for these regions through to June.

The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

HAZARD **NOTE**

bushfire&natural HAZARDSCRC

ISSUE 68 DECEMBER 2019

TOPICS IN THIS EDITION | FIRE IMPACTS | FIRE SEVERITY | FIRE WEATHER

AUSTRALIAN SEASONAL BUSHFIRE OUTLOOK: DECEMBER 2019

OVERVIEW

The 2019/20 fire season is well underway with multiple large bushfires occurring since the release of the previous Outlook in August. Queensland and New South Wales in particular have experienced severe fires, but all states have had challenging fire conditions. Catastrophic fire danger ratings have been issued in NSW, Western Australia, South Australia and Victoria, and there has been loss of human lives and animals, and damage to property and the environment.

2019 has seen the second warmest January to November period on record for Australia, 0.01°C behind 2013, coupled with the second-driest on record for the same period. Looking forward into the Outlook period, it is these conditions that lead to the continued above normal fire potential across most states and territories into 2020. A long and challenging fire season is expected, and all states and the ACT are warning of increased fire danger as the fire season progresses.

This December 2019 *Australian Seasonal Bushfire Outlook* covers all states and territories through summer 2019/20. It provides information to assist fire authorities in making strategic decisions such as resource planning and prescribed fire management to reduce the negative impacts of bushfire.

Bushfire potential depends on many factors. The volume, location and timing of rainfall are critically important when estimating vegetation (fuel) volumes and growth. The climate outlook for the next few months is also a crucial factor.

The Australian *Seasonal Bushfire Outlook: December 2019* is developed by the Bushfire and Natural Hazards CRC, AFAC, the Bureau of Meteorology, Queensland Fire and Emergency Services, the New South Wales Rural Fire Service, ACT Emergency Services Agency, ACT Parks and Conservation Service, Country Fire Authority, Department of Environment, Land, Water and Planning Victoria, Tasmania Fire Service, Country Fire Service, Department of Fire and Emergency Services and Department of Biodiversity, Conservation and Attractions Western Australia, and Bushfires NT.

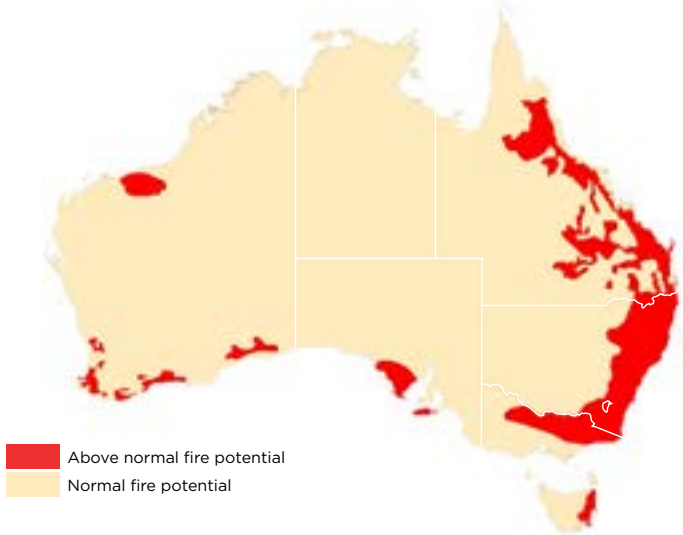


Figure 1: AUSTRALIAN SEASONAL BUSHFIRE OUTLOOK DECEMBER 2019. AREAS ARE BASED ON THE INTERIM BIOGEOGRAPHIC REGIONALISATION FOR AUSTRALIA AND OTHER GEOGRAPHICAL FEATURES.

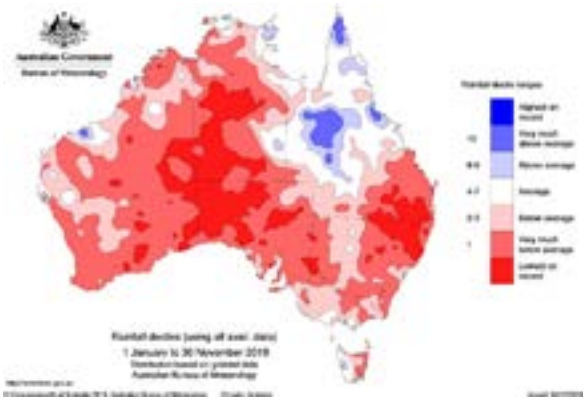
RECENT CONDITIONS

Seasonal fire conditions are a function of fuel amount and state, and seasonal weather conditions. The year to date has been unusually warm and dry for large parts of Australia (Figures 2 and 3, page 2), with many records set.

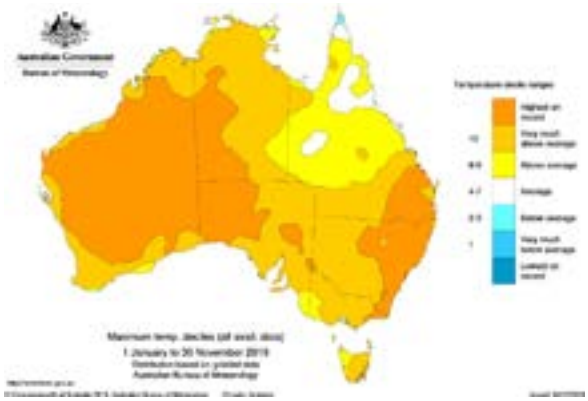
For January to November, rainfall has been below to very much below average over much of Australia. It has been the second-driest January to November on record for Australia (rainfall records begin in 1900), and the driest since the peak of the Federation Drought in 1902. It has been especially dry over the southern half of Australia (south of the Northern Territory/South Australia border), which had the driest January to November period on record. At a state level, rainfall deficiencies affect large areas, especially south eastern Queensland through eastern New South Wales, the ACT, South Australia, eastern Tasmania, south western WA, north western Australia and parts of eastern Victoria on a range of timescales. Areas of above average rainfall are largely confined to central Queensland, extending to the coast where heavy rainfall occurred early in the year.

Some areas, such as NSW extending into south eastern Queensland, are into their third year of dry conditions. It will take a prolonged period of above average rainfall to remove the deficiencies which are in place, meaning that general landscape dryness is likely to persist for many areas for some months. The combination of severe dry conditions over the long and short-term, coupled with high temperatures and record low humidity have contributed to the dangerous start to the southern fire season.

The warming trend means that above average temperatures now tend to occur in most years, and 2019 has followed this pattern. Temperatures in Australia for January to November have been the second warmest on record (1.37 °C above the 1961–1990 average, behind 1.38 °C for the same period



▲ Figure 2: RAINFALL DECILES FOR JANUARY TO NOVEMBER 2019 SHOWING DRY CONDITIONS OVER MUCH OF AUSTRALIA.



▲ Figure 3: MAXIMUM TEMPERATURE DECILES FOR JANUARY TO NOVEMBER 2019 SHOWING WARM CONDITIONS ACROSS AUSTRALIA.

DEFINITIONS

Bushfire potential: The chance of a fire or number of fires occurring of such size, complexity or other impact (such as biodiversity or global emissions) that requires resources (from both a pre-emptive management and suppression capability) beyond the area in which it or they originate. Fire potential depends on many factors including weather and climate, fuel abundance and availability, recent fire history and firefighting resources available in an area.

in 2013), with daytime temperatures clearly the warmest on record (1.9 °C above 1961-1990 average, temperature records begin 1910). These high temperatures add to the impact of reduced rainfall by increasing evaporation, further drying the landscape and vegetation. However, it should be noted that poor growth of grass and annual plants means that vegetation loads are reduced in many drought-affected areas. Dust storms may be a common occurrence.

With the combined hot and dry conditions in place it is not surprising that the southern fire season started early and has been severe to date. Large areas have seen record fire danger overall, as well as a very early start to the high fire danger period. In area average terms, the fire weather as measured by the Forest Fire Danger Index (FFDI) for spring was record high for Australia, as well as all states and territories apart from South Australia (second) and Victoria.

The tendency for fire seasons to become more intense and fire danger to occur earlier in the season is a clear trend in Australia's climate, reflecting reduced and/or less reliable cool season rainfall and rising temperatures (see State of the Climate 2018). Fire season severity is increasing across much of Australia as measured by annual (July to June) indices of the FFDI, with the increases tending to be greatest in inland eastern Australia and coastal Western Australia.

CLIMATE OUTLOOK

The climate outlook for summer is mainly influenced by the Indian Ocean, together with other factors including long-term trends. Ocean temperatures in the tropical Pacific remain close to average, with El Niño or La Niña unlikely to develop in the coming months.

The positive Indian Ocean Dipole pattern which has brought dry conditions to Australia in recent months is forecast to decay by mid-summer. Temperatures in Australia for January to November have been the second warmest on record (1.37 °C above the 1961–1990 average, behind 1.38°C for the same period in 2013), with daytime temperatures clearly the warmest on record (1.90 °C above 1961-1990 average, temperature records begin 1910). Usually Indian Ocean Dipole events break down at the end of spring or early summer with the arrival of the monsoon into the southern hemisphere. However, this year the monsoon has been slow to move south—in fact it was the latest retreat on record from India—and international climate models suggest the positive Indian Ocean Dipole is likely to last longer than usual.

The other unusually persistent climate driver is a negative Southern Annular Mode. A negative Southern Annular Mode means Australia's weather systems are further north than usual. At this time of the year, this means stronger westerly winds for Tasmania and the southern mainland. In areas where those winds are coming off the ocean, it's been cooler and wetter, but in parts where westerlies blow across long fetches of land, this air becomes dry and hot with reduced rainfall.

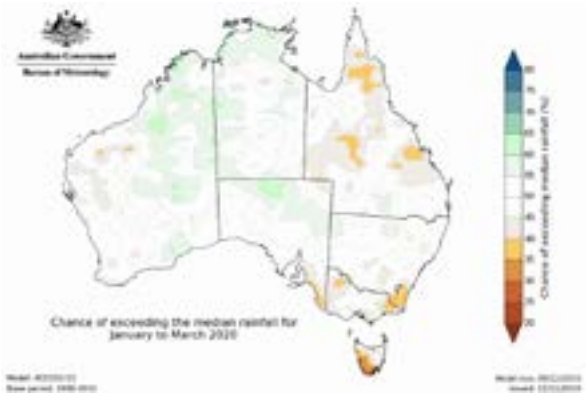
While both climate drivers are likely to decay by mid-summer, their legacy will take some time to fade. The positive Indian Ocean Dipole and the dry conditions experienced in winter and spring are known to be associated with a more severe fire season for south east Australia in the subsequent summer.

The rainfall outlook for January to March (Figure 4, page 3) suggests that rainfall is likely to be above average in western areas, while eastern Australia generally sees odds which are close to 50:50. The decay of the Indian Ocean Dipole means that probability swings are less strong than earlier in the season for eastern areas, suggesting that some relief in dry conditions is possible in the coming months.

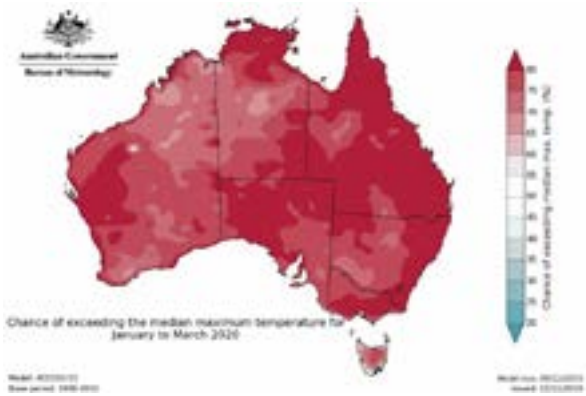
Historical outlook accuracy for January to March is moderate across western and southern mainland Australia, as well as the northern NT and northern Queensland. Elsewhere, accuracy is low to very low.

The outlook for January to March maximum temperature outlook (Figure 5, page 3) favours above average daytime temperatures for nearly all of Australia, exceeding 80 per cent across much of the eastern half of the country. The outlook for minimum temperatures (not shown) also strongly favours above average temperatures across much of Australia, excluding the south east. Historical accuracy for January to March maximum temperatures is moderate to high across most of Australia, but low surrounding the Great Australian Bight, and to the south of the Gulf of Carpentaria. Minimum temperature accuracy is moderate to high for most of Australia, except the central NT and central to western parts of Queensland, where accuracy is low to very low.

Updates to climate forecasts, including forecasts of monthly, fortnightly and weekly



▲ Figure 4: CHANCE OF EXCEEDING THE MEDIAN RAINFALL FOR JANUARY TO MARCH 2020.



▲ Figure 5: CHANCE OF EXCEEDING THE MEDIAN MAXIMUM TEMPERATURE FOR JANUARY TO MARCH 2020.

outlooks and the outlook for the Indian Ocean Dipole and the El Niño-Southern Oscillation will continue to be published at www.bom.gov.au/climate/ahead

REGIONAL SUMMARIES

QUEENSLAND

Following a record fire season in Queensland in 2018/2019, the 2019/2020 fire season started in late August. Since then Queensland has seen several intense pulses of fire weather affecting an already chronically dry and hotter landscape, mainly in the south east - from Rockhampton to the NSW border and extending inland to around St George.

As this season has progressed, the drought has intensified in many areas, particularly in the south east, with the Main/Border Ranges area, and the area bounded by Warwick, Toowoomba and the Lockyer Valley standing out. These areas are showing the lowest one per cent on record for the monthly relative root zone soil moisture deficit for November. The long-term, and recently more intense, drought has seen significant additional surface fuels (vegetation) added in forest areas due to stressed trees dropping significant amounts of branches and leaves over winter and spring. As a result, these areas are seeing fires continuing to carry more widely and with more intensity than usual, even when humidity increases overnight.

Normally wet and fire-resistant rainforest and wet forests are becoming available and burning for the second season in a row, with this phenomenon now extending into southern Queensland to areas such as the Lamington and Main Range National Parks. The rainfall deficit has also increased inland of Bowen, Townsville and Cairns over the past two months, and as a result the northern forests and heavier woodlands are showing above normal bushfire potential and will continue to do so until these areas experience significant rainfall.

Large areas of inland Queensland have been drought effected since 2013, and as a result there has been very little grass fuel available, with the exception of sporadic and short-lived growth due to irregular inland rain. The Darling Downs and Granite Belt districts are continuing to face severe water shortages as a result of the drought. This has impacted the availability of water for fire suppression. QFES continues to work closely with their partners to manage this risk. The longer the delay in the arrival of the monsoon, the likelihood of campaign fires in northern forest areas will continue to build.

NEW SOUTH WALES

The start to this fire season has been unprecedented for New South Wales, with large fires occurring across the state. Since July, more than 8,000 bush and grass fires have occurred, burning over 2.8 million hectares. Six human lives have been lost, more than 700 homes destroyed and more than 1,600 other buildings. Resources have been drawn from around NSW, other states and from overseas.

Much of the state has experienced very much below average rainfall during the last three months, with a small percentage of areas in northern NSW experiencing driest on record conditions. Long-term rainfall deficiencies, record-low for some areas in the north of the state, have severely impacted on water resources.

At the end of September, the NSW Department of Primary Industries mapped nearly all of NSW into one of three drought categories - intense drought, experiencing drought or drought affected.

With the short to medium-range climate outlooks forecasting warmer and drier than average conditions across the state, above normal fire potential will continue in forested areas on and east of the Great Dividing Range. Under these conditions, existing large fires will continue to remain a threat.

West of the Divide there is minimal grass fuels available due to the drought, and as a result reduced fire potential.

ACT

The ACT has received less than average rainfall for nearly three years, leading to a persistent and high level of drought. The lowland forests have been very dry for some time, while highland forests are now dry as well. This indicates that fuel flammability in the forests is high and could remain so. The forest fire risk is elevated. The dry conditions and grazing by farm stock and wildlife have led to lower levels of grass growth, resulting in reduced overall grass fire risk. On bad days grass fires may still reach and impact on unprotected property. This situation should persist until rains return. Heatwaves and dust storms may make bushfire detection and suppression more challenging at times during the season.

The overall bushfire risk for the ACT is above normal. Community members should continue to prepare for fire by taking actions to reduce the bushfire risks around and within their property and to review their bushfire survival plans.

VICTORIA

The potential for above normal bushfire activity continues across the coastal and foothill forests of East Gippsland, extending into parts of West Gippsland, Great Dividing Range, and into the central Goldfields. This is due to the above average temperatures and continuation of drying trends observed in these regions over the last three months,

coupled with three years of significant rainfall deficit across much of East Gippsland and across the Divide. During spring, cold fronts generated rainfall in southern Victoria, however much of inland Victoria received insufficient rainfall. In these inland areas soil moisture is lower compared to the long-term average. This is likely to cause moisture stress on live vegetation thereby increasing the quantity of dead fuel components and result in higher flammability in live vegetation. Wet forests (such as the Central Highlands and Otway Ranges) are generally close to average conditions for this time of year.

Across the rest of Victoria, mostly normal conditions are expected. In the west of the state, grassland fuel conditions indicate that curing is average for this time of year, and that there is average to above average quantities of grass and crop loads. When grasses and crops are close to or fully cured, there is potential in the coming months for fire behaviour that can rapidly escalate under elevated fire weather conditions.

TASMANIA

Tasmania experienced an early start to the fire season with serious fires in the north and south of the state in October. While there was easing in the fire weather during November, by the end of the month a very strong continuous westerly airstream coincided with a number of ignitions in the north and east, resulting in a continuing campaign fire west of Swansea in the Eastern Tiers. The weather conditions were very unusual and effective fire suppression was impossible during the conditions experienced.

The area of above normal fire potential in eastern Tasmania continues to expand, while the west of Tasmania is receiving good rains which are replenishing water tables and the moisture in organic soils. The area of above normal fire potential includes the far north east, the Fingal and Royal George valleys and the Midlands, the east coast from St Helens to Tasman Island and the lower Derwent Valley. The remainder of the state has normal fire potential, noting the dominance of fuels in the west for which soil moisture is less important than in forests.

SOUTH AUSTRALIA

Minimal rainfall, and predominately warmer than average temperatures have persisted across South Australia through spring. As a result, the fire danger season was brought forward, with most areas commencing two weeks early.

The early start to the fire danger season has coincided with a number of total fire bans, and several significant fires have occurred. The Eyre Peninsula experienced Catastrophic fire danger conditions twice in November alone.

On 20 November Catastrophic fire danger was predicted for seven of the 15 weather districts across the state. A total fire ban was declared statewide, with Catastrophic fire danger recorded simultaneously across half the state. Temperature records were broken and 45 new bush and grass fires occurred. Eleven homes were lost on the Yorke Peninsula.

The current three month outlook for January to March 2020 indicates that South Australia is highly likely to experience above average day and night time temperatures, and there is little chance of above average rainfall during this period. This would indicate that the current dry conditions, which have supported major fires, are likely to continue throughout summer.

Based on the current climate outlook, and observed fire behaviour, parts of the Lower Eyre Peninsula and Kangaroo Island continue to have above normal fire potential. Forecast and observed conditions have also demonstrated the rest of South Australia maintains the potential for significant bushfires, including in the populated areas of the Mount Lofty Ranges.

The prolonged dry conditions are also likely to create increased occurrences of raised dust during the windy conditions that often accompany high fire risk days. The dust may affect the operational capabilities of aerial firefighting assets and limit their effectiveness. Fire managers will carefully monitor this issue, noting that without rainfall, dust suppression is impossible on the scale required.

The fire danger season may be prolonged across parts of South Australia. Significant bushfires have occurred in similar conditions, and even areas of normal fire potential can expect to experience dangerous bushfires as per a normal South Australian fire season.

WESTERN AUSTRALIA

With the positive Indian Ocean Dipole delaying the onset of the monsoon, high temperatures and dry lightning in the northern part of Western Australia have resulted in heightened bushfire risk for the Kimberley until rain arrives. Above normal fire potential continues for parts of the south west, south coast, Nullarbor and Pilbara.

NORTHERN TERRITORY

The Top End's bushfire season started two months earlier in 2019 due to the preceding poor wet season. Large, long duration fires occurring from early in the season that typically would have pulled up in temporary watercourses.

The bushfire risk remains across the Top End in areas of the Gregory and Carpentaria Regions, with localised and patchy rainfall occurring in coastal areas. This risk will continue until the effects of the monsoon occur inland.

In central Australia, below average rainfall over the last 12 months has led to reduced growth of vegetation. Due to these dry conditions, mitigation programs conducted by pastoral enterprises has reduced as the need for retention of standing vegetation increases for cattle production. Despite this, the Northern Territory is expecting normal bushfire potential to continue for the remainder of the central Australian fire season. However, significant bushfires have occurred in similar conditions, and even areas of normal fire potential can expect to experience dangerous bushfires. This will be particularly relevant in areas that surround unmanaged land with remanent vegetation growth, particularly remote communities and outstations.

The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

HAZARD **NOTE**

bushfire&natural HAZARDSCRC

ISSUE 63 AUGUST 2019

TOPICS IN THIS EDITION | FIRE IMPACTS | FIRE SEVERITY | FIRE WEATHER

AUSTRALIAN SEASONAL BUSHFIRE OUTLOOK: AUGUST 2019

OVERVIEW

The 2019/20 fire season has the potential to be an active season across Australia, following on from a very warm and dry start to the year. Due to these conditions, the east coast of Queensland, New South Wales, Victoria and Tasmania, as well as parts of southern Western Australia and South Australia, face above normal fire potential.

This August 2019 *Australian Seasonal Bushfire Outlook* covers all states and territories. It provides information to assist fire authorities in making strategic decisions such as resource planning and prescribed fire management to reduce the negative impacts of bushfire.

Bushfire potential depends on many factors. The volume, location and timing of rainfall are critically important when estimating vegetation (fuel) volumes and growth. The climate outlook for the next few months is also a crucial factor. Of particular interest are the future tendencies of Pacific sea surface temperature associated with the El Niño-Southern Oscillation, as well as the Indian Ocean Dipole, major climate drivers over Australia. Other less quantifiable factors, such as the distribution and readiness of firefighting resources, are also considered.

The *Australian Seasonal Bushfire Outlook: August 2019* is developed by the Bushfire and Natural Hazards CRC, AFAC, the Bureau of Meteorology, Queensland Fire and Emergency Services, the New South Wales Rural Fire Service, ACT Emergency Services Agency, ACT Parks and Conservation Service, Country Fire Authority, Department of Environment, Land, Water and Planning Victoria, Tasmania Fire Service, Country Fire Service, Department of Fire and Emergency Services and Department of Biodiversity, Conservation and Attractions Western Australia, and Bushfires NT.

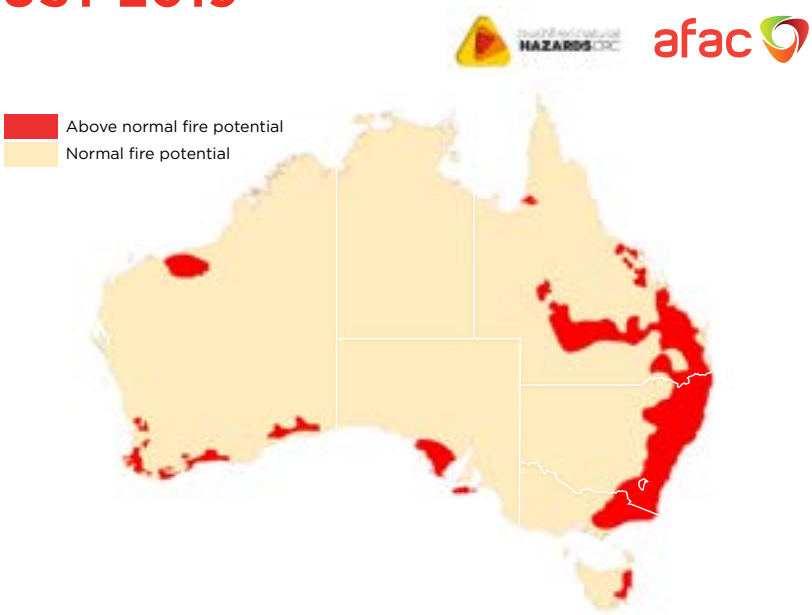


Figure 1: AUSTRALIAN SEASONAL BUSHFIRE OUTLOOK AUGUST 2019. AREAS ARE BASED ON THE INTERIM BIOGEOGRAPHIC REGIONALISATION FOR AUSTRALIA AND OTHER GEOGRAPHICAL FEATURES.

RECENT CONDITIONS

Seasonal fire conditions are a function of fuel amount and state, and seasonal weather conditions. The year to date has been unusually warm and dry for large parts Australia. For January to July, rainfall has been below to very much below average over much of Australia (Figure 2, page 2). It has been the fifth-driest start to the year on record, and the driest since 1970. This is especially the case over the southern half of the country, which has experienced the driest January to July on record (January to July 1902 is the second driest). Areas of above average rainfall are largely confined to central Queensland, extending to the coast.

Some areas, such as New South Wales into south eastern Queensland, are into their third year of dry conditions. It will take a number of months of above average rainfall to remove the deficiencies which are in place, meaning that general landscape dryness is likely to persist for many areas.

The warming trend means that above average temperatures now tend to occur in most years, and 2019 has followed this pattern. Across Australia, temperatures for January to July have been very much warmer than average (2nd warmest for this period on record, 1.46°C above the 1961–1990 average), with daytime temperatures the warmest on record (1.85°C above the 1961-1990 average, see Figure 3, page 2). Summer 2018/19 was exceptionally warm (2.14°C above average, over 0.8°C greater than the previous warmest summer on record). These high temperatures add to the impact of reduced rainfall, and increase evaporation, further drying the landscape and vegetation.

As might be expected given the broad climatic factors, an early start to the fire season has been declared in many areas across eastern Australia. The dry landscape means that any warm and windy conditions are likely to see elevated fire risk. Countering the climate signal, poor growth of grass and annual plants means that vegetation loads are reduced in drought affected areas.

Fire season severity is increasing across southern Australia as measured by annual (July to June) indices of the Forest Fire

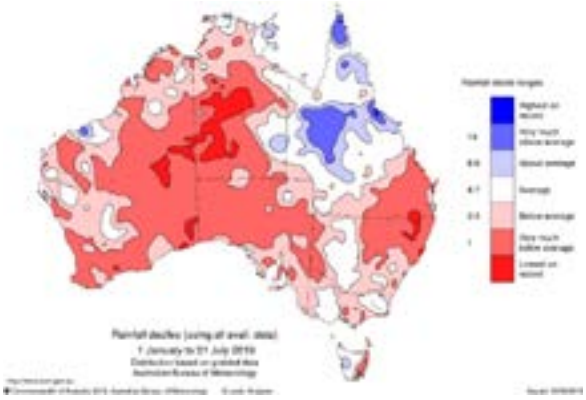


Figure 2: RAINFALL DECILES FOR JANUARY TO JULY 2019 SHOWING DRY CONDITIONS OVER MUCH OF AUSTRALIA.

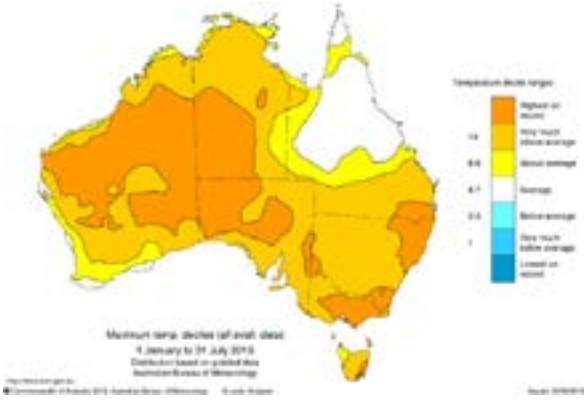


Figure 3: MAXIMUM TEMPERATURE DECILES FOR JANUARY TO JULY 2019 SHOWING WARM CONDITIONS ACROSS AUSTRALIA.

DEFINITIONS

Bushfire potential: The chance of a fire or number of fires occurring of such size, complexity or other impact (such as biodiversity or global emissions) that requires resources (from both a pre-emptive management and suppression capability) beyond the area in which it or they originate. Fire potential depends on many factors including weather and climate, fuel abundance and availability, recent fire history and firefighting resources available in an area.

Decile: A decile is a statistical technique that ranks observations into 10 equal groups. A decile map will show whether the rainfall or temperature is above average, average or below average.

Danger Index (FFDI). The increases are tending to be greatest in inland eastern Australia and coastal Western Australia. For example, the Victorian annual FFDI has increased by about 50 per cent since 1950, with 2018/19 the fourth highest on record, behind the severe fire seasons of 2002/03, 1982/83 and 2006/07. The increases reflect rising temperatures and below average rainfall during the cool season (April to October).

CLIMATE OUTLOOK

The climate outlook for spring is mainly influenced by the Indian Ocean, together with other factors including long-term trends. Ocean temperatures in the tropical Pacific remain close to average, with no El Niño or La Niña expected to develop in the coming months. A positive Indian Ocean Dipole during spring typically increases the chance of below average rainfall for southern and central Australia and has been linked to elevated summer fire danger. Other influences include Tasman Sea pressure patterns, which are favouring a reduction in onshore flow for parts of the east coast of Australia, and are likely contributing to the warmer and drier conditions forecast across NSW and southern Queensland.

The outlook for spring rainfall (Figure 4, page 3) shows a drier than average spring is likely for much of mainland Australia, especially for inland parts of southern Australia, and for large areas of northern Australia. Large areas of northern Australia are also likely to see a late northern rainfall onset, which may extend the fire season in the north. The likelihood of drier conditions is stronger in October compared with September. September is likely to be drier across northern Australia and small scattered areas of southern Australia, while October is likely to be drier across most of the mainland. Historical outlook accuracy for spring is moderate to high for most of the country, but low along the Northern Territory/Western Australia border, and the west coast of Western Australia.

The outlook for spring maximum temperatures favours above average daytime temperatures for nearly all of Australia. Probabilities are particularly high across much of northern Australia, where they widely exceed 80 per cent. Probabilities in the south are typically in the range of 50 to 80 per cent (Figure 5, page 3), implying that above average daytime temperatures are favoured. The outlook for minimum temperatures (not shown) suggests above average temperatures are favoured across northern and western parts of Australia, with probabilities above 80 per cent in western parts of the Northern Territory and northern Western Australia. Historical accuracy for spring maximum temperatures is moderate to high for most of Australia, except parts of northern South Australia. Minimum temperature accuracy is patchy, but generally moderate across much of eastern Australia including Tasmania, and the tropical north. Moderate to low accuracy is seen across western Western Australia and South Australia, with low accuracy in central Western Australia, the central Northern Territory and parts of western Queensland.

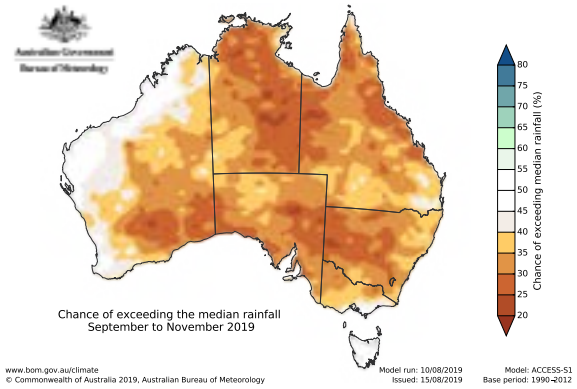
Updates to climate forecasts and the outlook for the Indian Ocean Dipole and the El Niño-Southern Oscillation will continue to be published at www.bom.gov.au/climate/ahead.

REGIONAL SUMMARIES

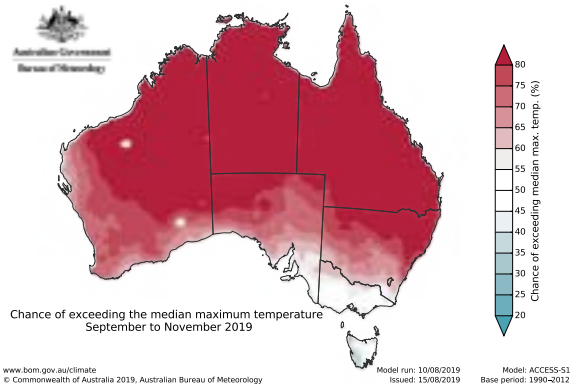
QUEENSLAND

2018/19 was a record fire season in Queensland, with November/December 2018 seeing unprecedented bushfires along the central to north coast. Following on from this, December 2018 saw record rainfall on the North Tropical Coast, as well as the Herbert and Lower Burdekin forecast districts. February and March 2019 also saw record and very much above average rainfall over northern parts of the state. Conversely for the 12 months to 31 July 2019, rainfall has been very much below average in south eastern parts of the state.

The lack of rain has resulted in the root zone soil moisture being below average – in



▲ Figure 4: CHANCE OF EXCEEDING THE MEDIAN RAINFALL FOR SEPTEMBER TO NOVEMBER 2019.



▲ Figure 5: CHANCE OF EXCEEDING THE MEDIAN MAXIMUM TEMPERATURE FOR SEPTEMBER TO NOVEMBER 2019.

the lowest one per cent on record for areas around Rockhampton and south to the New South Wales border. The rainfall and temperature outlooks make it very likely that this current soil moisture deficit will persist for the coming months, significantly increasing the available fuel in forested areas in south eastern Queensland.

Inland Queensland has been drought effected since 2013, and as a result there has been very little grass fuel available. However, the rainfall received this year will very likely see a return to average fuel loads in inland parts.

Since 1990, there has been a trend for Queensland fire seasons to start earlier and persist longer. This was the case last fire season, which saw record forest fire danger indices in August 2018 and February and March 2019. August 2019 has seen this trend continue, with Severe Fire Danger and successive days of Very High Fire Danger.

Above normal fire potential is expected in forested areas along the coast south of Rockhampton down to the NSW border, for woodland and grass fuels, inland areas in the south, and a small area west of Mackay. Although this was previously identified in the *Northern Australia Seasonal Bushfire Outlook 2019* (*Hazard Note* 62, June 2019), the hot and dry conditions experienced since June have dried the landscape even further. The Darling Downs and Granite Belt districts are facing severe water shortages as a result of the ongoing drought. This has the potential to impact the availability of water for fire suppression. QFES has been working closely with relevant local councils and their partners to manage this risk. Normal fire potential is expected for all other parts of Queensland.

NEW SOUTH WALES

Weather conditions have been exceptionally dry across NSW leading into the 2019/20 fire season. Much of central and northern NSW has experienced very much below average rainfall during the last three months, with a small percentage of areas experiencing driest on record conditions.

Long-term rainfall deficiencies, record-low for some areas in the north of the state, have severely impacted on water resources. With limited water availability, fire agencies in NSW are having to plan for firefighting tactics that minimise the use of water.

At the beginning of August, the NSW Department of Primary Industries mapped nearly all of NSW into one of three drought categories, with approximately 55 per cent of the state drought affected, 23 per cent experiencing drought, and 17 per cent experiencing intense drought.

Widespread significant soil moisture deficit has resulted in an early start to the fire danger period for many local government areas in NSW. Windy conditions in August have again resulted in many significant bushfires in forested areas north of the Hunter Valley.

With the short to medium-range climate outlooks favouring warmer and drier than average conditions across much of the state, there is significant concern for the potential of an above normal fire season in forested areas on and east of the Great Dividing Range.

Reports of grassland fuel conditions west of the Divide indicate that whilst grassy vegetation is cured, it is below average in quantity or load. With the chances of above median rainfall west of the Divide below 50 per cent to well below 50 per cent in the next three months, the balance of this situation has resulted in an assessment of normal fire potential for these areas. It should be noted that while grass load is reduced and therefore the potential intensity of grass fires may be reduced, highly cured grass creates the potential for grass fire to spread rapidly.

ACT

The ACT has received less than average rainfall over the last two years, leading to a persistent and high level of drought. The lowland forests are dry, while highland forests are relatively moist. This indicates that fuel flammability in the lowland forests could remain high, creating risks early in the fire season. The dry conditions and grazing by farm stock and wildlife have led to lower levels of grass growth, resulting in reduced grass fire risk. The outlook indicates a potential for the highland forests to dry out, however this could be delayed by the occurrence of summer rain. Heatwaves and dust storms may make bushfire detection and suppression more challenging at times during the season.

The overall bushfire risk for the ACT is above normal. Community members should continue to prepare for the fire season by taking actions to reduce the bushfire risks around and within their property, and to review their bushfire survival plans.

VICTORIA

Potential for above normal bushfire activity continues across the coastal and foothill forests of East Gippsland, extending into West Gippsland and the Great Dividing Range. These areas are now experiencing their third consecutive year of significant rainfall deficit, with severe levels of underlying dryness persisting in soils

and heavy forest fuels, along with higher abundance of dead fuel components and higher flammability of live vegetation.

Across the rest of Victoria, mostly normal bushfire activity is expected, however there is likely to be increased growth rates in pasture and croplands in the west due to winter rain. There is uncertainty around the effect of the Indian Ocean Dipole and warm/dry outlook, with some risk that ash forests in the central highlands and Otways may dry out at faster rates and become more flammable than normal during summer.

TASMANIA

For the early part of Tasmania's fire season, most of the state has normal fire potential. The western half of the state is wet, but the east is drier than normal, especially between the Forestier Peninsula and Scamander. This eastern dry area has above normal fire potential. Without significant rain in the coming months, this area will expand. As in recent years, increased fire activity is likely in this dry strip before December and will require considerable response efforts. Eastern peat soils will be susceptible to fire and will burn to depth, with traditionally wet or damp gullies already dry.

The fire season in the remainder of the state will commence more normally, in late spring or early summer, and provide good conditions for planned burning.

SOUTH AUSTRALIA

Average to below average rainfall has occurred across South Australia, with some areas experiencing persistent dry conditions since the start of 2018. In areas of ongoing dry conditions, grass fuel growth is either average, to well below average, which creates the likelihood of normal fire potential in these areas. This level of fire potential also continues in central and southern parts of South Australia, where average rainfall has occurred.

The Bureau of Meteorology's El Niño watch is currently neutral and the Indian Ocean Dipole is forecast to be positive. Similar forecasts have resulted in drier and warmer than average conditions in the lead up to, and throughout, South Australia's fire season. The dry spring forecast may result in an earlier start to the fire season in parts of South Australia.

The Mount Lofty Ranges have recorded almost average rainfall, which has reset the Soil Dryness Index to zero. However, late winter rainfall may promote increased vegetation growth before summer, and could increase the available bushfire fuels during the fire season. Forecast conditions maintain the potential for bushfire across the populated areas of the Mount Lofty Ranges.

Parts of the Lower Eyre Peninsula have received good rainfall, resulting in a bumper cropping season and higher than normal grass fuel growth. Due to the increased fuel load, these areas have above normal fire potential. Kangaroo Island also has above normal fire potential, with a combination of drier than average, and wetter than average conditions (depending on the vegetation type) across the island. These conditions may result in above average fuel loads in parts, and drier than average vegetation in others, especially in areas of forested and scrub vegetation.

The prolonged dry conditions across much of South Australia is also likely to create increased occurrences of raised dust during the windy conditions that often accompany high fire risk days. The dust may affect the operational capabilities of aerial firefighting assets and limit their effectiveness. Fire managers will carefully monitor this issue during the fire season, noting that without rainfall, dust suppression is impossible on the scale required.

There are currently no forecasts indicating any potential for above average rainfall during spring and summer, which may prolong the fire season across parts of South Australia. Significant bushfires have occurred in similar conditions, and even areas of normal fire potential can expect to experience dangerous bushfires as per a normal South Australian fire season.

WESTERN AUSTRALIA

Rainfall deficiencies have persisted across most of the south west of Western Australia, with this area experiencing its driest start to the year, followed by the seventh-driest autumn on record. In addition, drier and warmer than average conditions are forecast through to October, which will increase soil moisture deficits and stress in woody vegetation. These conditions have resulted in above normal fire potential for parts of the Swan Coastal Plain, Avon Wheatbelt, Jarrah Forest, Warren, Esperance Plains and Mallee regions. In parts of the Nullarbor, higher than normal fuel loads will contribute to above normal potential.

Above normal fire potential is also expected for coastal areas of the Pilbara which experienced heavy rainfall in association with Severe Tropical Cyclone *Veronica* in March 2019. This rainfall promoted good growth of soft grass and spinifex, as well as delaying curing compared to the rest of the region. As conditions dry out, greater continuity and loading of grassy fuels will increase the fire potential in parts of the Pilbara affected by *Veronica*.

NORTHERN TERRITORY

The late and weak monsoon activity for the 2018/19 wet season has led to dry conditions, with the Top End experiencing the driest wet season since 1992. Similarly, large areas of central Australia have received below average rainfall over the last 12 months.

This has led to reduced growth of vegetation, but despite this, the Northern Territory is expecting normal bushfire potential to continue for the remainder of the fire season, due to a shift in the timing of fire management activities. In the Top End, both mitigation activities and bushfires occurred two months earlier than normal, with large, long duration, early season fires that would normally be pulled up by temporary watercourses taking place. With a late onset to the 2019/20 wet season expected, dry conditions are likely to be extended.

The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

HAZARD **NOTE**

bushfire&natural HAZARDSCRC

ISSUE 62 JUNE 2019

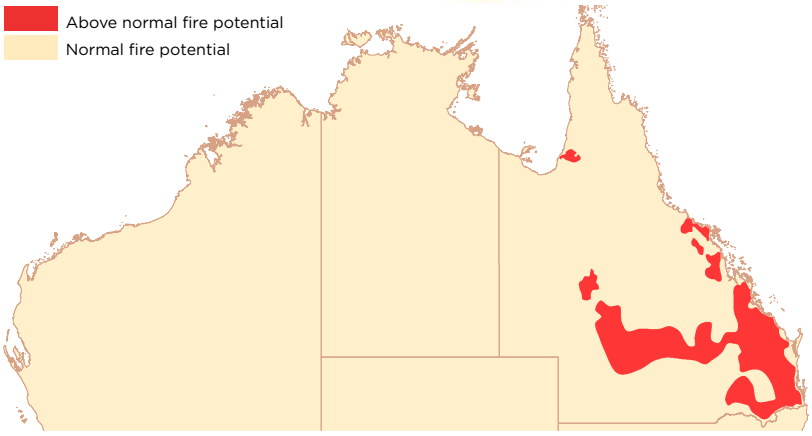
TOPICS IN THIS EDITION | FIRE IMPACTS | FIRE SEVERITY | FIRE WEATHER

NORTHERN AUSTRALIA SEASONAL BUSHFIRE OUTLOOK 2019

BUSHFIRE POTENTIAL

Covering Queensland, the Northern Territory, northern Western Australia and northern South Australia, the *Northern Australia Seasonal Bushfire Outlook 2019* provides information to assist fire authorities in making strategic decisions such as resource planning and prescribed fire management to reduce the negative impacts of bushfire. A *Seasonal Bushfire Outlook* incorporating southern Australia will be published in late August, and will include an update on the northern fire season if required.

Bushfire potential depends on many factors. In northern Australia, conditions are determined by the nature of the previous wet season. The volume, location and timing of rainfall are critically important when estimating vegetation (fuel) volumes and growth. They also affect the timing of the drying of the vegetation. The climate outlook for the next few months is also a crucial factor. Of particular interest are the future tendencies of Pacific sea surface temperature associated with El Nino-Southern Oscillation, a major climate driver over Australia. Other less quantifiable factors, such as the distribution and readiness of firefighting resources, are also considered.



▲ Areas are based on the Interim Biogeographic Regionalisation for Australia and other geographical features.

ANTECEDENT CONDITIONS

Seasonal fire conditions are a function of fuel amount and state, and seasonal weather conditions. In northern Australia recent weather and climate is particularly important, as it determines the condition and amount of available grass and woody fuels. Years with abundant summer rainfall due to an active monsoon and tropical cyclones tend to see more fuel growth and present increased fire risk when the fuels dry out. Years with reduced rainfall, which may be hotter and give more bad fire weather days, are often associated with reduced fuel growth, which may reduce fire activity.

The past two years have seen unusual climatic conditions affect most of Australia. Perhaps most notably, record warmth has been experienced across many regions nationally, particularly so for maximum temperatures. The two-year period ending June 2019 has seen the hottest national mean temperature on record at +1.65˚C above the 1961-1990 average (previous record +1.38˚C in 2014-2016). During these two years, many notable temperature records have been experienced including Australia's hottest summer on record (2018/19), along with many individual and multi-day high temperature extremes (Figure 1, page two). Accompanying the warm conditions has been widespread and significant rainfall deficiencies and drought, which has locally persisted for more than two years. The below average rainfalls have reflected both poor monsoonal rainfall and reduced winter rainfall in more southern areas.

The northern wet season (October 2018 to April 2019) was notably dry for much of northern Australia. In contrast, inland Queensland near Mount Isa, and the tropical Queensland coast from near Townsville to Cape York, experienced unusually wet conditions, with flooding evident in December, January and February (Figure 2, page two). Vegetation growth, which provides the fuel for bushfires, matches the overall pattern of rainfall and temperature, with poor growth affecting most of Australia including the tropics. A notable exception is north east Queensland, where greenness and recent fuel growth has been high due to the heavy summer rains.

The second half of 2018 saw the development of a positive Indian Ocean Dipole (IOD), a feature which tends to suppress rainfall across Australia. In the Pacific, sea surface temperatures have been persistently warmer than average, at times reaching the threshold typically used to declare an El Niño event. However, the atmosphere has not always been consistent with the presence of an El Niño. These extended near-El Niño conditions in the Pacific likely contributed to suppressing rainfall over Australia. Unusually, the pattern of ocean cooling which often occurs during late summer and autumn with past El Niño events did not occur in early 2019, meaning that the drying influence on rainfall persisted throughout the northern wet season.

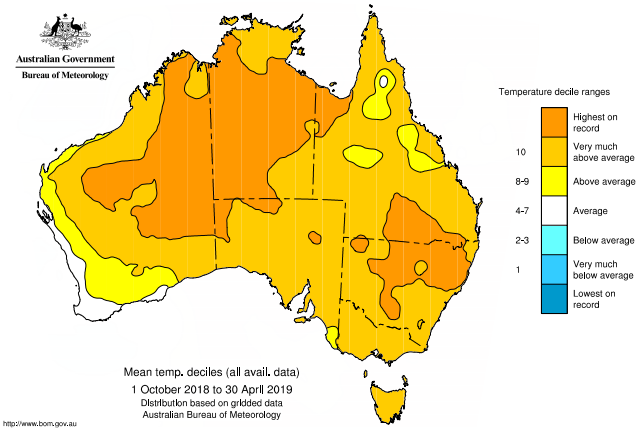
Recent high temperatures reflect the background global warming trend, in combination with natural variations. Australia's mean temperature has now

DEFINITIONS

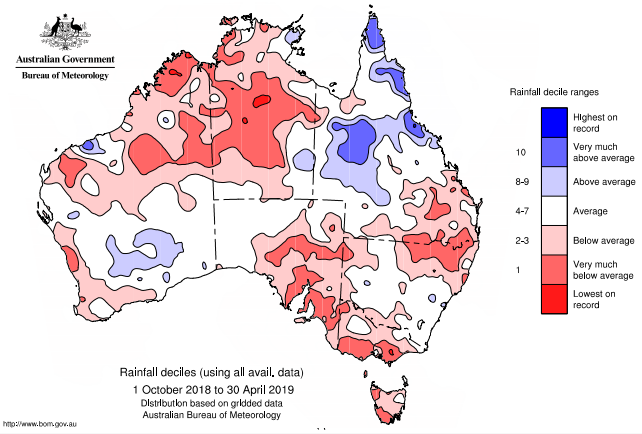
Bushfire potential: The chance of a fire or number of fires occurring of such size, complexity or other impact (such as biodiversity or global emissions) that requires resources (from both a pre-emptive management and suppression capability) beyond the area in which it or they originate. Fire potential depends on many factors including weather and climate, fuel abundance and availability, recent fire history and firefighting resources available in an area.

Rainfall decile: A decile is a statistical technique that ranks sorted observations into 10 equal groups. A decile rainfall map will show whether the rainfall is above average, average or below average for the chosen time period and area.

IBRA: Interim Biogeographic Regionalisation for Australia. Australia's landscapes are divided into 89 large geographically distinct bioregions based on common climate, geology, landform, native vegetation and species information.



▲ Figure 1: MEAN TEMPERATURE DECILES FOR OCTOBER 2018 TO APRIL 2019 SHOWING UNUSUALLY WARM CONDITIONS ACROSS AUSTRALIA.



▲ Figure 2: RAINFALL DECILES FOR OCTOBER 2018 TO APRIL 2019 SHOWING DRY CONDITIONS OVERS MUCH OF AUSTRALIA.

warmed by 1.4°C since 1910, which is significant compared to interannual variability, which is typically near 1°C. One consequence of the rising temperatures is an increase in fire weather severity, during the dry season in northern Australia and the warm season in southern Australia. As measured by fire weather indices, northern Australia experienced record high fire weather in 2017 and this record was broken again in 2018. The increase in the south also means that the northern and southern fire seasons are increasingly overlapping, particularly during the spring period.

The dry season in tropical Australia officially commences in May and ends in September. Large rainfall totals are rare, with the climate dominated by warm to hot temperatures, lower humidity and east to south east winds which may become gusty and elevate fire risk. Low rainfall and warm to hot temperatures mean that fuels are already dry. The combination of weather and climate factors means the 2019 fire season is now well underway, with dryness running a few weeks ahead of seasonal norms.

Winter into spring is historically a period of lower fire risk in more southern areas of Australia. However, notably dry conditions and severe drought in combination with a trend to earlier and more severe fire seasons means that there is again an increased risk of early fire activity affecting areas such as south east Queensland and eastern New South Wales. These areas will be covered in more detail in the *Southern Australia Seasonal Bushfire Outlook 2019* in late August.

CLIMATE OUTLOOK

The Pacific Ocean has experienced warmer than average conditions for more than twelve months and approached the threshold for an El Niño on a number of occasions. However, climate model guidance suggests that the Pacific is now likely to continue near or below the threshold for an El Niño, meaning an event is not likely. The ENSO Outlook status is now inactive.

The Indian Ocean continues to experience average or cooler than average waters to Australia's north west, and warmer waters further west. This pattern is typical of a positive Indian Ocean Dipole (IOD) event, with the IOD index sitting above the positive threshold in recent weeks. Most climate models surveyed by the Bureau suggest a positive IOD will persist through winter. A positive IOD often results in below average winter and spring rainfall over southern and central Australia, extending into northern Australia during spring.

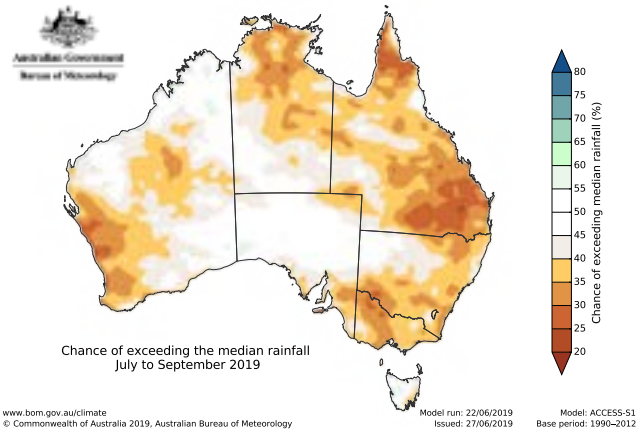
Overall, the Bureau's forecast suggests that the start to the 2018/19 wet season is likely to be delayed. The outlook for the coming wet season will be updated monthly as new data and model forecasts become available.

The outlook for July to September rainfall suggests that below average rainfall is likely across much of Australia, though probability shifts are not strong (Figure 3, page 3). The tendency for below average rainfall is consistent with a positive IOD, and the continued warmth in the tropical Pacific Ocean.

Historical outlook accuracy for July to September is moderate to high for most of the country, but low in parts of south east Australia and far northern Queensland. The July to September period is normally dry for northern Australia, with typically low

rainfall except near the Queensland coast. This means that the impact of rainfall in the coming months is likely to be modest.

July to September is likely to bring average to above average maximum temperatures to tropical parts, with probabilities favouring warmer days in the range of 60 to 80% (Figure 4, page 4). The one exception is far north Queensland, where probabilities are near 50:50. Overall the forecast suggests that recent warmer than average conditions are likely to continue through the remainder of the dry season. The outlook for minimum temperatures also favours warmer than average conditions (not shown) with probabilities broadly above 60%. Historical accuracy for July to September maximum temperatures is moderate to high for most of Australia, except parts of the inland north, and south east and south west Australia. Minimum temperature accuracy is moderate to high for the northern half of the country and Tasmania, but generally low elsewhere.



▲ Figure 3: CHANCE OF EXCEEDING THE MEDIAN RAINFALL FOR JULY TO SEPTEMBER 2019.

REGIONAL SUMMARIES

QUEENSLAND

Looking back at the previous fire season, both the *Northern Australia Seasonal Bushfire Outlook 2018* and the *Southern Australia Seasonal Bushfire Outlook 2018* (*Hazard Note 49*, July 2018 and *Hazard Note 51*, September 2018) identified above normal fire potential for forested areas along Queensland's Central Coast, Whitsundays and the Capricornia – areas that experienced unprecedented bushfires in November/December 2018. These bushfires were the result of long term climate drivers - a lack of rainfall along the coast had led to drier soils and hotter daytime temperatures. During the bushfires there were a series of low pressure systems over south eastern Australia that drove a strong westerly air flow. These systems brought hot dry winds from central Australia right to the Queensland coast and resulted in record temperatures and forest fire danger indices. The fire danger rating reached Catastrophic on the afternoon of 28 November in parts of Queensland, the first time the Catastrophic rating had been recorded in the state.

December 2018 saw record rainfall on the North Tropical Coast, as well as the Herbert and Lower Burdekin forecast districts. February and March 2019 also saw record and very much above average rainfall over northern parts of the state. Conversely for the six month period December 2018 to May 2019, rainfall has been below, and very much below average in south eastern parts of Queensland.

This rain has resulted in the root zone soil moisture being average or above average for most of the state, except for areas around Rockhampton and south to the New South Wales border, where the soil moisture is below average. In this area, the rainfall and temperature outlooks make it very likely that this current soil moisture deficit will persist into the fire season, increasing the available fuel in forested areas in south eastern parts of the state.

In grass and woodland areas, the rainfall has resulted in above average fuel in the far south west, and a high chance of above average growth for the south east and inland parts through until August, likely increasing the grass fuel load in these areas.

Inland Queensland has been drought affected since 2013, and as a result there has been very little grass fuel available. The rainfall received over the last six months will very likely see a return to average fuel loads in inland parts.

Since 1990, there has been a trend for Queensland fire seasons to start earlier and persist longer. This was the case in 2018/19, which saw record forest fire danger indices in August, February and March, in line with this trend. This trend is likely to continue in 2019 given the current conditions, climate outlook, and with a delayed start to the wet season likely.

Taking the antecedent conditions and climate outlook into account, above normal fire potential is expected in forested areas along the coast south of Rockhampton down to the NSW border for woodland and grass fuels, inland areas in the south, a small area west of Mackay and in the south west of Cape York. Normal fire potential is expected for all other parts of Queensland.

NORTHERN TERRITORY

Late and weak monsoon activity led to dry conditions for the 2018/19 wet season, with the Top End experiencing the driest wet season since 1992. Combined with the hottest wet season on record, this resulted in Top End rainfall being 34% below the long-term rainfall average. As an example, the total rainfall for Darwin Airport was 1,174 mm, with the long-term average being 1,677 mm. Areas of the north eastern Top End were affected by Severe Tropical Cyclone *Owen*, which saw rainfall totals and vegetation growth reach average conditions for this area. The effectiveness of planned mitigation activities across the Northern Territory have varied due to the differing conditions experienced during the wet season. Where planned burns have been undertaken by land managers, including carbon farming projects, good results have been achieved to minimise the risk of bushfires occurring later in the year.

Central regions

Large areas of central Australia have received very much below average rainfall in the previous 12 months. In some areas, rainfall totals have been the lowest on record. This in turn has led to below average, to well below average, grass growth across both the Alice Springs and Barkly regions.

Severe Tropical Cyclone *Trevor* in mid-March resulted in good rainfall totals in areas of the Mitchell Grass Downs and Simpson Strzelecki Dunefields regions. This has resulted in patchy grass growth across the area of rainfall and flooding, but not enough to suggest any more than normal bushfire potential. With lower than average fuel loads across most of central Australia, particularly in the Tanami, pastoralists in this region are de-stocking, and on a smaller scale some planned burning will continue to address

any patchy high fuel loads across Aboriginal lands and some Parks and Wildlife Reserves.

Top End region

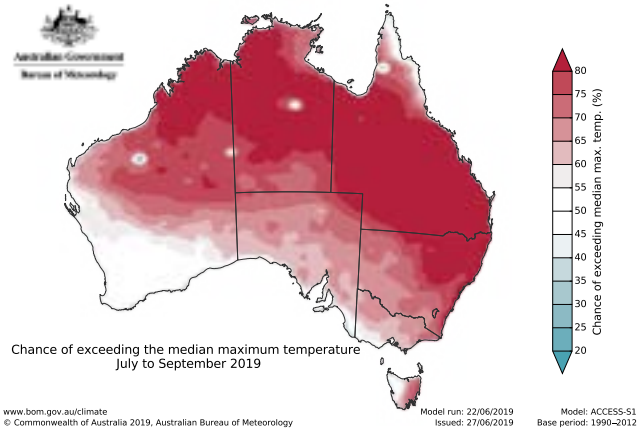
Below average rainfall across the majority of the Top End has resulted in mainly average and below average fuel loads. An exception to this is the Gulf Coastal region, with higher than normal fuel loads after rainfall from both *Owen* and *Trevor*. Grassland curing has been earlier than normal in the western regions, with the Gulf and Arnhem Coastal regions continuing to cure, as well as areas that received rain during May.

The relatively poor wet season allowed for earlier access to country for mitigation activities. Aerial mitigation works in the Daly Basin and Pine Creek regions commenced two weeks earlier than usual with good results. Finer scale burning close to populated areas has been undertaken, although with the late season rain in May, mitigation activity in the Darwin Coastal and Daly Basin regions will continue as weather permits. Mitigation has been reduced in most other Top End regions due to the dry conditions and the retention of grass fuels for primary production by landowners. Mitigation activities on carbon farming projects are continuing, especially across Arnhem Land.

Due to the dry conditions, flood plain areas will dry out early and become susceptible to fires.

Gamba grass prevalent area

Gamba grass continues to spread to new locations across the north west Top End, increasing fuel loads and changing fire and land management practices on properties. Targeted mitigation efforts have varied depending on tenure and the management objectives of landholders. Rainfall in May has seen rapid growth of Gamba grass in some locations closer to the Darwin Coastal region, with a lower curing rate than surrounding vegetation. Where burning has taken place, the residual Gamba matter may carry another fire later in the season.



▲ Figure 4: CHANCE OF EXCEEDING THE MEDIAN MAXIMUM TEMPERATURE FOR JULY TO SEPTEMBER 2019.

NORTHERN WESTERN AUSTRALIA

The late onset of the monsoon season and reduced thunderstorm activity over northern parts of Western Australia have contributed to the region's driest summer since 2004/05. Below average rainfall, low root zone soil moisture profiles and above average temperatures have resulted in an earlier start to grassland curing in the East Kimberley.

A combination of the 2018 dry season fire activity, the poor wet season, and prescribed burning and grazing in early 2019 have contributed to reduced grass fuel loads across the landscape. However, bushfire potential is still expected to be normal this year, due to remaining fuels from the previous year and the probability of the trend for elevated dry season fire weather conditions, as has been experienced over the past last two years.

With similar conditions in the Pilbara, grass curing rates have remained close to 100% for a substantially longer period than usual, other than for the Pilbara Coast which received rain during Severe Tropical Cyclone *Veronica* and is the only area to have experienced close to normal wet season grass regrowth. The remainder of the Pilbara has had very little grass regrowth and the vegetation remains very dry – this is expected to result in an earlier onset of the fire season.

NORTHERN SOUTH AUSTRALIA

Northern parts of South Australia have recorded average to below average rainfall over the past 12 months, leading to average vegetation growth in large parts of the North West and North East Pastoral areas.

Due to the drier conditions in parts of the Aṉangu Pitjantjatjara Yankunytjatjara (APY) Lands over the past 12 months, animals such as camels, donkeys and horses have been migrating from the west into the APY Lands in the search of water. The impact of this migration, combined with lower rainfall, has lowered available fuel in some parts of the APY Lands. As a result, a normal fire season is likely across the North West Pastoral, including the APY Lands.

An influx of floodwaters from Queensland has resulted in some areas of above average grass growth along the waterways and tributaries that flow into Kati Thanda–Lake Eyre. This growth is limited to the vicinity of the Kati Thanda-Lake Eyre basin, and is not anticipated to cause increased fire risk across the broader region beyond what would occur in a normal year.

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HAZARD **NOTE**

bushfire&natural HAZARDSCRC

ISSUE 61 JUNE 2019

TOPICS IN THIS EDITION | FIRE IMPACTS | FIRE SEVERITY | FIRE WEATHER

PYROCONVECTIVE INTERACTIONS AND SPOT FIRE DYNAMICS

ABOUT THIS PROJECT

This research is part of the project *Fire coalescence and mass spot fire dynamics*, which began in 2014. The project has two primary aims: to improve the understanding of pyroconvective interactions across fire lines of general geometric configuration; and to increase knowledge about how intrinsic fire dynamics, including drivers such as pyroconvection and radiation, affect the spread of fires across a landscape. The project combines mathematical modelling, numerical simulation and fire experimentation at laboratory and landscape scales.

AUTHORS

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SUMMARY

This pioneering project is developing the first, two-dimensional fire simulation model that can operate in faster than real time, while incorporating intrinsic, fire line dynamics. Fires that burn in close proximity can influence each other due to pyroconvective interactions between individual fires. The same processes can apply to different parts of a single fire line.

Above: AN EXPERIMENTAL SEPARATED V-SHAPED FIRE CONDUCTED IN THE CSIRO PYROTRON. PHOTO: ANDREW SULLIVAN, CSIRO

A typical example is when intense spotting causes many fires to form and coalesce. Interactions between individual spot fires and other parts of the main fire perimeter can increase local rates of spread, in unexpected directions, potentially producing broad, flaming zones that can entrap firefighters, and increase the likelihood of extreme bushfires.

By combining advanced mathematical modelling with laboratory and numerical experimentation, this research is providing insights into the physical drivers of these interactions. In particular, it elevates the critical role of pyroconvective interactions in many aspects of fire propagation. These findings are the basis of computationally efficient modelling techniques that enable pyroconvective effects and dynamic fire behaviours to be included in two-dimensional, fire spread simulators. More cost-effective than current simulators, they could ultimately help protect firefighters, communities at risk and property.

CONTEXT

Current operational fire simulation methodologies cannot account for dynamic modes of fire propagation (see definitions, page two) that are driven by complex interactions between the fire and the local atmosphere. Nor can they explain basic fire spread patterns, such as the observed parabolic rounding at the head of a wind-driven fire line. This project is developing modelling techniques that address these shortcomings.

BACKGROUND

Fire behaviour in dry eucalypt forests in Australia is characterised by spot fires – new fires ignited by the transport of burning debris, such as bark, ahead of an existing fire. This also applies to many other vegetation types, but to a lesser extent. Under most burning conditions, spot fires have little influence on the overall spread of a fire, except where spot fires can overcome hurdles, such as topography or breaks in fuel (vegetation). However, in severe bushfires, spot fires can become the dominant propagation mechanism – the fire spreads as a cascade of spot fires that forms a 'pseudo' front, way ahead of the main fire front.

It is well known that multiple, individual fires can affect the behaviour and spread of all fires present. Similarly, different parts of a single fire line can influence each other, particularly when the fire line develops certain geometric configurations. In such

instances, fire spread is driven by the combination of extrinsic influences, such as wind and terrain, and intrinsic effects that arise when different fires or different parts of a fire interact through pyroconvective (and other) processes (see definitions). In some cases, intrinsic effects can become significant and result in distinctly dynamic modes of fire propagation, such as occur in junction fires, for example, where fires meet and merge.

These dynamic modes violate an assumption behind all existing operational fire behaviour models – that fires spread at a quasi-steady rate. These operational models also assume that different fires, or different parts of a single fire line, essentially burn independently; this neglects any potential influence of intrinsic effects. These models cannot account for potential dynamic interactions, which may significantly influence the spread of a fire. The inability to accurately predict fire behaviours can place firefighters at risk and hinder effective warnings to the general public.

Some aspects of dynamic fire behaviour can be modelled using coupled fire-atmosphere models, but these models are too expensive for operational use. To meet this operational need, this research is developing computationally efficient, two-dimensional, fire-simulation methods, an innovation which, for the first time, can account for key, intrinsic dynamics of fire propagation.

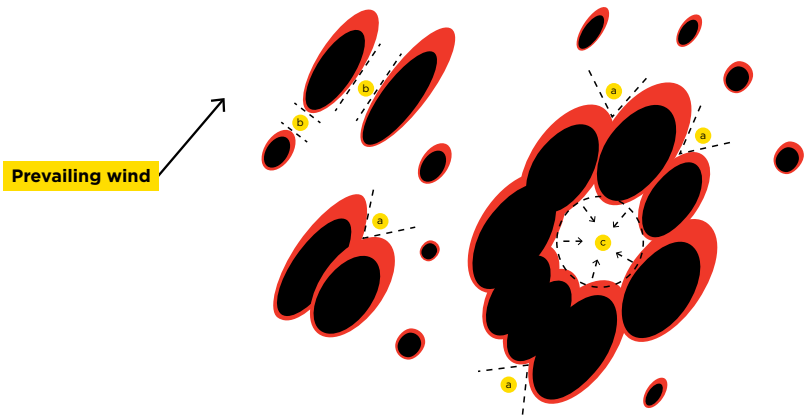


Figure 1: SCHEMATIC REPRESENTATION OF COALESCING SPOT FIRES AND THE DIFFERENT FORMS OF FIRE LINE INTERACTION BETWEEN INDIVIDUAL SPOTS. EXAMPLES OF FIRE LINE INTERACTIONS INCLUDE (a) INTERSECTING OBLIQUE LINES, (b) NON-INTERSECTING CONVERGING FIRE EDGES, AND (c) COLLAPSING OR CONSTRICTING PERIMETERS.

DEFINITIONS

Coalescence	The process of how nearby fires converge together.
Curvature	The degree to which a curve deviates from a straight line. In the case of fire, it is how curved the fire front is.
Dynamic fire propagation	Fire spread that abruptly changes its rate and intensity, without any significant changes in ambient environmental conditions.
Pyroconvection	The buoyant movement of fire-heated air, as distinct from normal atmospheric convection that mainly arises from solar heating and produces effects such as thermal winds, atmospheric instability and thunderstorms.
Quasi-steady rate of spread	A fire spreading from a point-source origin will increase its rate of forward spread until such time as an equilibrium state is reached, or in other words, until it reaches a more or less constant spread rate for the prevailing conditions.
Vorticity	The rotational component of the movement of a fluid such as air; for example, a fire whirl has a high degree of vorticity.
Vorticity-driven lateral spread (VLS)	A mode of dynamic fire behaviour – fire rapidly propagates across a steep, leeward slope in a direction nearly perpendicular to the wind direction.

BUSHFIRE AND NATURAL HAZARDS CRC RESEARCH

This project treats a spreading fire as an evolving interface between burnt and unburnt ground. Previous research has also investigated this, but the methods used often encountered difficulties when fire lines merge or when isolated pockets of unburnt vegetation remain, which typically occur when spot fires coalesce (see Figure 1, above right). A methodology that can successfully deal with these complexities is crucial – which is why researchers chose to use the level set methodology.

The level set method forms the basis for the development of efficient propagation models that use physically simplified proxies to account for complicated dynamic effects. To develop the model, the research team is conducting a series of experiments using the CSIRO Pyrotron facility.

These experiments target specific fire line configurations, such as:

- Parallel fire lines
- V-shaped 'junction' fires
- Ring fires
- Multiple spot fires.

These laboratory experiments were also complemented by field experiments conducted in Portugal by international collaborators, under the auspices of the Portuguese Foundation for Science and Technology's *Project firewhirl: vorticity effects in forest fires*.

Numerical simulations using coupled fire-atmosphere models also provided detailed data on the physical mechanisms driving intrinsic fire dynamics, and a better understanding of their scale dependence. Numerical simulations also yielded insights into ember transport dynamics, including the effect of terminal velocity assumptions on ember fall distributions. Overall, these simulations inform development of an end-to-end model for spot fire development, which can account for dynamic fire propagation.

RESEARCH FINDINGS

The research has highlighted the critical role that pyroconvective interactions play in many aspects of fire propagation. For example, it has discounted radiative heat transfer as the main driver of the local increase in rate of spread associated with junction fires — the observed effects were able to be accurately modelled using pyroconvective interactions alone. It has also highlighted the complex role that pyrogenic vorticity has in dynamic fire propagation.

Pyroconvective interactions can

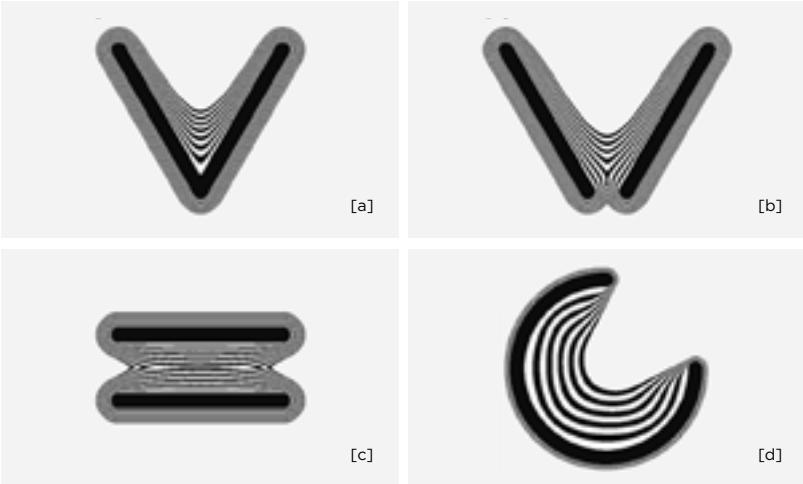
significantly affect fire behaviour — even in very basic patterns of fire spread, such as a line fire being driven by a uniform wind. The familiar 'parabolic head' shape that develops at the fire front is due to differences in the pyroconvective indraft along the fire line. Fire spread simulators now used operationally in Australia don't account for pyroconvective interactions, and cannot accurately model the development of a basic, straight-line fire.

To address these types of shortcomings, this research initially attempted to model pyroconvective interactions using fire line curvature. Fire line curvature served as a good predictor of dynamic fire spread in some, but not all, cases. The research then considered a very simple idea – to treat each point on the fire line as an independent 'sink point' for horizontal air flow.

This means that each point along a fire line creates its own radially symmetric indraft wind, the strength of which is determined by the intensity of the fire at that point. Considering the fire line as a whole, the indraft effects created by each of the individual points combine to produce an overall indraft wind, which is referred to as the 'pyrogenic flow'; that is, the flow of air created by the fire itself. This pyrogenic flow can then be added to the ambient wind flow to more accurately model the spread of the fire. This model is called the pyrogenic potential model, due to its similarity to models for determining the electrostatic potential of an array of electric point charges.

In effect, the pyrogenic potential model is a highly simplified, coupled fire-atmosphere model. The influence of the pyrogenic flow depends critically on the geometry of the fire line (for example, see Figure 2, above right). For certain configurations, the pyrogenic flow locally increases the rate of spread of certain parts of the fire line. For example, in a junction fire it produces the rapid advance of the point of intersection, as has been observed in experiments and numerical simulations (Figures 2a and 2b, above right). The pyrogenic flow causes two straight parallel fire lines to 'draw in' towards each other (Figure 2c, above right) and accounts for the higher rates of spread encountered as a closed arc of fire collapses upon itself (Figure 2d, above right).

Ongoing research will continue to develop the pyrogenic potential model. For example, the model was recently extended to account for other near-field effects, such as localised sources of vertical vorticity (see definitions). This has provided a way to model complex modes of dynamic fire propagation, such as vorticity-driven lateral spread (see definitions). VLS is highly efficient at triggering zones of deep and widespread flaming, consisting of many coalescing spot fires. This can increase the likelihood of pyrocumulonimbus (fire-thunderstorm) development.



▲ Figure 2: EXAMPLES OF OUTPUT FROM THE PYROGENIC POTENTIAL MODEL FOR DIFFERENT INITIAL FIRE LINE GEOMETRIES: (a) JUNCTION FIRE (V-SHAPED FIRE); (b) SEPARATED V-SHAPED FIRE; (c) TWO PARALLEL FIRE LINES; (d) A CLOSED (270°) ARC. THE BLACK AND WHITE BANDING INDICATES THE SPREAD OF THE FIRES OVER EQUALLY SPACED POINTS IN TIME, SO THICKER BANDS CORRESPOND TO RELATIVELY HIGHER RATES OF SPREAD.

These state-of-the-art, near-field models are easily applied in fire simulation models such as Spark. As such, this research offers fire managers and fire behaviour analysts a world-first ability to model landscape-scale, fire spread, incorporating dynamic fire behaviours, using a faster than real-time simulator.

HOW IS THE RESEARCH BEING USED?

The recognition that fires can mutually influence each other's spread has been used in various contexts, such as prescribed burning and back burning. This research provides a theoretical basis for such practises, enabling a more quantitative understanding of their effects.

By accounting for pyroconvective interactions between different fires or different parts of a fire line, this research improves the estimation of the overall power of a fire. When combined with research into the atmosphere's role, it can alert forecasters to a fire's likelihood of transitioning into a more extreme event, such as a pyrocumulonimbus storm. This could better inform burning operations and help to avoid unexpected fire blow-ups. It could also prevent repeating past mistakes, where backburns have been started with good intentions, but unfortunate outcomes.

This research has improved the understanding of the dynamics of how fires spread, including insights into the relative importance of convective heat transfer compared to radiative heat transfer. This knowledge is critical for fully understanding fire spread and to further development in areas such as building codes for bushfire-prone areas.

Ultimately, the research enables the modelling of key aspects of fire behaviour that was previously only possible using computationally expensive, coupled models. The near-field techniques that

END-USER STATEMENT

"Using a multi-streamed approach, including laboratory experiments, coupled fire-atmosphere physical modelling and simplified analogue modelling, this project has demonstrated the feasibility of using computationally efficient approaches as a proxy for more costly approaches to modelling dynamic fire behaviours, such as the effect of mass-spotting upon peak fire power and rates of spread. Investigation toward incorporating this work into trial operational models and training is both progressing and very promising. This exciting work is directly relevant to strongly enhancing our understanding and predictive capacity in terms of dynamic fire behaviours."

– Brad Davies, Fire Behaviour Analyst, NSW Rural Fire Service

form the pyrogenic potential model allow complex modes of fire propagation to be simulated within operational time frames.

The research team is discussing the potential uses of the research with end-users.

These potential applications include:

- The capacity to more accurately predict dynamic fire behaviours
- Better training materials that give firefighters a more complete understanding of fire behaviour potential
- Equipping fire behaviour analysts with technological tools to help them assess the likely progression of bushfires and the potential for their escalation.

CASE STUDY: FIREPOWER

The pyrogenic potential model has been used to investigate the effect of dynamic fire line interactions on the peak power generated by many, coalescing, spot fires. Figure 3 shows 25 simulated spot fires that have been allowed to spread. Interaction between spot fires creates localised regions of intense fire spread, which accumulate to produce higher peak fire power, with stronger coupling between separate fires producing higher intensities.

These results indicate that during mass spotting, fire line interactions can increase the power output of a fire complex. This increases the likelihood of violent pyroconvection and pyrocumulonimbus development.

FUTURE DIRECTIONS

The most compelling challenges ahead include:

- Using targeted experimentation and numerical simulation to investigate how the parameters defining the pyrogenic potential model scale across different fire sizes.
- Developing techniques for near-field modelling of modes of fire propagation driven by pyrogenic vorticity, such as VLS. This will combine research jointly funded by the Bushfire and Natural Hazards CRC and the Australian Research Council.
- Developing an end-to-end model for spot fire formation and coalescence.

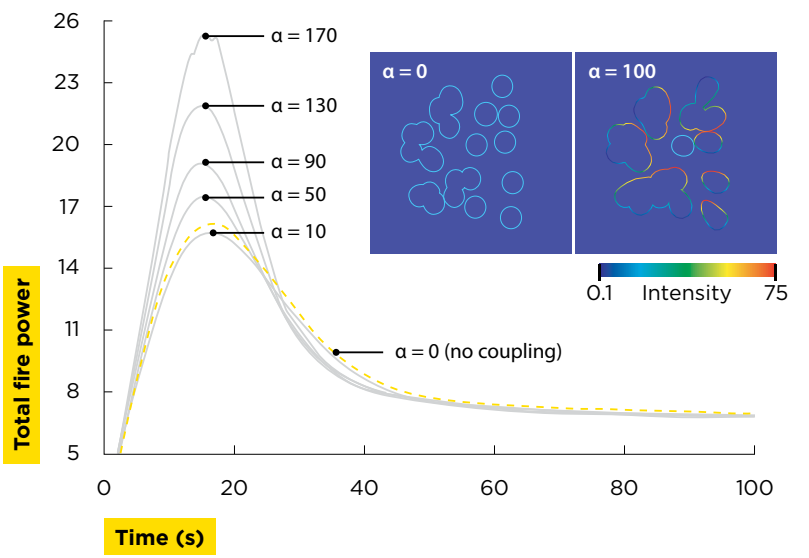


Figure 3: TOTAL (NON-DIMENSIONAL) FIRE POWER EMANATING FROM 25 COALESCING SPOT FIRES, MODELLED USING THE PYROGENIC POTENTIAL MODEL WITH DIFFERENT DEGREES OF COUPLING, PLOTTED AGAINST TIME SINCE IGNITION. NOTE THAT HIGHER VALUES OF THE PARAMETER α CORRESPONDS TO STRONGER COUPLING BETWEEN ADJACENT FIRES. THE DASHED LINE (α=0) CORRESPONDS TO THE CASE WHERE THERE IS NO INTERACTION BETWEEN ADJACENT FIRES. THE COLOURED INSET SHOWS THE EVOLUTION OF THE SPOT FIRES 15 SECONDS AFTER IGNITION WITHOUT COUPLING (α=0) AND WITH COUPLING (α =100). IT CAN BE SEEN THAT PYROCONVECTIVE INTERACTIONS BETWEEN THE DIFFERENT FIRES RESULTS IN LOCAL ENHANCEMENT OF THE RATE OF SPREAD AND INTENSITY OF THE FIRE. THE FIGURE HAS BEEN ADAPTED FROM HILTON *ET AL.* (2017).

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The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

HAZARD **NOTE**

bushfire&natural HAZARDSCRC

ISSUE 58 FEBRUARY 2019

TOPICS IN THIS EDITION | COMMUNICATION | COMMUNITIES | FIRE | WARNINGS

BLACK SATURDAY TEN YEARS ON – WHAT DID WE DISCOVER?

SUMMARY

It has been ten years since Australia's most deadly bushfire, in which 173 people lost their lives and thousands of houses were destroyed. Like Black Friday, Ash Wednesday and other catastrophic bushfires in Australia's history, the lessons from Black Saturday, 7 February 2009, are still resonating today. This *Hazard Note* highlights the key findings of the Bushfire CRC report *Victorian 2009 bushfire research response*. This research was supported by a substantial database of scientific observations, photographs and interviews, and the findings led to the second stage of research by the Bushfire CRC (2010 to 2014), which investigated the issues arising from the Black Saturday bushfires in depth.

Above: WITH SOME FIRES STILL BURNING, RESEARCHERS QUICKLY BEGAN LOOKING INTO THE FACTORS THAT TOOK THE LIVES OF 173 PEOPLE. PHOTO: DAVID BRUCE, BUSHFIRE AND NATURAL HAZARDS CRC

BACKGROUND

Less than 48 hours after the bushfires began, a group of researchers from various state fire agencies and research organisations was assembled by the Bushfire CRC to look at key issues arising out of the fires.

The purpose of the research was to provide the Australian fire and land management agencies with an independent analysis of the factors surrounding the fires. The research focused on three aspects – fire behaviour, human behaviour, and building and planning issues. Three research teams looked at the impacts of a sample of fires in order to gain a broader understanding of all the fires.

In one of the largest post-hazard studies ever undertaken, the research task force assessed more than 1,300 homes, interviewed more than 600 residents and took more than 21,000 photographs.

FIRE BEHAVIOUR

Key findings

Researchers considered which fires were ordinary or extreme, and which were extraordinary; that is, exhibiting fire behaviour outside known experience. They found that ember spotting – the distance that an ember can travel in the wind – was an influential factor in the progression of the fire. Some spotting was recorded as reaching more than 30 kilometres in front of the main fire, exacerbated by wind gusts that reached up to 100 km/h.

The fire behaviour models under-predicted the speed that the fires spread, with a key recommendation suggesting that further work was required to understand the detailed progression of the fire across the landscape. The research team also measured and compared the intensity of the Black Saturday bushfires with other similar fires, including Black Friday in 1939 and Ash Wednesday in 1983, to determine the differences in vegetation, humidity and conditions.

Since 2009, much research has gone into fire spread simulators, with researchers working alongside fire operations personnel to improve modelling accuracy. In turn, this has enabled agencies to issue more informed emergency warnings for the safety of firefighters and communities. When the predicted path of a fast-moving bushfire places a community or firefighting resources in great potential danger – specific warnings can be immediately enacted, firefighting resources redirected, and the safety of all those in the fire path can be ensured.

Current Bushfire and Natural Hazards CRC research is building on this by investigating extreme bushfire behaviour further, including how bushfires influence weather, as well as create their own; how spot fires impact bushfire spread; how to detect fires quickly using satellites; developing satellite-based tools to assess how dry vegetation is and if it will burn in a bushfire; and informing the first major update to the fire danger rating system since the 1960s.

HUMAN BEHAVIOUR

Key findings

Key human behaviour issues examined included planning and preparedness; information and warnings; intentions and actions. Many people were not prepared for the severity of the fires; most only took last-minute measures on the day to combat the fire threat.

Several weak links resulted in a lack of planning and preparation and affected people's ability to implement their fire plan. Many residents waited to assess the severity of the bushfires before deciding whether to stay or go. They identified public buildings, ovals and facilities with emergency services as relatively safe places of refuge during the bushfires.

Over the last ten years, fire agencies have adapted their community engagement approaches. They now place emphasis on the reality that the safest place to be is away from the fire, and that under severe weather conditions, defending a house from a bushfire will be impossible.

CRC research continues to uncover better ways to warn communities under threat as identified in the Black Saturday report. Science is identifying not just the limitations of current warnings and emergency information but helping to construct a new language that has impact and elicits the desired response. In recognition of the complexities involved in community warnings, CRC research has helped emergency managers and community groups incorporate planning for animals – both pets and livestock – and continues to influence the development of children's bushfire education across the country.

BUILDING AND PLANNING

Key findings

The level of detail in house design, building quality and the age of the property were all considered to be crucial factors that contributed to the likelihood of house loss during the fires.

In all, 2,029 houses were destroyed during the Black Saturday fires. This included houses further than 380 metres away from continuous bush. Brick houses were more fire-resistant than mud brick and light-weight construction clad with timber or cellulose cement sheet, while vegetation overhanging or immediately adjacent to houses, either isolated or continuous, was a key factor influencing the likelihood of house loss. Metal and concrete water tanks were more likely to maintain an effective water supply for house defence compared to polyethylene and fibreglass tanks, while the design, location and degree of protection of water pumps and piping were important factors in maintaining an effective water supply.

Soon after 2009, this research informed new building standards that were strengthened to account for fires at the most extreme. The changes made to Australian Standard 3959 ensure that new buildings in bushfire prone areas are safer and more likely to survive during a fire. CRC scientists are now working with urban planners to mitigate risk across wider geographical areas in the design and management of communities as they expand into potentially hazardous zones.

A FOUNDATION FOR FUTURE STUDIES

The themes covered in the *Victorian 2009 bushfire research response* research report remain points of concern for fire and land agencies, governments and planning authorities today.

The Bushfire and Natural Hazards CRC continues to play an active role in research after major fires and other natural hazards, particularly in preparedness, warnings and mitigation strategies for hazard-prone communities. These post-event studies are highly valued by CRC partners and are an effective way to gather important data.

Since 2009 many studies have been undertaken, each building on previous research that has combined to create an invaluable long-term database for emergency policy makers and other researchers. This includes data collected after major bushfires in Western Australia in 2011 and 2014 (Department of Fire and Emergency Services), New South Wales in 2013, 2017 and 2018 (NSW Rural Fire Service), South Australia in 2014 and 2015 (Country Fire Service), and Tasmania in 2013 (Tasmania Fire Service). Fire and Rescue NSW also received additional insights into the effectiveness of equipment and training provided to their community fire units during the Blue Mountains bushfires in 2013. Research for the Queensland Fire and Emergency Services after 2015's Severe Tropical Cyclone *Marcia* investigated how the cyclone would impact vegetation for the following fire season and beyond.

The report *Victorian 2009 bushfire research response* and all other post-event studies are available online at the websites of the Bushfire CRC and the Bushfire and Natural Hazards CRC.

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HAZARD **NOTE**

bushfire&natural HAZARDSCRC

ISSUE 55 NOVEMBER 2018

TOPICS IN THIS EDITION | FIRE IMPACTS | FIRE SEVERITY | FIRE WEATHER

SOUTHERN AUSTRALIA SEASONAL BUSHFIRE OUTLOOK 2018-19: NOVEMBER

▲ Above: AREAS BASED ON INTERIM BIOGEOGRAPHIC REGIONALISATION FOR AUSTRALIA AND OTHER GEOGRAPHICAL FEATURES.

OVERVIEW

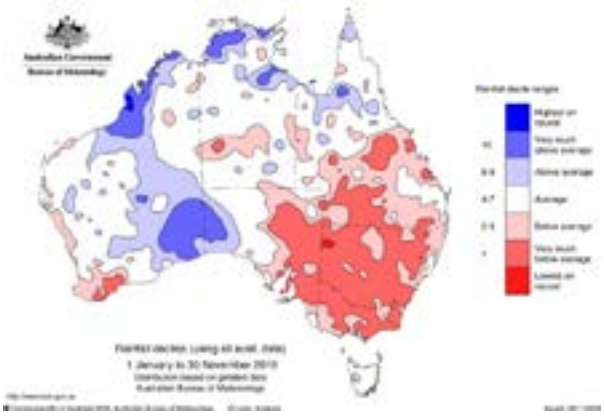
Above normal fire potential remains across large parts of southern Australia, as first identified in September's *Southern Australia Seasonal Bushfire Outlook 2018 (Hazard Note 51)*. Rain in areas of eastern Australia during spring, while welcome, was not enough to recover from the long-term dry conditions. Wet conditions currently being experienced across coastal New South Wales will help, but it will not take long once heat and dry conditions return for vegetation to dry out. For example, the April-to-November period has seen Queensland record the ninth driest and fourth hottest period on record, New South Wales the eighth driest and fourth hottest period on record, and Victoria the 13th driest and seventh hottest period on record. These conditions have resulted in the expectation of above normal fire potential across large parts of Queensland, New South Wales, the ACT, Victoria, Tasmania, South Australia and Western Australia.

ANTECEDENT CONDITIONS

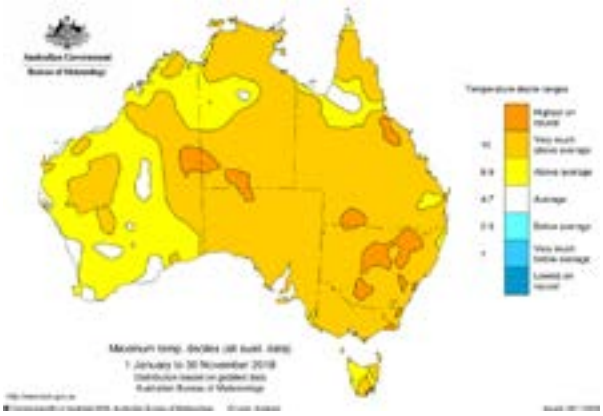
The year-to-date has been unusually warm and dry for large parts of southern and eastern Australia (Figure 1, page 2). The focus of the dry conditions has been New South Wales, where almost the entire state has experienced rainfall in the lowest decile (driest 10% of recordings). This represents serious to severe rainfall deficiencies. Rainfall deficiencies also affect most of northern and eastern Victoria, parts of southern and central Queensland, eastern South Australia and southern Western Australia. Across southern Australia above average rainfall is limited to the arid regions of western South Australia and adjacent parts of Western Australia, as well as small parts of western Tasmania.

In some contrast, October and November have seen near average rainfall at many locations. This rain has not been sufficient to remove the large negative rainfall anomalies which accumulated earlier in the year; it will take a number of months of above average rainfall to remove the deficiencies, meaning that general landscape dryness is likely to persist for many areas for some months.

The warming trend means that above average temperatures now tend to occur in most years, and 2018 has followed this pattern. Temperatures in Australia for the year-to-date have been very much warmer than average, with 2018 likely to finish amongst Australia's 10 warmest years on record. The overall mean temperature for January to November is currently tracking third-warmest on record for Australia (0.95 °C above the 1961–1990 average, Figure 2, page 2). Maximum temperatures have been particularly warm, tracking second-warmest on record for January to November (1.35 °C above average).



▲ Figure 1: PRELIMINARY JANUARY TO NOVEMBER 2018 RAINFALL DECILES.



▲ Figure 2: PRELIMINARY JANUARY TO NOVEMBER 2018 MAXIMUM TEMPERATURE DECILES.

These high temperatures add to the impact of reduced rainfall and increase evaporation further drying vegetation.

As might be expected given the broad climatic factors, spring saw elevated fire danger for much of Australia, with several significant bushfires. The dry landscape means that any warm windy conditions are likely to see elevated fire risk. Countering the climate signal, poor growth of grass and annual plants means that vegetation loads are reduced in drought-affected areas. Recent rainfall has not been significant enough to drastically change the vegetation (fuel) loads, with many southern and eastern areas already cured or carrying little grass growth.

Fire season severity is increasing across southern Australia as measured by annual indices of the Forest Fire Danger Index (FFDI). The increases are tending to be greatest in inland eastern Australia and coastal Western Australia. For example, the Victorian annual FFDI has increased by about 50% since 1950, with particularly high values during the severe fire seasons of 2002/03, 2006/07, 2008/09 and 2015/16. The increases reflect rising temperatures and below average rainfall during the cool season (April to October).

Ocean temperatures in the tropical Pacific now exceed El Niño thresholds, but tropical winds, cloudiness, air pressure and broadscale patterns of rainfall are yet to reach El Niño levels, suggesting that the ocean and atmosphere are not yet coupled (i.e., yet to have formed a feedback). Coupling is required to drive widespread global and Australian impacts. As a result, the Bureau of Meteorology's El Niño-Southern Oscillation Outlook remains at El Niño ALERT. El Niño ALERT means there is approximately a 70% chance of El Niño forming in 2018; about triple the normal chance. International models suggest that ocean conditions are likely to remain above El Niño thresholds for the coming months, suggesting that coupling will occur late in the year. El Niño impacts in Australia over summer typically include higher fire risk, a greater chance of heatwaves and fewer tropical cyclones.

A positive Indian Ocean Dipole (IOD) has affected Australia in 2018, acting to reduce rainfall. However, climate model outlooks suggest it will decay by early summer, consistent with its natural decay cycle. A positive IOD during spring typically increases the chance of below average rainfall for southern and central Australia, and has been linked to higher summer fire danger in southern Australia. The IOD typically has little direct influence on Australian climate from December to April.

CLIMATE OUTLOOK

The climate outlook for the coming three months of summer is mainly influenced by the Pacific and Indian Oceans, together with other factors including long-term trends.

The outlook for summer rainfall (Figure 3, page 3) shows a mixed signal across Australia. The expected decline in the positive IOD by early December, and a forecast for high pressure systems to be further south than usual in the Tasman Sea, means that probabilities in south eastern Australia generally sit near 50%. Below average rainfall is favoured in tropical Australia, and particularly so in north eastern parts. Most of Queensland has above median rainfall probability of in the range of 25-40%. Historical outlook accuracy for December to February is moderate across western and northern Australia. Elsewhere, accuracy is low to very low.

The outlook for summer maximum temperatures favours above average daytime temperatures for nearly all of Australia. Probabilities are particularly high in northern and western areas where they widely exceed 80%. Probabilities in the south are typically in the range of 60-80% (Figure 4, page 4). The outlook for minimum temperatures (not shown) is similar to that for maximum temperatures, with above average temperatures favoured across almost all of Australia and probabilities widely above 80% in the tropics. Historical accuracy for December to February maximum temperatures is moderate across most of Australia, but low in the eastern Northern Territory, western Queensland, and southern South Australia. Minimum temperature accuracy is moderate for most of Australia, except the central Northern Territory, central to northern parts of Queensland, and along the South Australia eastern border, where accuracy is low to very low.

Updates to climate forecasts and the outlook for the IOD and the El Niño-Southern Oscillation will continue to be published at www.bom.gov.au/climate/ahead.

DEFINITION

Bushfire potential: The chance of a fire or number of fires occurring of such size, complexity or other impact (such as biodiversity or global emissions) that requires resources (from both a pre-emptive management and suppression capability) beyond the area in which it or they originate. Fire potential depends on many factors including weather and climate, fuel abundance and availability, recent fire history and firefighting resources available in an area.

REGIONAL SUMMARIES

QUEENSLAND

Below average rainfall and above average temperatures have been experienced across much of the state in 2018, with similar conditions forecast for the coming months. With Queensland currently experiencing severe bushfires in several locations, above normal fire potential is expected to continue until substantial rainfall is received. This above normal fire potential takes in the areas identified in September's *Southern Australia Seasonal Bushfire Outlook 2018* – south east Queensland and the Coral Coast north to Capricornia.

NEW SOUTH WALES

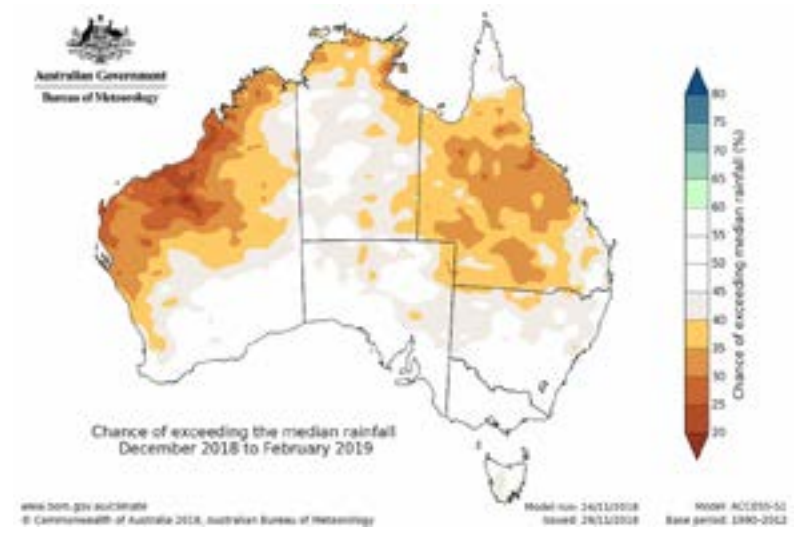
The potential for above normal fire activity in forested areas remains along the NSW coast and to the west of the divide. In the west, this is due to the continuation of prolonged rainfall deficits and the likelihood of warmer than average temperatures.

Rain in coastal areas during spring saw soil moistures recover to average levels, however this benefit is expected to be short-lived due to predicted warmer than average temperatures over summer. For this reason the east coast of NSW has above normal fire potential, as first identified in September in the *Southern Australia Seasonal Bushfire Outlook 2018*. The fire potential will be highest in mid-to-late summer.

There has been some spring growth in grasslands west of the divide, however vegetation (fuel) loads continue to remain at or below average levels. Curing rates in grasslands are expected to increase with the onset of hot dry conditions over coming months. Fire potential in these areas is expected to be normal.

ACT

Although the ACT has received some useful rain over the last month, a high level of drought remains for this time of year. Recent benign conditions have reflected a pool of warm sea surface temperatures in the Tasman Sea, which has favoured the development of rain-bearing low pressure cells near south east Australia. It is not expected that this situation will persist and, under the influence of El Niño and the IOD, warmer weather and a dry landscape should characterise the season ahead. ACT grasslands have shown poor growth over spring, and it is expected that curing will rise quickly when hot weather returns. Bureau of Meteorology hydrological modelling, drought indices and stream flow data all indicate a significant water deficit. This causes high availability of fine forest fuels, as seen in recent fire activity. The latest climate outlook suggests both above average temperatures and around average rainfalls – insufficient to relieve the current drought level. It is expected that above normal fire potential will continue in the ACT, along with the continued occurrence of heat and dust, which will contribute to a challenging summer and reinforce the need for the community to be fully prepared.



▲ Figure 3: THE OUTLOOK FOR SUMMER (DECEMBER TO FEBRUARY) RAINFALL.

VICTORIA

Much of East Gippsland has experienced two consecutive years of record low rainfall during autumn, winter, and below average rainfall in spring. As a result, forests are significantly more flammable than normal due to an increase in dead material in the near surface and elevated fuels. Unusually early bushfire activity occurred in East Gippsland during July and August, highlighting the severe level of dryness in forests. These dry conditions are likely to be exacerbated during summer with the climate outlook for average rainfall and above average temperatures resulting in above normal evaporation rates. These areas can expect above normal fire potential this season, as first identified in September in the *Southern Australia Seasonal Bushfire Outlook 2018*. Further north, the Great Divide and Alpine regions experienced above average snowfall, but the current seasonal streamflow forecast indicates below average stream flows are likely for summer. As a result, normal bushfire potential is expected across these regions. In the west and central regions, normal bushfire potential is also expected as infrequent rain has kept soil moisture within the range commonly experienced during spring. There is uncertainty around how much dryness may carry over from previous seasons, as well as how quickly warm and dry conditions expected in summer may increase flammability in forests. The far South West region, extending to the Barwon Otway region, experienced above average rainfall in July, which has led to saturation in the soil moisture profile. August to October was drier than normal in these areas, and November close to average. The timing and severity of grass fires will depend strongly on patterns of wind and relative humidity during summer, and as a result, a normal fire season is expected in these areas. North and north western Victoria have experienced below average rainfall this year, resulting in reduced cropping activity and pasture growth. These areas are likely to experience a normal fire season. It should be noted that due to the uncertainties in the longer-term climate outlook, areas of normal fire potential may still experience unpredicted severe bushfire activity during late summer.

TASMANIA

The fire season has commenced in the east and south of the state. However recent rains have eased the strong drying trend seen during late winter and spring. As a result, the majority of Tasmania has fuel moisture levels close to normal for early summer, apart from King Island, Circular Head and the far south east.

HAZARD **NOTE**

Only a relatively short drying period is needed to return the eastern coastal strip to dangerously dry conditions, and so the strip between Dunalley and St Helens is now regarded as having above normal fire potential. This area has extended south since September's *Southern Australia Seasonal Bushfire Outlook 2018*. Fire activity in the period up to the end of December should be relatively normal across Tasmania, and rain during that time will determine where fires will occur after grasslands have cured.

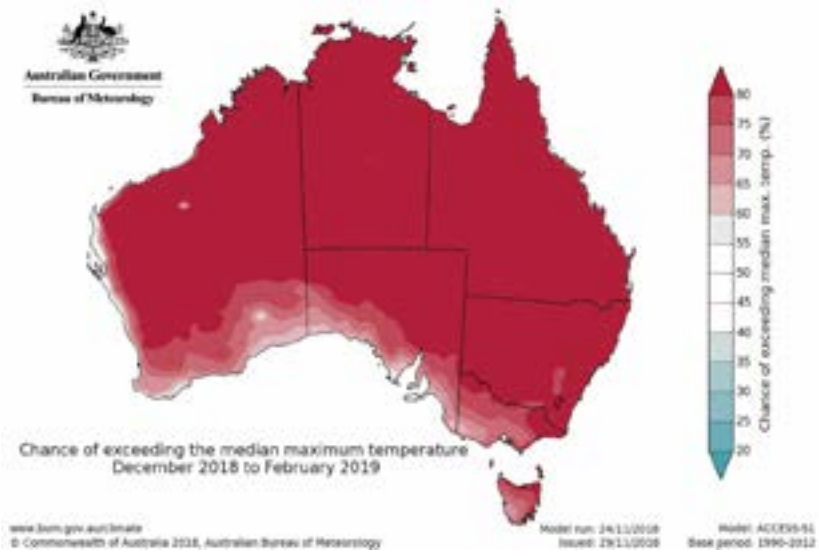
SOUTH AUSTRALIA

Large parts of South Australia have experienced drier than average conditions since the start of 2018. On the basis of the forecast dry conditions, and the cumulative effects of the long-term moisture deficit, the underlying dryness remains, despite some recent rainfall in several areas. The areas identified in September in the *Southern Australia Seasonal Bushfire Outlook 2018* remain as having above normal fire potential. These areas are particularly dry, including parts of the Riverlands, Murraylands and the Flinders Ranges.

Populated areas of the APY Lands, particularly those parts infested with buffel grass, also have above normal fire potential, with a number of fires already occurring this season. Without effective control mechanisms to limit the spread of buffel grass, the abundance of fuel it creates could create an increased and ongoing risk.

Despite some spring rainfall, the fuel growth and forecast dry conditions indicate that the potential for bushfire across the populated areas of the Mount Lofty Ranges remains.

The dry conditions in agricultural areas have resulted in less cropping activity, with South Australia forecast to record a decrease in areas planted and in yields from sown crops. This may reduce the risk of fires from agricultural activity in some areas. Due to the conditions already experienced, the fire danger season has already commenced in the majority of districts across the state, and may need to be extended. Significant bushfires have occurred in similar conditions, and areas of normal fire potential can expect to experience dangerous bushfires as per a normal South Australian fire season.



▲ Figure 4: THE OUTLOOK FOR SUMMER (DECEMBER TO FEBRUARY) MAXIMUM TEMPERATURES.

WESTERN AUSTRALIA

As a result of bushfires in previous seasons, and mitigation achieved by prescribed burning, higher fuel loads in the forests and shrublands across the Darling Range have been fragmented into smaller parcels. This has resulted in the break-up and reduction of above normal fire potential areas within the Swan Coastal Plain, Avon Wheatbelt, Jarrah Forest, and Warren regions.

Despite good winter rainfall, the underlying and persistent deep root zone soil moisture deficits along the Darling Range, south west corner, South Coast, Mallee and Esperance Plains have resulted in the forest and shrubland vegetation in these areas being subject to additional water stress. Rainfall has been below normal during September, October and November. As first identified in September in the *Southern Australia Seasonal Bushfire Outlook 2018*, above normal fire potential is expected to persist in these areas.

Further north, cooler and wetter wet season conditions were experienced in parts of the Pilbara, Gascoyne and Carnarvon regions in 2017-18, which contributed to the accumulation of higher than average grass fuel loads. This has resulted in above normal fire potential in these regions, again as first classified in September in the *Southern Australia Seasonal Bushfire Outlook 2018*. Rainfall for these areas is expected to be below average, and temperatures above average for the coming months, which may see above normal fire potential persist for longer than average in these regions.

The Gascoyne Coast missed the subtropical low rainfall which travelled further to the east, and as a result is experiencing a rainfall deficit. This has affected grass growth and therefore the region is expected to experience normal fire potential.

Parts of south eastern Western Australia received significant rain in the early part of 2018, which is evident in the elevated surface soil moisture in some areas. This has led to increased growth of the shrubs and grasses in these areas. Due to this increased vegetation growth, and therefore expected fuel loads, above normal fire potential is expected in these parts of the Mallee, Coolgardie, Nullarbor, Hampton and Great Victoria Desert regions, as noted in September's *Southern Australia Seasonal Bushfire Outlook 2018*.

The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

HAZARD **NOTE**

bushfire&natural HAZARDSCRC

ISSUE 53 OCTOBER 2018

TOPICS IN THIS EDITION | FIRE IMPACTS | FIRE SEVERITY | MODELLING

CAPTURING THE VARIABILITY OF WIND FOR MODELLING THE VARIABILITY OF BUSHFIRES

ABOUT THIS PROJECT

This research was part of a PhD study, *Statistical characterisation of wind fields over complex terrain with application in bushfire modelling*, which was part of the Bushfire and Natural Hazards CRC project *Fire spread prediction across fuel types*.

AUTHOR

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SUMMARY

Understanding uncertainty in fire modelling, and characterising predictions in terms of likelihood or risk, allows fire managers and emergency services to make more informed decisions. With the emergence of probabilistic fire modelling frameworks, where predictions capture multiple possible scenarios, it has become clear that to characterise the full extent of the uncertainty within bushfire prediction, the variability of input parameters must be accurately captured. In particular, the variability of wind has been shown to account for much of the variability in fire spread. By adopting a statistical approach, this study analysed the variability of wind direction and strength, working towards a statistical characterisation of wind over complex terrain. Better modelling of the uncertainty of wind can feed directly into fire spread models, allowing fire behaviour analysts and managers to make more informed decisions.

▲ **Above:** THE BENDORA FIRE, CANBERRA 2003, SHOWING THE WIND'S INTERACTION WITH THE COMPLEX TERRAIN CREDIT: LANNON HARLEY. SUPPLIED BY ACT EMERGENCY SERVICES AGENCY

CONTEXT

After 30 years of discussion, probabilistic approaches to fire modelling are emerging to tackle the issue of uncertainty. These approaches allow for random fluctuations in inputs and consider a range of fire prediction outputs in terms of likelihood, probability or risk. However, these approaches still rely on deterministic models or simplified assumptions; they are trying to capture the uncertainty of fire spread without capturing the variability of its drivers.

BACKGROUND

The spread of bushfires is highly sensitive to wind speed and direction, with sudden changes often resulting in drastic changes in the rate and direction of fire spread. Accurate estimation of wind across the landscape and over time is therefore a critical component of fire spread modelling. However, estimation of wind across rugged terrain is far from trivial. The complex interactions between prevailing winds and varying landscape features are often over-simplified within operational bushfire models due to computational constraints.

BUSHFIRE AND NATURAL HAZARDS CRC RESEARCH

This PhD research aimed to improve the understanding of wind through a statistical characterisation capable of complementing current modelling approaches; providing a more informed wind modelling framework for bushfire prediction.

A key issue in addressing this aim was the lack of wind data available. Data were collected across Flea Creek Valley, west of Canberra. This region was significantly impacted by the 2003 bushfires and wind

data had been collected in 2007, leading to questions of how vegetation regrowth might impact wind flow.

In 2015, data were also collected at the National Arboretum Canberra, allowing for a more controlled vegetation environment. Analysis from this study enabled a comparison of wind speed and direction over contrasting vegetation but similar topography, and varying topography but uniform vegetation.

RESEARCH FINDINGS

To analyse this data, new statistical techniques were needed to account for the circular nature of wind direction. Firstly, wind was considered in terms of directional wind response distributions. These distributions exhibit circular properties, but it was shown that simple data strategies could be adopted to account for this in analysis. These not only performed better than existing techniques, but are easily available for fire and land managers, not just mathematicians.

Statistical comparison of directional wind response showed that vegetation and topography had an interactive impact on wind. For example, post fire vegetation regrowth had a significant impact on wind direction across Flea Creek Valley, except on the valley floor where broader mechanisms dominated the wind flow. Equally, clear thresholds in vegetation and aspect were found for the generation of wind reversal regions at the National Arboretum Canberra.

The probabilistic representation of wind fields as directional wind response was used to evaluate an operational deterministic wind model in the context of ensemble-based fire modelling. It was shown that the application of this model can be adapted to capture the variability of wind direction observed across the landscape.

HOW COULD IT BE USED?

This research consisted of four key contributions to the scientific community. Firstly, two new wind datasets were collected across topography and spatial and temporal resolutions most relevant to significant surface fire behaviours. These datasets are now available for continuing research into wind dynamics in mountainous landscapes and varying vegetation.

Secondly, wind was recast in probabilistic terms to better suit emerging probabilistic fire modelling frameworks. Capturing wind behaviours in terms of likelihood enables the quantitative characterisation of risk throughout the fire modelling process.

Thirdly, new statistical comparison techniques were developed and used to formally identify areas of the landscape where topography and vegetation had significant impacts on windspeed and direction. This has significant implications for bushfire prediction where identified wind patterns have been consistently linked to extreme fire behaviour.

Finally, the evaluation of current wind models highlighted the potential for complementary use of physics-based deterministic approaches and statistical analysis to model uncertainty in wind. Better modelling of this uncertainty will feed directly into ensemble-based and stochastic fire models aiming to capture the uncertainty of the entire fire modelling framework, and provide managers and decision makers with as much accurate information as possible.

FUTURE DIRECTIONS

As with many PhD projects, this research asks many more questions than it answers. The data collected is available for further interrogation and analysis to aid the answering of numerous further questions. The new mathematical and statistical techniques introduced require further validation and analysis to ensure they are robust and ready for generalisation. Finally, the statistical analysis of wind and the wind models developed through this research provides the building blocks for statistical modelling of wind over complex terrain capable of complementing the currently operational wind models used for bushfire prediction.

DIRECTIONAL WIND RESPONSE

The directional wind response of the prevailing wind to changes in the landscape beneath it can be represented as the distribution of the observed prevailing wind direction and that measured at the same time on the surface within the landscape.

END-USER STATEMENT

"Firefighting in the ACT, like much of south east Australia, involves working in rugged terrain. We have long had a good understanding of how wind and slope can change the spread of a fire. However, we all have on occasions been caught out by a fire doing unexpected things. To avoid this we need a solid understanding of how the prevailing wind flow is altered by its interaction with terrain.

"It is only through the hard work of measuring winds in places that are difficult to get to that we have begun to know what to expect. Rachael's work provides tools to help us suppress bushfires safely and more effectively, and to light up hazard reduction burns with the least chance of problems occurring."

- Rick McRae, Risk Analyst and Fire Behaviour Analyst, ACT Emergency Services Agency

FURTHER READING

Quill R (2017), Statistical characterisation of wind fields over complex terrain with applications in bushfire modelling, PhD Thesis. School of Physical, Environmental and Mathematical Sciences, University of NSW Canberra

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HAZARD **NOTE**

bushfire&natural HAZARDSCRC

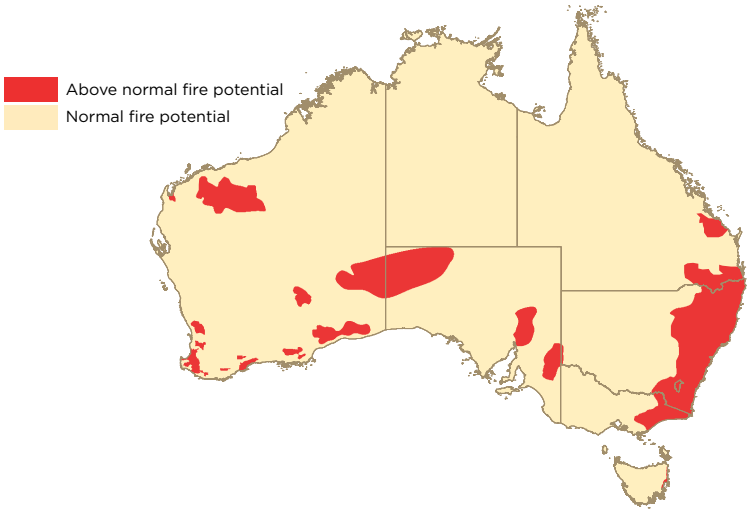
ISSUE 51 SEPTEMBER 2018

TOPICS IN THIS EDITION | FIRE IMPACTS | FIRE SEVERITY | FIRE WEATHER

SOUTHERN AUSTRALIA SEASONAL BUSHFIRE OUTLOOK 2018

OVERVIEW

The *Southern Australia Seasonal Bushfire Outlook* is used by fire authorities to make strategic decisions on resource planning and prescribed fire management for the upcoming fire season. At the 2018 Southern Seasonal Bushfire Assessment Workshop in August, the Outlook was assessed and a range of broad climate factors were considered. The map to the right shows the bushfire outlook for southern Australia through to the end of 2018. This map has been combined with the outlook for the northern Australia bushfire season, which was released in July, to show the areas of fire potential for all of Australia (see *Hazard Note* 49, July 2018).



▲ Above: AREAS BASED ON INTERIM BIOGEOGRAPHIC REGIONALISATION FOR AUSTRALIA AND OTHER GEOGRAPHICAL FEATURES.

ANTECEDENT CONDITIONS

Most of eastern and parts of south west Australia have experienced a dry 2018 to date (Figure 1, page 2). The focus of the dry conditions has been New South Wales, where almost the entire state has experienced rainfall in the lowest decile (driest 10 per cent of recordings), representing serious to severe rainfall deficiencies. Rainfall deficiencies also affect most of northern and eastern Victoria, parts of southern and central Queensland and eastern South Australia. Across southern Australia above average rainfall is limited to the arid regions of western South Australia and adjacent parts of Western Australia, as well as western areas of Tasmania. While August has seen some rainfall in drought affected inland areas, this has fallen well short of that required to remove the longer-term deficiencies which remain extensive.

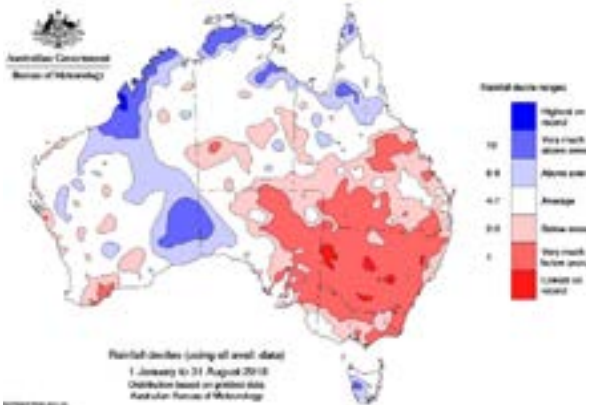
The combination of dry weather and the background warming trend has resulted in much warmer than average temperatures. Daytime maximum temperatures have been unusually warm in 2018, with a year-to-date maximum temperature anomaly of +1.36°C, the warmest on record (Figure 2, page 2). High daytime temperatures add to the impact of reduced rainfall, and act to increase evaporation, further drying the landscape and vegetation.

Dry and warm weather has seen poor vegetation growth for most of southern Australia. The general landscape dryness means that warm, windy conditions are likely to see elevated fire risk, and make an early start to the fire weather season likely. Countering this risk, the poor growth of grass and annual plants means that vegetation loads are reduced in drought affected areas. Further north, low rainfall conditions since March mean that vegetation is dry with very low greenness evident in satellite data, meaning that the northern fire season is well underway.

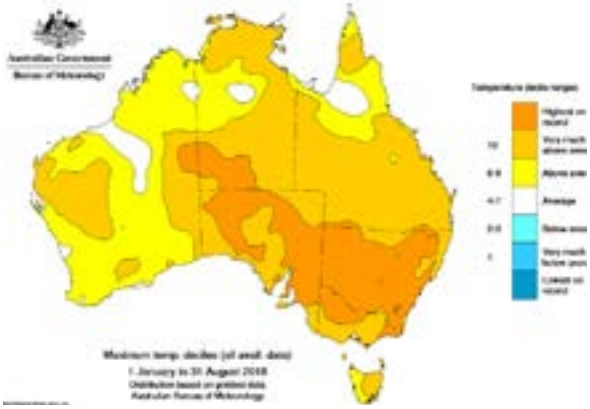
Fire season severity is increasing across southern Australia as measured by annual indices of the Forest Fire Danger Index. The increases are tending to be greatest in inland eastern Australia and coastal Western Australia. For example, the Victorian annual Forest Fire Danger Index has increased by about 50 per cent since 1950, with particularly high values during the severe fire seasons of 2002/03, 2006/07, 2008/09 and 2015/16. The increases reflect rising temperatures and below average rainfall during the cool season (April to October). Southern Australia has now experienced above average temperatures in 22 consecutive years, with the last below average season back in 1995.

The combination of short and long-term rainfall deficits serves to increase the fire risk in the coming spring and summer. A shift towards below average rainfall first affected south west Australia around the 1970s, and has largely dominated the south east since the mid-1990s. For south west Australia and Victoria, 17 of the past 20 years have now seen below average cool season rainfall, while the Murray-Darling Basin has experienced below average rainfall in 15 of the past 20 years. It is very likely that Victoria and the Murray-Darling Basin will see a 2018 total which is substantially below average, adding to this pattern. The combination of warming and drying has led to extensive and historically unprecedented landscape dryness across much of southern Australia.

The El Niño–Southern Oscillation (ENSO) is currently neutral. However, the overall



▲ Figure 1: JANUARY TO AUGUST 2018 RAINFALL DECILES.



▲ Figure 2: JANUARY TO AUGUST 2018 MAXIMUM TEMPERATURE DECILES.

pattern resembles the early stages of past El Niño events, with warmer than average ocean temperatures in central parts of the tropical Pacific, and above average temperatures in the ocean subsurface. The Bureau's *ENSO Outlook* remains at El Niño WATCH. El Niño WATCH means there is approximately a 50 per cent chance of El Niño forming in 2018; about double the normal chance. International climate models surveyed by the Bureau predict further warming of the tropical Pacific is likely as we move into spring. All models suggest El Niño thresholds are likely to be reached by the end of the year, though it is likely that a developing event will be short lived. El Niño typically means below average rainfall in eastern and northern Australia, while daytime temperatures are typically above average over the southern two-thirds of Australia.

The Indian Ocean Dipole (IOD) is neutral. However, the ocean to the north west of Australia remains cooler than normal, which is likely contributing to suppressed rainfall over southern and south east Australia in recent months. Three of six international climate models suggest a short-lived positive IOD event may develop. A positive IOD during spring typically reduces rainfall in central and southern Australia and can exacerbate any El Niño-driven rainfall deficiencies.

CLIMATE OUTLOOK

The climate outlook for spring is mainly influenced by the Pacific and Indian Oceans, together with other factors including long-term trends. As previously noted, the Pacific and Indian Ocean are neutral, though the development of an El Niño and positive IOD is possible.

The outlook for September and spring rainfall (Figures 3 and 4, page 3) shows an increased likelihood of below average rainfall in the south west, south east and much of Queensland. This is particularly so for September, when large areas have a less than 35 per cent probability of exceeding median rainfall. In the arid interior and parts of the north west, probabilities are close to 50 per cent; however it is seasonally dry over these regions at this time, so low rainfall totals are expected. Historical outlook accuracy for September to November is moderate to high over most of the country, except for the west of Western Australia, where accuracy is low to very low.

The outlook for spring maximum temperatures favours above average daytime temperatures for nearly all of Australia. Probabilities are particularly high in northern and western areas where they exceed 80 per cent. Probabilities in the south east are typically in the range of 60 to 75 per cent (Figure 5, page 4), implying that above average daytime temperatures are favoured. The outlook for minimum temperatures (not shown) is similar to that for maximum temperatures, though the overall shift towards likely warmer than average temperatures is less strong. Historical accuracy for September to November maximum temperatures is moderate to high for most of the country. Minimum temperature accuracy is moderate for eastern Australia, the Top End, and parts of central Australia. Elsewhere, accuracy is either patchy or low to very low.

Taken as a whole, the current warmer and drier than average climate conditions and the outlooks suggest that the southern fire season is likely to commence earlier than usual and be more active than normal.

Updates to climate forecasts and the outlook for the Indian Ocean Dipole and the El Niño-Southern Oscillation will continue to be published at www.bom.gov.au/climate/ahead.

REGIONAL SUMMARIES

QUEENSLAND

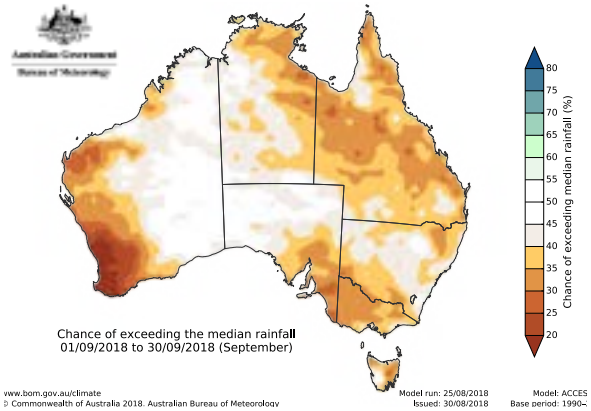
While October 2017 saw record rainfall across the southern part of Queensland, summer was relatively dry. This changed during autumn, which was the wettest autumn state wide since 2012. Much of this rain fell during March in central and southern Queensland. Locally, areas that missed this rain experienced their driest autumn in several decades. It was hot too, with Queensland's summer being the second warmest on record.

These conditions have led to areas south and west of Dirranbandi, Bollon, Boulia enduring one of the most severe droughts in decades. As a result, almost all of inland southern Queensland has very sparse vegetation and fuel loads. While this reduces the potential for high intensity grassfires it should be noted that fully cured grass even with low fuel loads can carry fast moving fires in hot, dry and windy conditions.

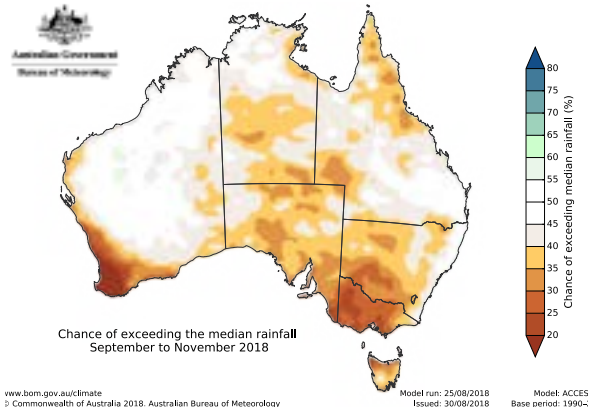
Vegetation along the Coral Coast around Hervey Bay and Bundaberg, north to the Capricornia around Rockhampton, has experienced below average rainfall over the past 12 months. This drying trend is forecast to continue through September and October, with above normal fire potential expected.

Further south, both the forest and grassy fuels around Toowoomba, north to Kingaroy, south to Warwick and Stanthorpe, east to Gatton and south to Boonah and Beaudesert have very much below average soil moisture. Fuel loads in these areas are above the long term average. With the outlook for hotter, and average or dryer than average conditions, there is little chance that the fuel availability will return to the long term average during the bushfire season. Grassland curing rates are more advanced than normal for this time of year

HAZARD **NOTE**



▲ Figure 3: THE OUTLOOK FOR SEPTEMBER RAINFALL.



▲ Figure 4: THE OUTLOOK FOR SPRING (SEPTEMBER TO NOVEMBER) RAINFALL.

following the very cold clear nights in these areas during winter. With a drier and hotter outlook for September, and generally average conditions for the remainder of spring, these areas are likely to have above normal fire potential for the 2018 bushfire season.

Queensland's fire season is already well underway, with August seeing record fire danger in the south east. The amount and severity of fires was above normal in this area, with the Queensland Fire and Emergency Services increasing its community engagement and preparedness levels around fire preparation.

NEW SOUTH WALES

Weather conditions have been exceptionally dry over New South Wales during 2018, with the Murray Darling Basin recording its driest January-July since 1965 (over 50 years). This has allowed severe rainfall deficiencies to accumulate in many areas west of the Great Dividing Range, but also through the Greater Sydney region. At the end of August, the Department of Primary Industries mapped nearly all of NSW being in some state of drought, with 21 per cent classified as in intense drought, 49 per cent experiencing drought conditions, and a further 30 per cent as drought affected.

Widespread significant soil moisture deficit has resulted in an early start to the fire danger period for many local government areas in NSW. Windy conditions in August resulted in many significant bushfires in forested areas up and down the east coast. With the short to medium-range climate outlooks favouring warmer and drier than average conditions across much of the state, there is significant concern for the potential of an above normal fire season in forested areas on and east of the Divide.

Reports of grassland fuel conditions west of the divide have indicated that whilst grassy vegetation is cured, it is below average in quantity or load. With the chances of above median rainfall west of the divide below 50 per cent to well below 50 per cent in the next three months, the balance of this situation has resulted in an assessment of normal fire season potential for grassland areas west of the divide. It should be noted that while grass load is reduced and therefore the potential intensity of grass fires may be reduced, highly cured grass creates the potential for grassfire to spread rapidly.

ACT

Along with many parts of Australia, the ACT has for some months experienced below average rainfall. As a result, there is severe soil dryness across the ACT, which could reduce spring grass growth and dry out the forests. The seasonal weather outlooks issued by the Bureau of Meteorology indicate there will be insufficient rain in the coming months to relieve the underlying dryness.

Because of this dryness, there is an expectation that grasslands and forests will become flammable earlier than is typical. This resulted in the ACT bushfire season being declared a month early, on 1 September. Nearby fire activity in NSW during August reinforces the need to be prepared early. Large fires requiring regional-level bushfire suppression operations can be expected. While lower than average grassland fuel loads can also be expected, grass fires could still be a problem in rural and metropolitan areas due to the ongoing drought conditions. It is too early to anticipate the chance of major rain occurring prior to summer.

The community is advised to begin preparations for the coming bushfire season. A high level of preparedness will be needed to mitigate the elevated bushfire risks.

VICTORIA

Much of East Gippsland has experienced two consecutive years of record low rainfall during autumn and winter. As a result, forests are significantly more flammable than normal, due to an increase in dead material in the near surface and elevated fuels. Unusually early bushfire activity occurred in East Gippsland during July and August, highlighting the severe level of dryness in forests. These dry conditions are likely to be exacerbated during spring and summer with the climate outlook for drier and warmer conditions. These areas can expect above normal fire potential from August right through summer.

Further north, the Great Divide and Alpine regions are experiencing good levels of streamflow and snowfall, with the spring forecast for continuing average streamflow in the Alpine region. As a result, normal bushfire potential is expected across these regions.

In the west and central regions, normal bushfire potential is also expected as rain has kept soil moisture at relatively high levels, but there is some uncertainty around how much dryness may carry over from previous seasons, as well as how quickly warm and dry conditions expected in spring may increase flammability in forests. The far South West region, extending to the Barwon Otway region, is currently experiencing above average rainfall, which has led to saturation in the soil moisture profile. Current expectations are for average to above average pasture growth in south west and western Victoria. The timing and severity of grass fires will depend strongly on rainfall patterns during late summer – as a result, a normal fire season expected in these areas.

North and North Western Victoria has experienced below average rainfall during autumn and winter, resulting in reduced cropping activity and pasture growth. These

areas are likely to experience a normal fire season. It should be noted that due to the uncertainties in the longer term climate outlook, areas of normal fire potential may still experience unpredicted severe bushfire activity during late summer.

TASMANIA

For the early part of Tasmania's fire season, most of the state has normal fire potential. The western half of the state is very wet, and only the strip between Orford and St Helens on the east coast is drier than average. This dry strip has above normal fire potential, and this area may expand without significant rain in the coming months. As in recent years, increased fire activity will probably occur in this dry strip before December and will require considerable response efforts. The fire season in the remainder of the state will commence more normally, in late spring or early summer, and provide good conditions for planned burning.

SOUTH AUSTRALIA

Large parts of South Australia have experienced drier than average conditions since the start of 2018. Late winter rains have helped reduce the soil dryness indices in some parts of the state, however, the rainfall has not been enough to overcome the total moisture deficits in these areas. Rainfall from now will also promote vegetation growth before summer, which will increase the available fire fuels during the fire season. The current Bureau of Meteorology forecast is for dry conditions to persist through spring which may also erode any benefits from recent rainfall.

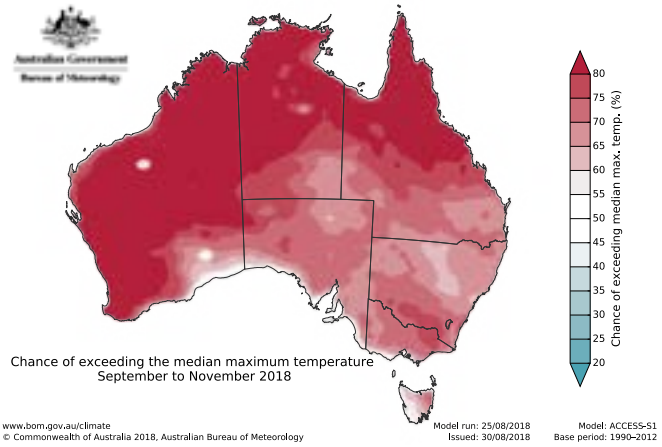
The recent El Niño watch also suggests that the dry spring conditions are likely to continue throughout summer. On the basis of the forecast dry conditions, and the cumulative effects of the long term moisture deficit, several areas have been identified as having above normal fire potential. Parts of the Riverlands, Murraylands, and the Flinders Ranges are particularly dry, which means that areas of scrub and woodland have increased fire potential.

Populated areas of the APY Lands, particularly those parts infested with buffel grass, also have above normal fire potential. Without effective control mechanisms to limit the spread of buffel grass, the abundance of fuel it creates could create an increased and ongoing risk.

Despite average winter rainfall, the fuel growth and forecast dry conditions indicate that the potential for bushfire across the populated areas of the Mount Lofty Ranges remains.

The dry conditions in agricultural areas have resulted in less cropping activity, with South Australia forecast to record a decrease in areas planted and in yields from sown crops. This may reduce the risk of fires from agricultural activity in some areas.

It is important to note that no forecast models are indicating any likelihood of increased rainfall across South Australia, which means the fire danger season has the potential to commence early and finish late in parts of the state. Significant bushfires have occurred in similar conditions, and areas of normal fire potential can expect to experience dangerous bushfires as per a normal South Australian fire season.



▲ Figure 5: THE OUTLOOK FOR SPRING (SEPTEMBER TO NOVEMBER) MAXIMUM TEMPERATURES.

WESTERN AUSTRALIA

As a result of bushfires in previous seasons, and mitigation achieved by prescribed burning, higher fuel loads in the forests and shrublands across the Darling Range have been fragmented into smaller parcels. This has resulted in the break up and reduction of above normal fire potential areas within the Swan Coastal Plain, Avon Wheatbelt, Jarrah Forest, and Warren regions.

Despite good winter rainfall, the underlying and persistent deep root zone soil moisture deficits along the Darling Range, south west corner, South Coast, Mallee and Esperance Plains have resulted in the forest and shrubland vegetation in these areas being subject to additional water stress. Above normal fire potential is expected in these areas.

Further north, cooler and wetter wet season conditions were experienced in parts of the Pilbara, Gascoyne and Carnarvon regions, which contributed to the accumulation of higher than average grass fuel loads. This has resulted in above normal fire potential in these regions. The Gascoyne Coast missed the subtropical low rain which travelled further to the east and is experiencing a rainfall deficit. This has affected grass growth and therefore the region is expected to experience normal fire potential.

Parts of south eastern Western Australia received significant rain in the early part of the year, which is evident in the elevated surface soil moisture in some areas. This has led to increased growth of the shrubs and grasses in these areas. Due to this increased vegetation growth, and therefore expected fuel loads, above normal fire potential is expected in these parts of the Mallee, Coolgardie, Nullarbor, Hampton and Great Victoria Desert regions.

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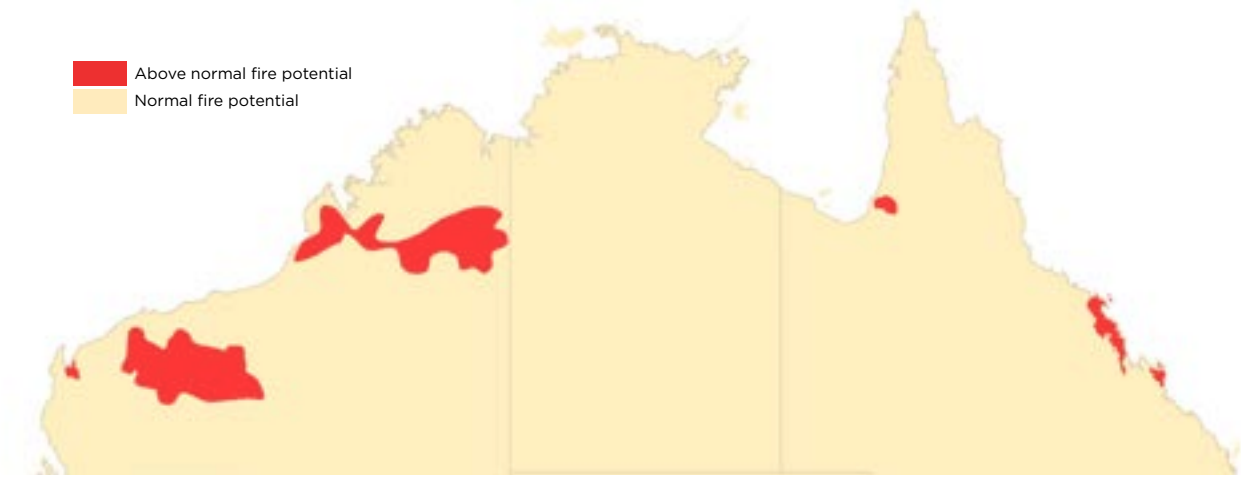
HAZARD **NOTE**

bushfire&natural HAZARDSCRC

ISSUE 49 JULY 2018

TOPICS IN THIS EDITION | FIRE IMPACTS | FIRE SEVERITY | FIRE WEATHER

NORTHERN AUSTRALIA SEASONAL BUSHFIRE OUTLOOK 2018



▲ Areas are based Interim Biogeographic Regionalisation for Australia and other geographical features.

BUSHFIRE POTENTIAL

This *Northern Australia Seasonal Bushfire Outlook* provides information to assist fire authorities in making strategic decisions such as resource planning and prescribed fire management to reduce the negative impacts of bushfire.

A *Seasonal Bushfire Outlook* for southern Australia will be published in early September, and will include an update on the northern fire season.

Bushfire potential depends on many factors. In northern Australia, conditions are determined by the nature of the previous wet season. The volume, location and timing of rainfall are critically important when estimating vegetation (fuel) volumes and growth. They also affect the timing of the drying of the vegetation.

The climate outlook for the next few months is also a crucial factor. Of particular interest are the future tendencies of Pacific sea surface temperature associated with the El Niño-Southern Oscillation, a major climate driver over Australia. Other less quantifiable factors, such as the distribution and readiness of firefighting resources, are also considered.

The annual Northern Australian Fire Managers' Forum, chaired by the Bushfire and Natural Hazards CRC, met in Townsville, Queensland, in June. This year marked the 20th anniversary of the forum, which gathers fire managers over three days from a range of public and private organisations from across northern Australia. The forum discussed the seasonal outlook for the imminent fire season, enabling the production of this *Hazard Note*. All other presentations from the Forum are online at www.bnhcrc.com.au/events/2018-nafm.

Forum attendees included representatives of the Queensland Fire and Emergency Services, Queensland Parks and Wildlife Service, Bushfires NT, WA Department of Fire and Emergency Services, WA Department of Biodiversity, Conservation and Attractions, NSW Rural Fire Service, the Department of Defence, the Bureau of Meteorology, the Australian Institute for Disaster Resilience, Charles Darwin University and the Australian Wildlife Conservancy.

ANTECEDENT CONDITIONS

The past 12 months has seen Australia dominated by record warm daytime (maximum) temperatures, with highly variable rainfall. The months of October, November, January and March delivered widespread above average rainfall to tropical Australia, while September, December, April and May saw most areas experience average to below average rainfall.

The second half of 2017 saw the development of a weak La Niña in the Pacific Ocean, which peaked early in 2018 before rapidly declining. The overall impact of the La Niña on Australia's climate was modest, with intra-seasonal (month-to-month) variability tending to dominate rainfall patterns. This intra-seasonal variability led to near average northern wet season rainfall overall (October 2017 to April 2018), tending towards above average in the far north west, Top End and Gulf of Carpentaria, and below average in parts of inland Queensland (Figure 1, page 2).

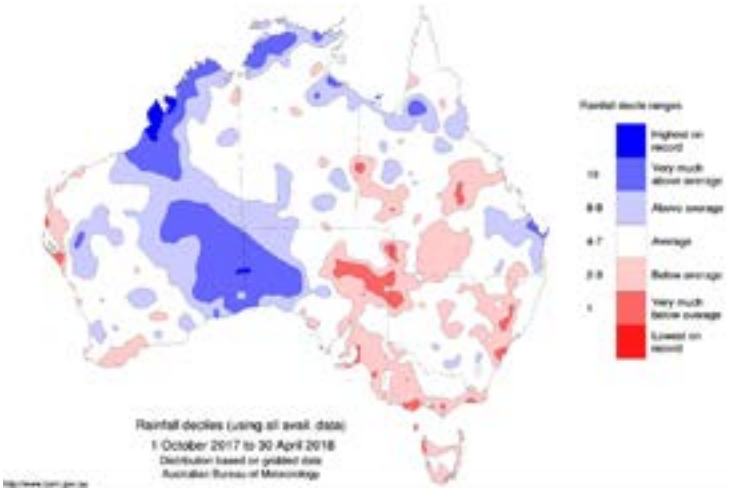
The anomalies of the past wet season, with wetter conditions in the west, tending to drier in parts of Queensland, has been repeated in recent years. As a result, there are now large multi-year rainfall deficiencies across most of Queensland, extending south

DEFINITIONS

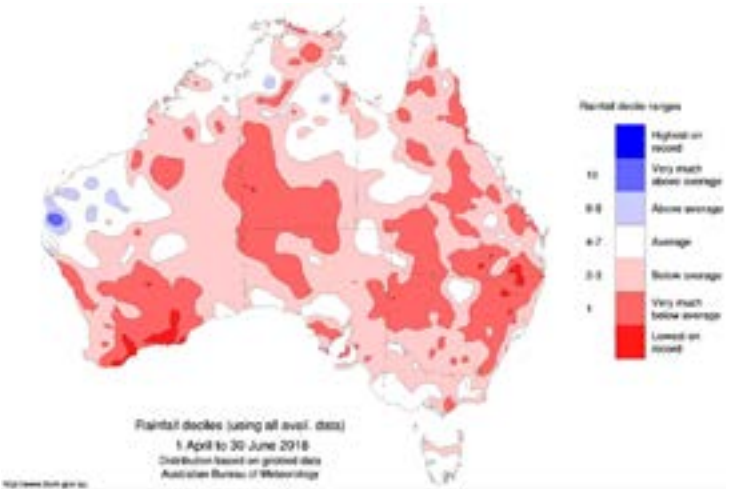
Bushfire potential: The chance of a fire or number of fires occurring of such size, complexity or other impact (such as biodiversity or global emissions) that requires resources (from both a pre-emptive management and suppression capability) beyond the area in which it or they originate. Fire potential depends on many factors including weather and climate, fuel abundance and availability, recent fire history and firefighting resources available in an area.

Rainfall decile: A decile is a statistical technique that ranks sorted observations into 10 equal groups. A decile rainfall map will show whether the rainfall is above average, average or below average for the chosen time period and area.

IBRA: Interim Biogeographic Regionalisation for Australia. Australia's landscapes are divided into 89 large geographically distinct bioregions based on common climate, geology, landform, native vegetation and species information.



▲ Figure 1: RAINFALL DECILES FOR 1 OCTOBER 2017 TO 30 APRIL 2018.



▲ Figure 2: RAINFALL DECILES FOR APRIL TO JUNE 2018 SHOWING DRY CONDITIONS OVER MOST OF AUSTRALIA.

into New South Wales. In contrast, nearly all of north west Australia has seen above average rainfall conditions over the past four to five years. These very long-term rainfall patterns influence vegetation growth in the region, which tends to be heavier where rainfall is above average and lighter where rainfall is below normal.

Australian temperatures continue to warm in-line with global trends, rising by 1.1°C since 1910. The past 12 months (July 2017 to June 2018) was the second warmest on record for Australian mean temperatures, with an anomaly of +1.09°C (compared to the 1961-90 average), while maximum temperatures were the warmest on record with an anomaly of +1.46°C. One consequence of the rising temperatures is an increase in fire season severity, particularly during the dry season in northern Australia and the warm season in southern Australia. As measured by fire weather indices, northern Australia saw unusually severe fire weather conditions in 2017, with indices showing the second most severe fire weather season since 1950, behind the severely drought-affected 2002.

The dry season in tropical Australia officially commences in May and ends in September. Significant rainfall is uncommon, with the climate dominated by warm to hot temperatures, lower humidity and east to south east winds which may become gusty and elevate fire risk. Australia's climate turned sharply drier in April 2018, with low rainfall conditions becoming established in the north a month earlier than is normal (Figure 2, above). Temperatures during this period have also been warmer than average across nearly all of Australia. As a result, vegetation has rapidly dried, with little greenness left in the tropical region. The combination of weather and climate factors means the fire season is now well underway, as is expected for the time of year.

CLIMATE OUTLOOK

The El Niño–Southern Oscillation remains neutral. However, climate model outlooks and recent warming in the tropical Pacific Ocean mean there is a greater than usual chance of an El Niño forming later this year. The Bureau's El Niño–Southern Oscillation Outlook is currently at El Niño WATCH, which means the likelihood of El Niño forming in 2018 is approximately 50%, or about double the normal chance.

Most international climate models surveyed by the Bureau suggest more warming is likely in sea surface temperatures, with a majority indicating

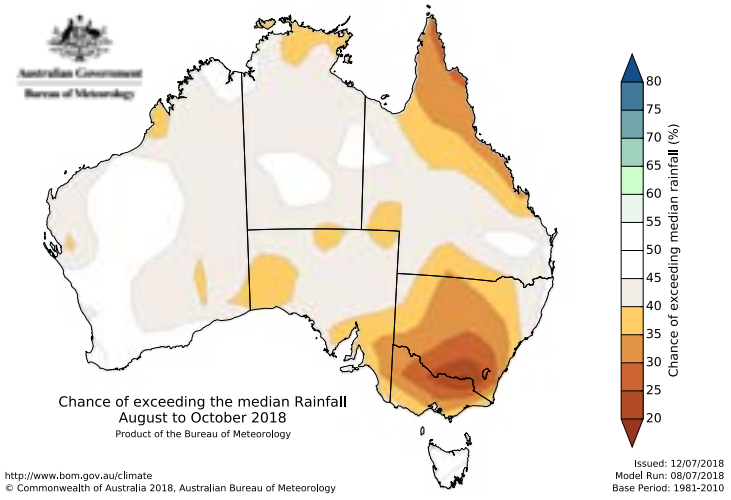
this warming will reach El Niño levels in the southern hemisphere spring. Historically, El Niño is associated with reduced rainfall in northern and eastern Australia during winter and spring. With dry conditions in place, this combination means that fire weather conditions are likely to be challenging and elevated compared to normal.

Overall, the Bureau's forecast suggests that the start to the 2018/19 wet season is likely to be near average, though some parts of Queensland slightly favour a late start. The outlook for the coming wet season will be updated monthly as data and model forecasts become available.

The probability of above-median rainfall is generally in the range of 30-50% in tropical and subtropical areas, with below average conditions tending to be favoured (Figure 3, above right). The tendency for below average rainfall to be favoured is consistent with the Pacific Ocean showing conditions that may lead to the development of El Niño. Historical outlook accuracy for August to October is moderate over most of northern Australia, except for the interior of Western Australia, where accuracy is low. The August to October period is normally dry during the first two months for northern Australia, with typically low rainfall except near the tropical Queensland coast. Rain may begin to become more widespread during October. This means that the impact of rainfall in the coming months, even if it is above average, will tend to be quite modest.

August to October is likely to bring above average maximum temperatures to tropical parts of the country, with probabilities generally in the range of 60-80% (Figure 4, page 4). This suggests that recent warmer than average conditions are likely to continue through the remainder of the dry season. The pattern is similar for minimum temperatures, with the probability of above median typically in the range of 60-75%, except near Cape York where probabilities are closer to 50%. Maximum temperature accuracy is moderate to high over most of northern Australia for this time of year, except the southern Northern Territory and parts of northern Western Australia, where accuracy is low. Minimum temperature accuracy is moderate to high over the northern half of Australia.

The climatic conditions and outlooks generally present a consistent picture, with recent unusually warm and dry conditions likely to continue for many areas.



▲ Figure 3: CHANCE OF EXCEEDING THE MEDIAN RAINFALL FOR AUGUST TO OCTOBER 2018.

REGIONAL SUMMARIES

NORTHERN QUEENSLAND

The early part of the northern Queensland wet season saw average rainfall. This changed in March, with well above average rainfall across the Gulf Country, Northern Goldfields, North Tropical Coast, and the Herbert and Lower Burdekin. As a result, grass fuel loads as compared to the long-term average are variable across the north. Cape York and areas east of Georgetown have below average grass fuel loads, while west of Georgetown grass fuel loads are around average. Around Normanton and to the north along the western part of Cape York, grass fuel loads are very much above average. Areas that received above average rainfall in March have grass fuel loads that are greener than average for this time of year. Drought declarations are still in force in 23 local government areas, with a further four under partial drought declaration.

Soil moisture is generally close to the long-term average, except for areas inland from Proserpine, Collinsville, Mackay and south to Rockhampton, where soil moisture is below average.

As noted in both the 2016 and 2017 *Northern Australia Seasonal Bushfire Outlooks* (*Hazard Notes* 18 and 36), Severe Tropical Cyclone *Marcia* in February 2015, followed by Severe Tropical Cyclone *Debbie* in March 2017, caused significant damage to coastal vegetation south of Bowen. Very strong winds stripped leaves from the canopy, increasing the fine fuel loads and changing the structure of the vegetation. The increased fire potential in the areas impacted by *Marcia* led to the creation of a strategic mitigation plan. This plan has been implemented and the risk has largely been mitigated. A similar program was undertaken in the central region following *Debbie*, and to date these activities have mitigated the risk in parts. Ongoing hazard mitigation activities will continue to reduce the risk in cyclone-damaged vegetation, but there remains an increased fire risk in these areas.

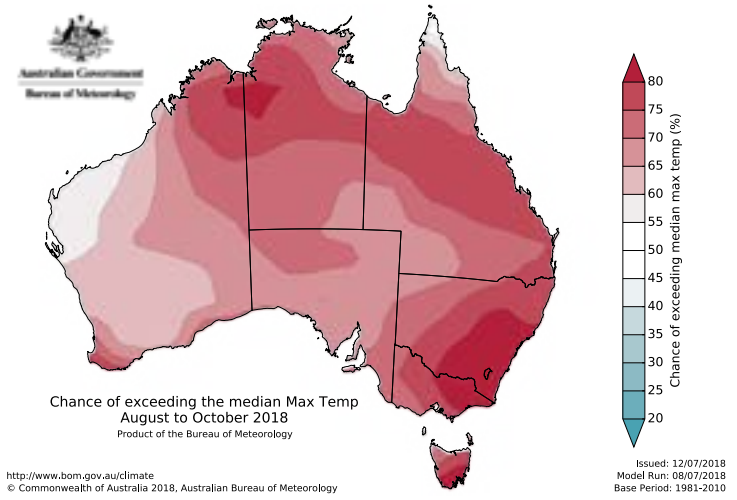
Above normal fire potential is expected for these forested areas along the Central Coast, Whitsundays and the Capricornia. Woodland areas, the savanna country around Normanton and to the north are expected to have normal fire potential, with the exception of a small area in the south west of Cape York, where above normal fire potential is predicted.

Normal fire potential is expected for all other areas north of latitude S25°. Regions of south east and western Queensland south of latitude S25° will be assessed for the *Southern Australia Seasonal Bushfire Outlook 2018*, to be published in September.

NORTHERN TERRITORY

The Top End wet season commenced in November 2017, generally easing the threat to landholders of late season bushfires. Rainfall has since varied in quantity, extent, and timing, resulting in inconsistent rainfall. Some areas around the Victoria River district recorded totals below the season average, with the rain finishing relatively early in the wet season.

The effectiveness of mitigation burns across the Northern Territory have varied due to the differing conditions experienced during the wet season. Where planned burns have been undertaken by agencies and landholders, including carbon farming projects, good results have been achieved to minimise the risk of bushfires occurring later in the year. Finer scale burning has been restricted close to populated areas in locations where above average rainfall occurred. This was due to high soil moisture retention that prevented access to undertake broader planned burning. In addition, the delayed curing of gamba grass meant that mitigation burns in areas infected were delayed. These mitigation burns will continue to be completed when conditions allow.



▲ Figure 4: CHANCE OF EXCEEDING THE MEDIAN MAXIMUM TEMPERATURE FOR AUGUST TO OCTOBER 2018.

Central regions

Large areas of central Australia have received high amounts of rain over the past two years, which has increased the fuel loads. In particular, the Lasseter region has observed above average rainfall that has led to good grass growth. Large areas with a high distribution of buffel grass have an increasing bushfire risk due to this strong growth, particularly within road reserves, drainage areas and water courses. Although fuel loads are increasing, grazing and planned burning efforts suggest that normal bushfire conditions can be expected.

The effectiveness of mitigation efforts has varied depending on land tenure. Landscape scale aerial burning is occurring throughout most Aboriginal Land Trusts. Mitigation efforts within the Tanami region have been widely successful and this has reduced the overall bushfire risk to that region.

Top End region

Inconsistent rainfall across the wet season has led to average levels of fuel loads across the region. The dry end to the wet season allowed for earlier access to country in some locations for mitigation purposes. Curing has been mostly consistent across the Top End except for areas that received below average rainfall, including the Victoria River district, which resulted in earlier than normal curing. As a result of the dry conditions, these regions had reduced mitigation works. Grass fuels have been retained for primary production by landowners.

Gamba grass prevalent area

Gamba grass continues to spread to new locations across the north west Top End, increasing fuel loads and changing fire management practices on properties. Mitigation efforts have varied depending on tenure, land value or the management objectives of landholders. Soil moisture has been above average since April, which has restricted on ground mitigation programs in some areas. The onset of strong winds has impacted aerial mitigation works. Where burning has taken place, good results have been achieved, with mitigation works in in the Darwin Coastal and Daly Basin regions continuing as weather permits.

NORTHERN WESTERN AUSTRALIA

Northern Western Australia has experienced its third wettest wet season on record. This above average rainfall has resulted in higher than average soil moisture for most of the Dampierland, parts of the Great Sandy Desert and the northern Kimberley. Above average June rain over the north west of Western Australia has alleviated soil moisture deficiencies in the coastal south east of the Pilbara and north eastern Gascoyne. However, June rainfall was below average in the Kimberley.

Cooler and wetter wet season conditions have resulted in the accumulation of higher than average grass fuel loads. This has contributed to above normal fire potential for the Dampierland and parts of the Pilbara and Carnarvon regions. The central Kimberley and Ord Victoria Plain received less rainfall and have cured earlier, with the areas not subjected to prescribed burning classified as above normal fire potential.

For other areas of northern Western Australia, normal and reduced fuel loads through wet season fires, grazing and prescribed burning efforts suggest that normal bushfire conditions can be expected.

The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

HAZARD **NOTE**

bushfire&natural HAZARDSCRC

ISSUE 43 NOVEMBER 2017

TOPICS IN THIS EDITION | FIRE IMPACTS | FIRE SEVERITY | FIRE WEATHER

SOUTHERN AUSTRALIA SEASONAL BUSHFIRE OUTLOOK 2017-18: NOVEMBER UPDATE

OVERVIEW

The bushfire seasonal outlook for 2017-18 has been re-examined for southern Australia, due to drier and warmer than average conditions since autumn 2017. Queensland experienced an early start to the fire season, with significant fires occurring in August. Early season fires of significance were also experienced in New South Wales, Victoria and Tasmania.

Most states are warning of an above normal fire season. The exception to this is coastal and south east Queensland, and north eastern New South Wales; these areas have received above average rainfall since October and have been reassessed as having normal bushfire potential. Previously these areas were classified as above normal fire potential.

There is potential of a late-forming, weak, La Niña, but if it does occur, this event, brings little prospect of high rainfall due to competing climate drivers from the Indian Ocean. Weak and late-developing La Niña events have had a variable impact on Australian rainfall in the past. Above average temperatures are expected for much of the eastern two thirds of the country. These conditions have resulted in an update to the *Southern Australia Seasonal Bushfire Outlook*. This new edition, released as *Hazard Note* 43, replaces the previous Outlook, published as *Hazard Note* 37 in September 2017.

The map on this page reveals the updated bushfire outlook for 2017-18 for southern Australia. It is important to remember that normal fire conditions can still produce fast running and large fires.

▲ **Above:** BUSHFIRE POTENTIAL AREAS BASED ON INTERIM BIOGEOGRAPHIC REGIONALISATION AND OTHER GEOGRAPHICAL FEATURES.

ANTECEDENT CONDITIONS

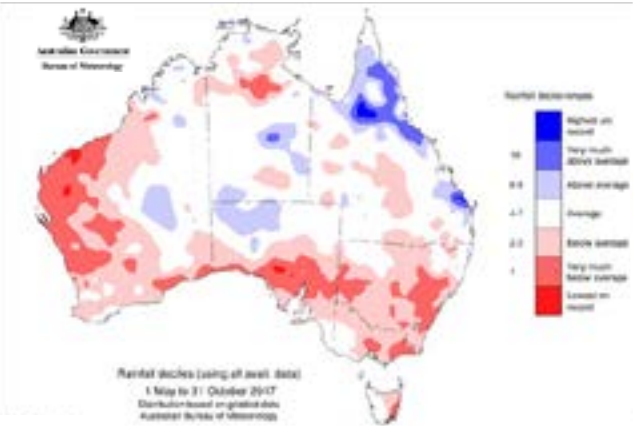
Most of southern and western Australia has experienced drier and warmer than average conditions since autumn 2017. Winter was the eighth driest on record for southern Australia and the driest since 2002. This was followed by a dry and warm September for most of eastern Australia. State record temperatures were set in Queensland, New South Wales and Victoria. In NSW, September was the driest September on record, which coincided with severe heatwaves and fire weather conditions experienced in the latter half of the month.

In contrast, October saw fewer temperature extremes and above average rainfall across coastal areas of Queensland and in north eastern NSW. This helped to relieve long-term dry conditions in those areas, but large parts of southern Australia including inland New South Wales, eastern Victoria, Western Australia, eastern Tasmania and northern agricultural and southern pastoral districts of South Australia are still experiencing serious rainfall deficiencies (Figure 1, page 2).

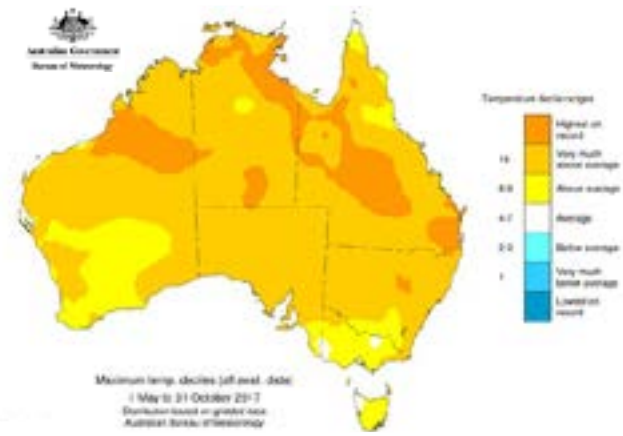
Below average rainfall in 2017 adds to much longer-term drying trends which are affecting the more populated parts of southern Australia during the cool season (April-October). For example, the south west of Western Australia has now experienced 12 consecutive cool seasons with below average rainfall, while Victoria has experienced below average cool season rainfall in 17 of the past 20 seasons. Very long-term deficiencies like these are not seen in the earlier historical record, and have been associated with a marked increase in fire weather severity. The combination of short and long-term rainfall deficits serves to increase the fire risk in the coming months.

Recent dry conditions and hence less evaporative cooling, combined with the long term warming trend, means Australia has observed its equal warmest May to October period on record for daytime temperatures (Figure 2, page 2). In contrast, night time temperatures have been cooler than average in parts of inland southern Australia. This has been due to the clear skies and dry soils allowing much of the daytime heat to escape.

Below average rainfall has also meant poor vegetation growth for most of southern



▲ **Figure 1:** RAINFALL DECILES FOR 1 MAY TO 31 OCTOBER 2017.



▲ **Figure 2:** MEAN MAXIMUM TEMPERATURE DECILES FOR 1 MAY TO 31 OCTOBER 2017.

Australia. Further north, the dry conditions mean that very low greenness is evident in satellite data. The dry state of vegetation means that warm windy conditions are likely to see more elevated fire risk than is normal for the time of year.

Climate conditions over Australia have been unusual in recent months because they have occurred without a strong climate driver. The El Niño—Southern Oscillation (ENSO) is currently neutral, though models and observations suggest that a late forming La Niña may develop. The Bureau's ENSO Outlook is currently at La Niña ALERT, with international climate models surveyed by the Bureau suggesting La Niña thresholds may be reached in late-2017. Weak and late-developing La Niña events have had a variable impact on Australian rainfall in the past.

The Indian Ocean Dipole (IOD) is neutral, with consensus amongst climate models suggesting neutral conditions will continue. The IOD typically has little impact upon Australian climate from December onwards.

CLIMATE OUTLOOK

The climate outlook for the summer months is influenced by the potential La Niña in the Pacific Ocean, and cooler than normal waters in the eastern Indian Ocean, as well as other factors including long-term climate change.

There is an estimated 70% likelihood that a short-lived and weak La Niña may develop over the coming summer. This is around triple the normal chance. While this would typically mean a wetter than average summer, cooler than average waters in parts of the eastern Indian Ocean – as well as near average sea surface temperatures around northern Australia – are reducing the amount of moisture available for rain systems, and increasing the chance of warmer days.

These competing climate drivers are resulting in a mixed rainfall forecast for the coming summer. Rainfall probabilities are close to 50% for most parts, indicating no strong shift towards widespread wetter or drier than average conditions (Figure 3, page 3). Historical outlook accuracy for summer rainfall is moderate to high over most of Western Australia and moderate over the eastern mainland. Elsewhere, accuracy is low.

The preliminary outlook for summer maximum temperatures favours above average conditions for much of the eastern two thirds of Australia (Figure 4, page 4). The probability that temperatures will be above average is typically in the range of 60 to 70%. The outlook for minimum temperatures (not shown) is similar to that for maximum temperatures. Maximum temperature accuracy is moderate over western and eastern parts of Australia and low across central regions and western Tasmania. Minimum temperature accuracy is moderate over most of Australia.

DEFINITION

Bushfire potential: The chance of a fire or number of fires occurring of such size, complexity or other impact (such as biodiversity or global emissions) that requires resources (from both a pre-emptive management and suppression capability) beyond the area in which it or they originate. Fire potential depends on many factors including weather and climate, fuel abundance and availability, recent fire history and firefighting resources available in an area.

In summary, the southern fire season is likely to continue against a background of warmer than usual climatic conditions, and despite the increased chance of a late-forming La Niña, no strong indication of widespread wet or dry.

Updates to forecasts and the outlook for ENSO and IOD will continue to be published at www.bom.gov.au/climate/ahead.

REGIONAL SUMMARIES

QUEENSLAND

After a very hot and dry winter, Queensland experienced an earlier start than usual to the fire season. Homes were threatened on the Sunshine Coast at Caloundra by a bushfire on 18 August. This was a significant fire for so early in the fire season.

September continued the hot, dry and windy trend, with the state experiencing record Forest Fire Danger across the month. This increased fire danger across south east Queensland saw fire prevention activities, communication and media engagement a primary focus for Queensland Fire and Emergency Services.

October was a stark contrast to the preceding months, with the third wettest October on record across Queensland, including the wettest since 1975. The areas highlighted as above normal bushfire potential in September's *Southern Australia Seasonal Bushfire Outlook* received very much above average or record rainfall. Consequently, these areas are now considered to have normal bushfire potential.

NEW SOUTH WALES

Rainfall for much of NSW over winter and early spring was below to very much below average. This resulted in the prediction for

above normal fire potential being realised for many areas. September saw an early escalation in fire danger and the amount of bush and grass fires, particularly over the coast and ranges north of Sydney. Incident reports for September include 2,481 bush and grass fires resulting in the destruction of six houses and 11 sheds or outbuildings. A further two houses and two sheds were damaged.

October saw a slight reprieve to the unusually dry conditions, particularly in the north east of NSW, with above average rainfall reducing the drought deficit. Despite the reprieve, the coast and ranges from Port Macquarie south still have areas with long term soil moisture deficit.

The rainfall outlook through to January is indicating a likelihood of even odds of drier or wetter conditions for southern and western NSW, with a reduced chance of receiving average rainfall in central and northern NSW.

Temperature outlooks are for above average maximum temperatures across the state for the December to February period.

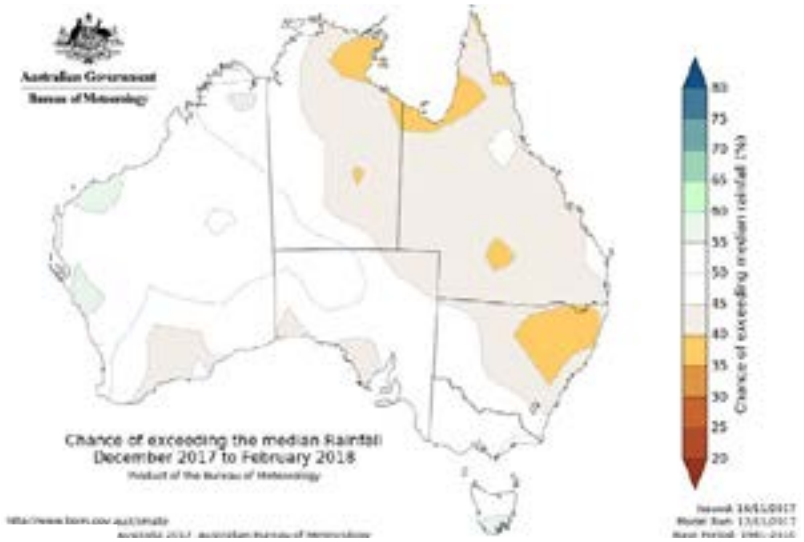
The potential La Niña, if it does occur, is not expected to have the usual widespread heavy rainfall that is typically associated with La Niña due to late development of the event. While El Niño events are traditionally associated with bad fire seasons, some of the most significant bushfires in NSW in recent history have occurred during neutral El Niño conditions. With the potential for warmer conditions, it is expected that significant fires could occur this fire season.

Current soil moisture deficits, particularly coastal areas south of Port Macquarie, and the likelihood of higher than average temperatures through to February, continue to mean that eastern forested areas have above normal fire potential. Due to the above average rainfall received in the north east, this area has now been assessed as having normal fire potential.

Spring rains have facilitated growth in grassland areas west of the divide. In response to this rain, grass fuel loads are likely to increase, but still within normal fire potential expectations.

ACT

After having limited rain since the beginning of the year, the upper soils in the ACT are drier than average for this time of year, with reduced river flows. With the potential for a weak La Niña and a neutral IOD, average rainfall is the most likely outcome over the coming months. It is unlikely that the ACT will receive enough rain during this period to recover from the existing soil moisture deficit. This could cause an early onset of forest fuel flammability as warmer, drier weather arrives with summer. Grasslands have greened-up for the spring flowering season, however growth has been below average and a rapid change to flammability might be possible. The bushfire potential for this outlook period is assessed as above normal, as with surrounding NSW areas. Conditions will be closely monitored to ensure a suitable level of preparedness across the community.



▲ **Figure 3:** THE PROBABILITY OF EXCEEDING THE MEDIAN RAINFALL FOR DECEMBER 2017 TO FEBRUARY 2018.

VICTORIA

Since the initial *Southern Australia Seasonal Bushfire Outlook* in September, Victoria has experienced some resumption of moisture-bearing cold fronts, though this influence has been largely confined to coastal areas. September brought a strong drying influence across Victoria's north and the continuation of dry conditions in the east; while October saw a resumption of drier than average conditions through central parts, including Melbourne's water catchments and foothill forests of West and South Gippsland, and on coastal areas between Warrnambool and Seaspray.

The lateness of a transition to La Niña conditions, if it does occur, brings mixed signals for rain. La Niña conditions can also increase the potential for extended warm spells across Victoria over the summer months. Some historically damaging fires across Victoria have occurred during La Niña events. Any rainfall in the coming months will be much less effective at soaking soil profiles due to longer days and higher average daily maximum temperatures.

Late September saw extreme heat over eastern Australia and significant fire activity in East Gippsland, where a fire near Buchan burnt through approximately 8,000 hectares with fire intensities normally experienced in January. This fire is still being monitored and will continue to consume significant resources as conditions warm over summer. As East Gippsland continues to experience high levels of bushfire activity, the change in bushfire activity with warmer weather indicates this area has had an early start to fire season and is experiencing above normal conditions.

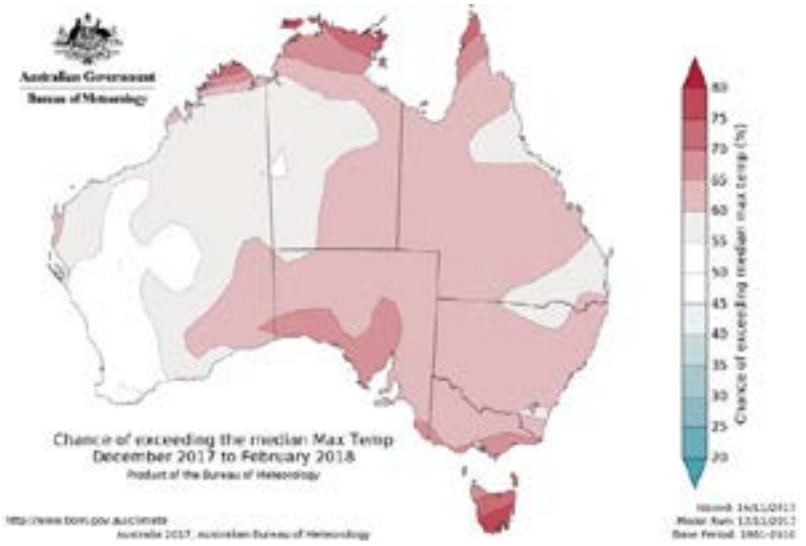
Longer term severe rainfall deficiencies in southern forests along the Great Divide between Swifts Creek and Melbourne's water catchments mean that these forested areas are now dry enough for widespread fire. The rainfall outlook for even chances of either wetter or drier conditions in the coming three months reflects a tension between wetter Pacific (La Niña) and drier Indian Ocean climate drivers. The overriding consideration is the absence of any signal in the Bureau's outlook that can reverse the long term drying trend that has settled over eastern Victoria, and the absence of a clear signal that heatwaves are not likely.

Good prospects for spring growth in the northern and central western grain growing areas have been realised, yet the timing of the beginning of the fire season in these areas looks set to occur as it would in a normal year. Much of these areas have a good base of deep soil moisture.

In the north east and northern side of alpine areas, the rate of pasture curing has slowed, with average rainfall occurring from mid-September to early October. Rain has also extended into the central highlands, though not of sufficient duration or taking in a large enough area to reduce fire potential.

Severe rainfall deficits persist on and south of the Great Dividing Range. There is a good chance forests in these areas will experience sudden changes in fire activity with the onset of warmer or windier weather. Melbourne's water catchment areas and higher value forests along the southern slopes of the Great Dividing Range have a long-term history of dryness, with expected weather patterns looking set to continue this trend.

The background conditions of dryness and the likelihood of above average maximum temperatures this summer places Victoria in a vulnerable position. Rainfall since May has been below average in many areas. A longer-term history of dryness in critical areas and a backdrop of warming temperatures and more frequent weather extremes continues to create above normal fire potential, especially where there is existing dryness. However, there are some factors that have the potential to moderate the risk of fire in some areas, including a good base of soil moisture in western Victoria, soaked gullies along the southern side of the Great Dividing Range and mixed signals for rain over summer. These areas will be closely monitored for emerging trends in the coming months.



▲ **Figure 4:** THE PROBABILITY OF EXCEEDING THE MEDIAN MAXIMUM TEMPERATURE, DECEMBER 2017 TO FEBRUARY 2018.

TASMANIA

The expected early start to the fire season did not eventuate, however there was a period of significant activity during late October on the east coast. Soil moisture levels and vegetation are still drier than normal, with dry areas expanding along the east coast from about St Helens down to Marion Bay, and across the south east to the lower Derwent Valley. These areas continue to have above normal bushfire potential, while the rest of Tasmania has normal bushfire potential.

SOUTH AUSTRALIA

The fire danger season has commenced in South Australia and many of the conditions forecast in September's *Southern Australia Seasonal Bushfire Outlook* have been realised. Fires have occurred across parts of the state, with the past three months remaining drier than average.

This period of continued reduced moisture, combined with the abundant growth of fine fuel caused by 2016's rain, has resulted in areas of above normal fire potential. As previously identified this area of increased risk includes the APY Lands and Northern Pastoral areas, as well as parts of the Riverland, the Clare Valley, the York Peninsula, the Eyre Peninsula, and the West Coast. Additionally, despite receiving some rainfall, the drier than average conditions on Kangaroo Island remain conducive to above normal fire potential.

The remainder of South Australia can expect normal fire potential. In addition, the reduced rainfall in some agricultural areas has resulted in less cropping activity, with South Australia forecast to record a decrease in areas planted and in yields from sown crops. This may reduce the risk of fires from agricultural activity.

Despite the recent La Niña ALERT, the climate forecast for South Australia does not indicate an increased likelihood of wetter than average conditions. La Niña is typically a weather pattern that has the greatest influence on Australia's east coast, and as such any impacts on South Australia are likely to be minimal if a La Niña were to occur.

Significant bushfires have occurred under similar conditions. It should be noted that there are no areas of below normal fire potential predicted across South Australia, and that even areas of normal fire potential can expect to experience dangerous bushfires as per a normal South Australian fire season.

WESTERN AUSTRALIA

Fire potential remains as described in *Southern Australia Seasonal Bushfire Outlook*, released in September as *Hazard Note* 38.

The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

HAZARD **NOTE**

bushfire&natural HAZARDSCRC

ISSUE 38 SEPTEMBER 2017

TOPICS IN THIS EDITION | FIRE IMPACTS | FIRE SEVERITY | FIRE WEATHER

SOUTHERN AUSTRALIA SEASONAL BUSHFIRE OUTLOOK 2017

OVERVIEW

The *Southern Australia Seasonal Bushfire Outlook* is used by fire authorities to make strategic decisions on resource planning and prescribed fire management for the upcoming fire season. The Outlook is developed at an annual workshop convened by the Bushfire and Natural Hazards CRC and AFAC.

At the 2017 Southern Seasonal Bushfire Assessment Workshop in August, the Outlook was assessed and a range of broad climate factors were considered. The map to the right shows the bushfire outlook for southern Australia through to the end of 2017. This map has been combined with the outlook for the northern Australia bushfire season, which was released in July, to show the areas of fire potential for all of Australia (see *Hazard Note* 36, July 2017).

Fire season potential depends on several factors. The amount, location and timing of rainfall in the period leading up to the fire season are critically important for estimating fuel loads and dryness. The temperature and rainfall outlooks for the next few months are crucial factors for influencing the development of fire threat.

Of particular importance are the future tendencies of sea surface temperatures in the Pacific Ocean, associated with the El Nino-Southern Oscillation, and those in the Indian Ocean. These are major drivers of climate over much of Australia. Other factors considered include the distribution of firefighting resources to meet potential threats, as well as previous fire activity and the amount of prescribed burning that can reduce the threat.

The workshop discussed the weather, landscape conditions and cross-border implications leading into spring and summer, and determined areas that had the potential for a fire season that was above normal, normal or below normal.

▲ **Above:** AREAS BASED ON INTERIM BIOGEOGRAPHICREGIONALISATION FOR AUSTRALIA AND OTHER GEOPGRAPHICAL FEATURES.

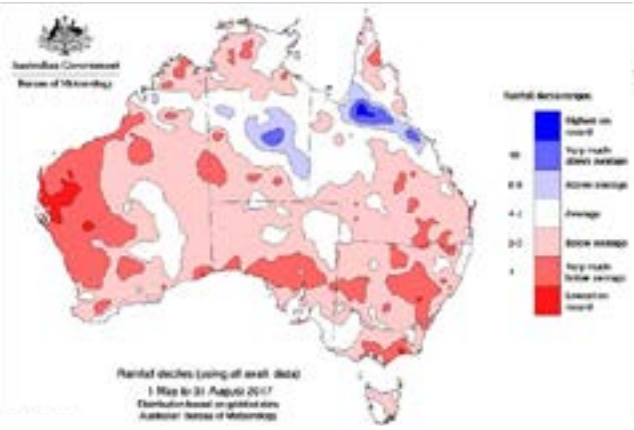
ANTECEDENT CONDITIONS

Most of Australia has experienced drier and warmer than average conditions since autumn 2017. The four months from May to August (Figure 1, page 2) saw below average to record dry conditions for most of southern Australia. August has seen somewhat better rainfall in some southern areas, particularly in the far south west of Western Australia and across parts of South Australia and Victoria, but this rainfall has not been sufficient to compensate for earlier dry conditions. New South Wales and southern parts of Queensland have remained unusually dry, meaning that rainfall deficiencies have continued to expand across these states.

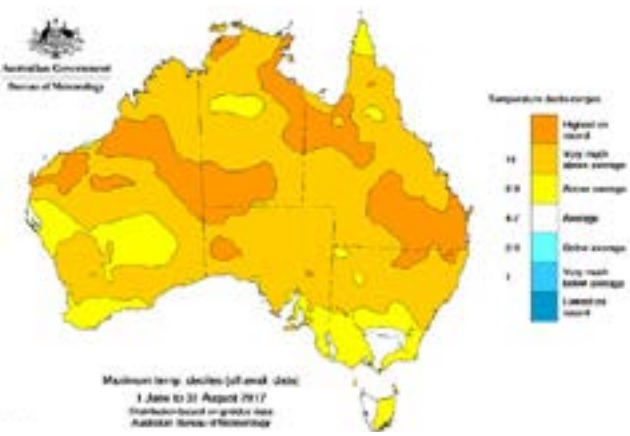
Below average rainfall in 2017 adds to much longer-term drying trends that are affecting parts of southern Australia during the cool season. For example, the south west of Western Australia has now experienced 11 consecutive cool seasons (April-October) with below average rainfall, while Victoria has experienced below average cool season rainfall in 17 of the past 20 seasons. Very long-term deficiencies like these are not matched in the historical record, and have been associated with a marked increase in fire weather severity in the past decade. The combination of short and long-term rainfall deficits serves to increase the fire risk in the coming spring and summer seasons.

Climate change now means that Australian temperatures are usually above average. Recent dry conditions in combination with the trend have seen large areas experience their hottest June to August daytime temperatures on record, with a national anomaly near +1.9°C above the 1961-1990 average (Figure 2, page 2). In some contrast, clear skies and dry soils have allowed cooler than average temperatures at night in parts of inland southern Australia.

The below average rainfall has seen poor



▲ **Figure 1:** RAINFALL DECILES FOR 1 MAY TO 31 AUGUST 2017.



▲ **Figure 2:** MEAN MAXIMUM TEMPERATURE DECILES FOR 1 JUNE TO 31 AUGUST 2017.

vegetation growth for most of southern Australia. Further north, the dry conditions now mean that vegetation is already dry with very low greenness evident in satellite data. The dry state of vegetation means that warm, windy conditions are likely to see more elevated fire risk than is normal for the time of year.

While climatic conditions over Australia have been unusual in recent months, they have occurred without a stronger natural driver, with the El Niño—Southern Oscillation (ENSO) currently neutral. All international climate models surveyed by the Bureau suggest the tropical Pacific Ocean is likely to stay ENSO neutral for the remainder of 2017. This means that the Pacific Ocean is not likely to play a significant role in the coming fire season.

The Indian Ocean Dipole (IOD) also remains neutral, with consensus amongst climate models suggesting neutral conditions are likely to persist. However, the ocean temperatures off the north west coast are somewhat cooler than average, which has suppressed rainfall in recent months. This also leads to below average rainfall forecasts in western areas. Some models suggest positive IOD thresholds could be reached in the coming months, but these values are unlikely to be sustained long enough to classify as a positive IOD event. Positive IOD events are typically associated with below average winter and spring rainfall over central and southern Australia.

CLIMATE OUTLOOK

The climate outlook for spring is influenced by both the Pacific and Indian Oceans, together with other factors including long-term climate change. As noted previously, the ocean patterns in the broader Pacific Ocean are currently neutral and this region is having little effect on outlooks. More localised effects are influencing this outlook, including cooler than average waters off the WA coast reducing available moisture for rain systems, and warmer waters off the north and east coasts driving the warmer than average spring temperatures. The cool waters are not extensive enough to reach the threshold for a positive IOD, but they are acting to suppress rainfall. The tendency for above average temperatures for Australia also reflects the global warming trend by increasing the warmth of the global oceans and atmosphere.

The outlook for spring (Figure 3, page 3) shows that below average rainfall is likely for much of Western Australia and small areas of the tropics. In these regions, there is generally a 60% to 65% chance that rainfall will be below average. Along the east coast, from Tasmania to north of Brisbane, the outlook favours above average rainfall (typically 55% to 65%). Through inland areas, probabilities are generally close to 50:50, implying little shift in the rainfall odds from the long-term average. The exception to this is a strip to the east and north east of Adelaide, where wetter conditions are slightly favoured. Historical outlook accuracy for September to November is moderate to high over most of Australia.

The outlook for spring maximum temperatures favours above average conditions for most parts of northern and eastern Australia (Figure 4, page 4). The probability that temperatures will be above average is typically in the range of 60% to more than 80%. The outlook for minimum temperatures (not shown) is very similar, with warmer conditions generally favoured. Maximum temperature accuracy is moderate to high over most of Australia, except for some small patches in WA, where accuracy is low to very low. Minimum temperature accuracy is moderate over much of the country but patchy in WA and parts of the northern tropics.

Taken as a whole, the current warmer and drier than average climate conditions and the outlooks suggest that the southern fire season is likely to commence earlier than usual and be more active than normal.

Updates to forecasts and the outlook for the IOD and ENSO will continue to be published at www.bom.gov.au/climate/ahead.

REGIONAL SUMMARIES

QUEENSLAND

Coastal areas south of Rockhampton to the NSW border have received above average rainfall, due to Severe Tropical Cyclone *Debbie* in March and a subsequent coastal low in May. This rain has increased fuel growth, and in some areas these fuels have already dried out and are available to burn as fine fuels. Additionally, winds associated with *Debbie* have stripped canopies of leaves, leaving the fuels below exposed to sunlight where they would normally be in shade. These leaves are now suspended as elevated and near surface fuels. This damage to the canopy also changes the wind field, so that any fires in these areas will be exposed to higher velocity winds, as well as drier air, compared to normal. This has led to above average fuel growth in this coastal strip, up to several hundred kilometres inland, as well as for a majority of south east Queensland. Queensland Fire and Emergency Services have worked closely with Queensland Parks and Wildlife in the central region to assess the changes to the vegetation and quantify any increase in risk. This has built on successful work conducted with the Bushfire and Natural Hazards CRC following Severe Tropical Cyclone *Marcia* in February 2015.

Inland, a wetter than average 2016 winter and spring has resulted in large areas returning to average fuel loads.

Coastal areas south of Rockhampton also

have a high likelihood of exceeding median maximum and minimum temperatures, with an average to slightly above average chance of spring rainfall expected. These factors indicate an increased potential for bushfire activity in the indicated area. July and August saw record temperatures for Queensland, along with frosts in inland parts, increasing fuel availability for the fire season.

Gladstone, Biloela, all of the North Coast region including Maryborough, Kingaroy and Monto, as well as Chinchilla, Toowoomba, Inglewood, and the South East are expecting above normal fire potential. The remainder of southern Queensland is expecting normal potential for fire season.

NEW SOUTH WALES

Rainfall for much of NSW has been below to very much below average over winter. The rainfall outlook through to November is indicating a likelihood of slightly less to even odds of drier conditions, and in the case of the south west of the state, very unlikely of receiving above average rainfall.

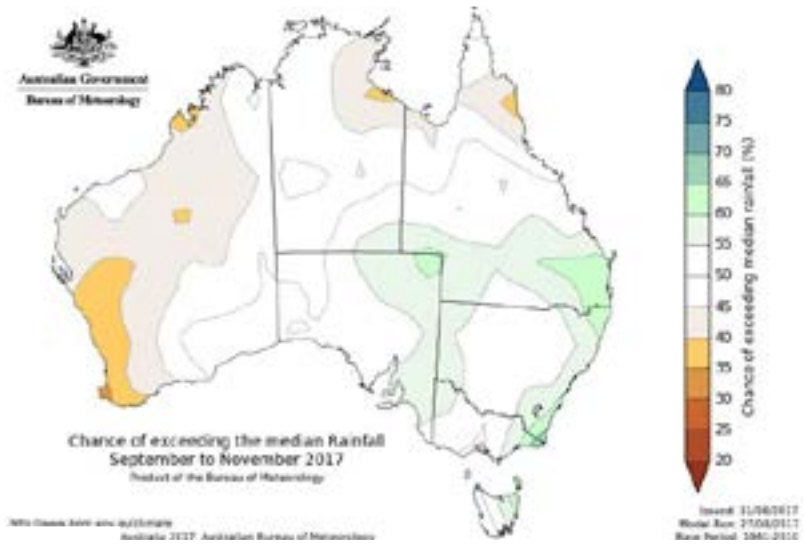
Although minimum temperatures have been mostly cooler than average, maximum temperatures have been warmer than average over the last three months. This has the effect of pre-conditioning fuels to be more susceptible to fire. In the case of forests, this dries the fine fuels, and in the case of grasslands, frosts cause grass to cure early. Both maximum and minimum temperature outlooks through to November indicate conditions are likely to be much warmer than average.

The El Niño outlook is for neutral conditions through to the end of 2017, and while El Niño events are traditionally associated with bad fire seasons, some of the most significant bushfires in NSW in recent history have occurred during neutral El Niño conditions. With another neutral El Niño outlook, warmer and potentially drier conditions forecast, it is expected that significant fires could occur this fire season.

Current soil moisture deficits (particularly west of the ranges) and the likelihood of higher than average temperatures through to November have led to the conclusion that forest fuels have above normal fire potential.

Grassland curing is significantly higher at this stage in comparison to last year due to significant frost, although grass fuel loads are significantly reduced west of the divide. The potential for grass growth is significantly reduced due to the rainfall deficit, although this could change dependent on spring rainfall.

The current NSW outlook is for above normal fire potential for eastern forested areas of the state. The exception to this is the Far North Coast, where a normal fire season is predicted. Grassland areas are predicted to have normal fire potential due to reduced fuel loads.



▲ **Figure 3:** THE PROBABILITY OF EXCEEDING THE MEDIAN RAINFALL, SEPTEMBER TO NOVEMBER 2017.

ACT

After three dry months the upper soils in the ACT are drier than average for this time of year, with average to slightly above average rainfall expected to at least November. It is unlikely that the ACT will receive enough rain during this period to recover from the existing soil moisture deficit. Forest fuels are drier than usual for this time of year. Frost curing of grasslands has been above average over winter and due to the prolonged frost period, a greater than average area has been affected. The bushfire potential for this outlook period is assessed as above normal, as with surrounding NSW areas. As summer approaches, conditions will be closely monitored, particularly if there is a change to wetter conditions.

VICTORIA

Signals of sufficient strength and confidence are beginning to emerge that lead to an expectation for an early start to fire season in some parts of Victoria. This will be reviewed by Victorian fire authorities throughout September and October. Over the last three months, rainfall in south eastern Australia has been dominated by a contracting belt of westerly winds and anomalously high atmospheric pressure. These weather patterns have removed some triggers for rainfall, as well as suppressing others. Record warm ocean temperatures create a vital link for weather systems to tap into either high amounts of moisture, heat, or both, so there is little established precedent on which to base expectation. This, coupled with longer term severe rainfall deficiencies in southern forests and the Bureau of Meteorology's outlook for drier and warmer conditions, gives rise to an expectation of above normal fire potential.

Good prospects for spring growth in the northern and central western grain growing areas present a risk of an early fire season, as these areas are expected to increase biomass during spring and cure during October. This will occur as available soil water becomes depleted. Closer to the north east alpine areas, the rate of pasture curing will depend on September rain.

Severe rainfall deficits persist along the Great Dividing Range in Victoria. Forests in these areas may experience sudden changes in fire activity with the onset of warmer or windier weather. Melbourne's water catchment areas and higher value forests along the southern slopes of the Great Dividing Range have a long-term history of dryness, with expected weather patterns looking set to continue this trend. Westerly winds continue to dry out undergrowth despite their very low temperatures. This may be creating a moisture differential between west facing and east facing slopes, in addition to the existing differential between northern and southern slopes.

The severity of early bursts of heat on north westerly winds across Victoria depends on rainfall and daily maximum temperature in South Australia's northern pastoral districts during spring. As soils in the interior warm

and dry, any moisture bearing air is heated and dried by the time it reaches Victoria. These bursts of heat, combined with forecast average rainfall and temperatures to the end of October, may be enough to move drought indices in some tall forests up to 100 by the commencement of summer. This is a critical threshold for these forests, allowing them to support fire growth. These areas will be closely monitored for emerging trends in the coming months.

TASMANIA

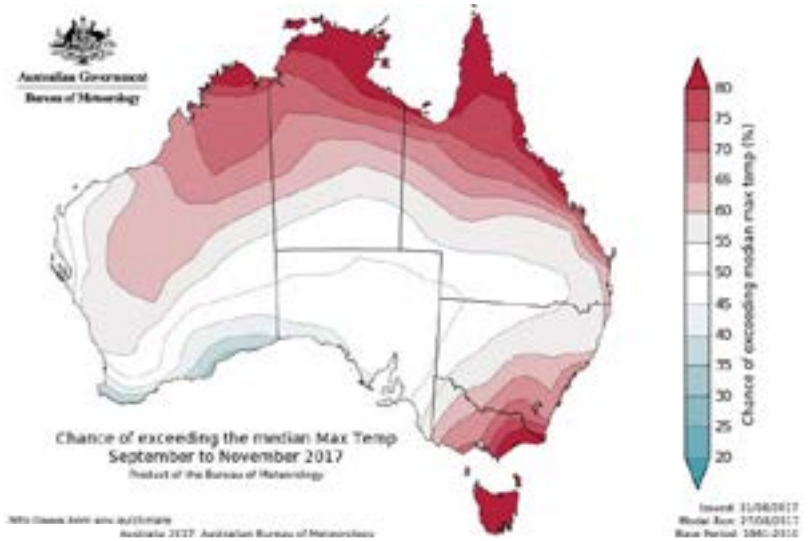
Despite significant floods during the winter of 2016 in many catchments, long term underlying dryness continues in some parts of Tasmania. Most of the state has received below average rainfall during 2017, with recent months very dry, especially in the south and east. Soil moisture levels are still well below normal in some places and significant rain would be required to recharge these soils.

Tasmania is expecting above normal fire potential in the South, in the Derwent Valley and in the East, along the coastal strip. The fire season will commence early in these areas, and subject to spring conditions, may produce significant fires. The remainder of Tasmania is classified as normal fire potential.

SOUTH AUSTRALIA

While 2016 saw South Australia's second wettest winter on record, 2017 has seen very different conditions, with a period of below average rainfall recorded across large parts of the state. The May to July rainfall deciles and the soil dryness indices (SDIs) highlight the areas that are considerably dryer than they would normally be in an average year.

This period of reduced moisture, combined with the abundant growth of fine fuel caused by last year's rain, has resulted in areas of above normal fire potential. This area of increased risk includes the APY Lands and Northern Pastoral areas, as well as parts of the Riverland, the Clare Valley, the Yorke Peninsula, the Eyre Peninsula, and the West Coast.



▲ **Figure 4:** THE PROBABILITY OF EXCEEDING THE MEDIAN MAXIMUM TEMPERATURE, SEPTEMBER TO NOVEMBER 2017.

In addition, Kangaroo Island has also experienced well below average rainfall, with parts of the island recording the driest June since records began in 1887. Unless significant rainfall is received, the current deficit will contribute to above normal fire potential on Kangaroo Island.

The remainder of South Australia, including the Upper and Lower South East, has experienced average or just above average winter rainfall. These areas can expect normal fire potential. In addition, the reduced rainfall in some agricultural areas has resulted in less cropping activity, with South Australia forecast to record a decrease in areas planted and in yields from sown crops. This may reduce the risk of fires from agricultural activity.

It is unlikely that spring and early summer will provide any substantial rainfall. Significant bushfires have occurred in similar conditions. It should be noted that even areas of normal fire potential can expect to experience dangerous bushfires as per a normal South Australian fire season.

WESTERN AUSTRALIA

On top of persistent soil moisture deficits, the South West recorded its driest autumn for five years. This has resulted in forest vegetation experiencing additional water stress, with dead surface leaf litter and woody materials also continuing to dry out. Consequently, there is potential for above normal bushfire activity within the southern parts of the Swan Coastal Plain, the majority of the Southern Jarrah Forest and the Warren biogeographic regions.

A record wet 2016/2017 summer period for Western Australia, from the Midwest to the South Coast, has seen high perennial grassland fuel loads develop. However, the pattern of rainfall, recent bushfires, prescribed burning, cropping and grazing activities have constrained potential above normal grass fuel loads in many areas, with the exceptions being the Eastern Gascoyne, Pilbara and Eucla regions. Higher than average perennial grassland fuel loads, combined with drying soil moisture as summer approaches, have resulted in some areas in these regions being assessed as having an above normal fire potential for the southern bushfire season.

The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

HAZARD **NOTE**

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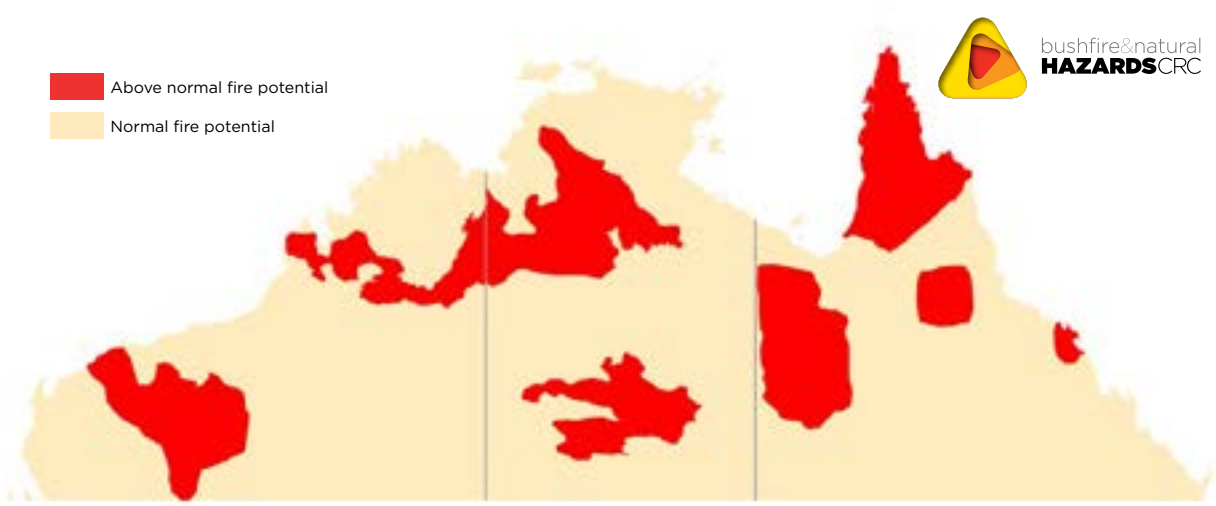
NORTHERN AUSTRALIA SEASONAL BUSHFIRE OUTLOOK 2017



Areas are based Interim Biogeographic Regionalisation for Australia and other geographical features.

BUSHFIRE POTENTIAL

This *Northern Australia Seasonal Bushfire Outlook* provides information to assist fire authorities in making strategic decisions such as resource planning and prescribed fire management to reduce the negative impacts of bushfire.

A *Seasonal Bushfire Outlook* for southern Australia will be distributed in early September, and will include an update on the northern fire season.

Bushfire potential depends on many factors. In northern Australia, conditions are determined by the nature of the previous wet season. The volume, location and timing of rainfall are critically important when estimating fuel volumes and growth. They also affect the timing of the drying of the fuel.

The climate outlook for the next few months is also a crucial factor. Of particular interest are the future tendencies of Pacific sea surface temperature associated with the El Niño-Southern Oscillation (ENSO), a major climate driver over Australia. Other less quantifiable factors, such as the distribution and readiness of firefighting resources, are also considered.

The annual Northern Australia Fire Managers' Forum, chaired by the Bushfire and Natural Hazards CRC, met in Kununurra, WA, in June. During the two-day proceedings, the forum discussed the seasonal outlook for the imminent fire season, enabling the production of this *Hazard Note*. All other presentations from the Forum are online at www.bnhcrc.com.au.

Forum attendees included representatives of the WA Department of Fire and Emergency Services, WA Department of Biodiversity, Conservation and Attractions, Bushfires NT, NT Fire and Rescue Service, Queensland Fire and Emergency Services, Queensland Parks and Wildlife Service, the Bureau of Meteorology, AFAC and Charles Darwin University.

ANTECEDENT CONDITIONS

The second half of 2016 was dominated by a strong negative Indian Ocean Dipole (IOD) that decayed in November, associated with the development of the monsoon. The Pacific Ocean was ENSO neutral, with little clear influence on the Australian climate over summer. Ocean waters around northern Australia remained near record warm temperatures during the northern wet season (October to April).

Rainfall in northern Australia was largely split between unusually heavy falls in the north west, the Northern Territory and most of central Australia, and below average rainfall across most of Queensland (Figure 1, page 2). Most tropical areas west of the Northern Territory-Queensland border saw October to April rainfall which was in the top 20% of records or higher, with record heavy falls near the Kimberley region of Western Australia. In contrast, Queensland rainfall was patchy and mostly average to below average. Above average falls were mainly limited to the central Queensland coast, which was affected by Severe Tropical Cyclone *Debbie* in March.

The anomalies of the past wet season are similar to those seen in recent years. As a result, there are large multi-year rainfall deficiencies across much

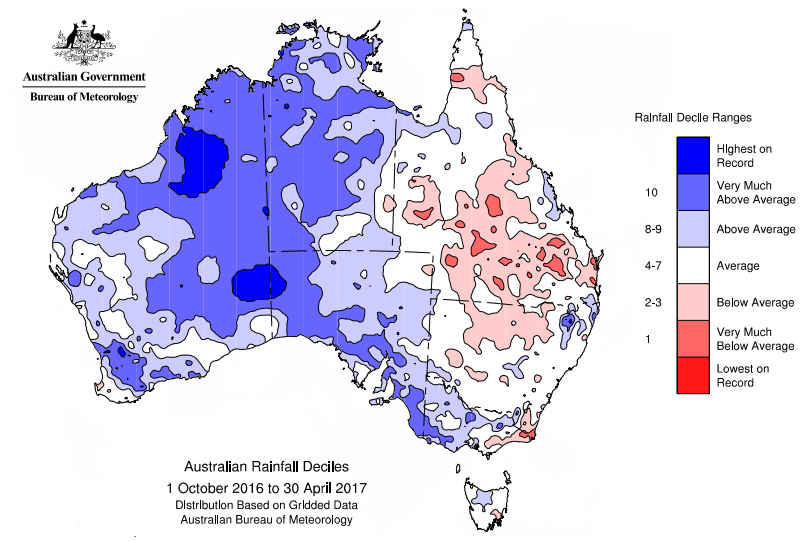
HAZARD **NOTE**

DEFINITIONS

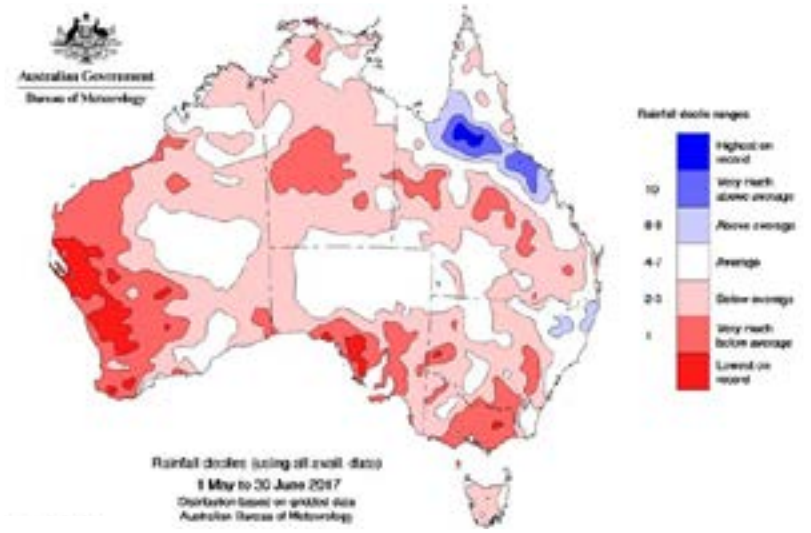
Bushfire potential: The chance of a fire or number of fires occurring of such size, complexity or other impact (such as biodiversity or global emissions) that requires resources (from both a pre-emptive management and suppression capability) beyond the area in which it or they originate. Fire potential depends on many factors including weather and climate, fuel abundance and availability, recent fire history and firefighting resources available in an area.

Rainfall decile: A decile is a statistical technique that ranks sorted observations into 10 equal groups. A decile rainfall map will show whether the rainfall is above average, average or below average for the chosen time period and area.

IBRA: Interim Biogeographic Regionalisation for Australia. Australia's landscapes are divided into 89 large geographically distinct bioregions based on common climate, geology, landform, native vegetation and species information.



▲ **Figure 1:** RAINFALL DECILES FOR 1 OCTOBER 2016 TO 30 APRIL 2017.



▲ **Figure 2:** RAINFALL DECILES FOR 1 MAY TO 30 JUNE 2017.

of northern and central Queensland, extending to near the New South Wales border. In contrast, virtually all of north west Australia has seen unusually wet conditions over the last three to four years. These very long-term rainfall patterns influence fuels in the region, which tend to be heavier where rainfall is above average and lighter where rainfall is below average.

Climate change and the associated long-term warming trend means that seasonal temperatures are now mostly above average. The rise in temperature has been associated with a general increase in fire season severity across Australia. After a record-warm northern wet season in 2015/16 (+1.3°C above the 1961-1990 average), the temperatures for 2016/17 were closer to average with an anomaly of +0.3°C. The pattern of seasonal temperature in northern Australia broadly followed that of rainfall, with near to slightly below average temperatures in the inland north west, where rainfall was heavy, while parts of Queensland experienced above average to locally record warm temperatures.

The start of the 2017 dry season (May and June) has seen the return of low rainfall as is expected for the time of year. May and June have been somewhat drier, with the exception of some northern and coastal regions of Queensland (Figure 2, above), and warmer than average across most of northern Australia. As a result, vegetation has rapidly dried, with little greenness left.

CLIMATE OUTLOOK

The tropical Pacific Ocean is currently ENSO neutral. All major climate models indicate it is likely to remain ENSO neutral for the remainder of 2017. This means the Bureau of Meteorology's ENSO Outlook is currently INACTIVE, with neither El Niño nor La Niña expected to influence Australia's climate this year. The influence of the Pacific Ocean on Australian climate for the remainder of the northern fire season is expected to be minor.

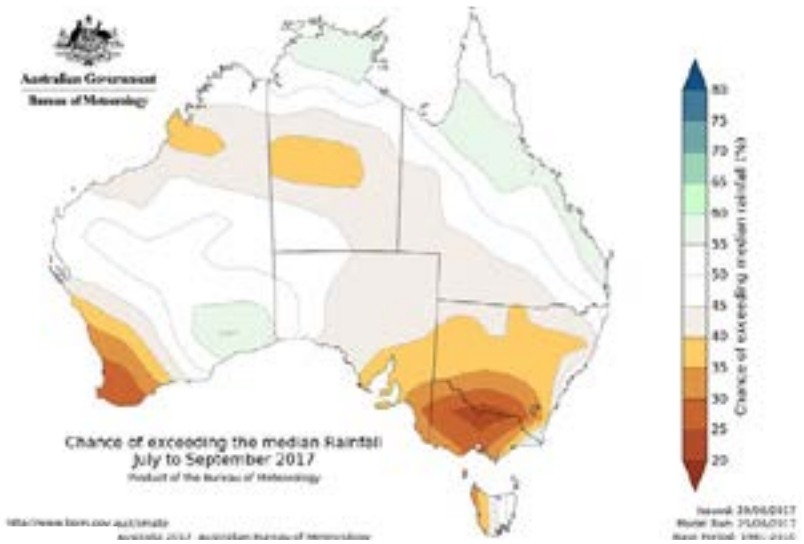
In the tropical Indian Ocean, the IOD is currently neutral, with no sign of either negative IOD or positive IOD present in the ocean or atmosphere. However, some climate models suggest a positive IOD could develop in the coming months. Positive IOD events are typically associated with below average winter and spring rainfall over much of Australia. This includes central Australia and most of northern Australia, apart from WA, which is consistent with the seasonal outlooks

described for each state and territory. Overall, the Bureau's forecast suggests that the start to the 2017/18 wet season is likely to be near average, though some parts of north west WA and Queensland slightly favour an earlier start.

The July to September period is normally dry for northern Australia, with low rainfall except near the tropical Queensland coast. This means that the impact of rainfall in the coming months, even if it is above average, will tend to be quite modest. The probability of above-median rainfall is generally in the range of 40 to 60% in tropical and subtropical areas, indicating little shift away from seasonal average conditions (Figure 3, right). The northern areas as a whole slightly favour above average rainfall, while in some southern areas probabilities tend to favour below average rainfall. The lack of a strong rainfall signal reflects a relative lack of influence by the Pacific and Indian Oceans, where climate conditions remain neutral. Historical outlook accuracy for July to September is moderate over most of northern Australia, except around the border of Western Australia and the Northern Territory, and areas surrounding the Gulf of Carpentaria, where accuracy is low.

July to September is likely to bring above average maximum temperatures to the tropics, with probabilities generally in the range of 60 to 80% (Figure 4, page 4). This suggests that recent warmer than average conditions are likely to continue through the remainder of the fire season. The overall pattern is similar for minimum temperatures, with the probability of above average minimum temperatures typically in the range of 80% or higher near the tropical coast, dropping to near 60% inland. Maximum temperature accuracy is moderate to high over most of Australia for this time of year. Minimum temperature accuracy is moderate over the northern half of Australia for this time of year.

The climatic conditions and the climate outlook overall presents quite mixed signals for the fire season. For this reason, the state and amount of available fuels is the best guide to the fire season in many parts.



▲ **Figure 3:** THE PROBABILITY OF EXCEEDING THE MEDIAN RAINFALL, JULY TO SEPTEMBER 2017.

REGIONAL SUMMARIES

NORTHERN QUEENSLAND

The bushfire season across northern Queensland is primarily influenced by geographic location, the relationship between climate and vegetation, and long-term, seasonal and short-term climatic, conditions. The 2016/17 wet season comprised of mainly storm rain in western shires, with the main wet season monsoonal activity restricted to the Gulf of Carpentaria, Cape York and eastern coastal areas south of Bowen. Western local authority areas of Mount Isa, Cloncurry, Boulia, Diamantina, Winton, Barcoo and Longreach received significant dry season (winter) rain in 2016, producing high pasture growth. However, low levels of wet season rain (summer) and heatwave conditions resulted in this fuel being 80% to 90% cured by April 2017.

Following three years of drought, much of western and central Queensland has been destocked. This year's rain has led to increased fuel loads in some of these areas. However, due to both the high price and shortage of store cattle, these areas remain either destocked or only lightly stocked. This has created higher than normal fuel loads that will carry into this northern Queensland fire season.

Severe Tropical Cyclone *Marcia* In February 2015, followed by Severe Tropical Cyclone *Debbie* in March 2017, caused significant damage to coastal vegetation south of Bowen. Very strong winds stripped leaves from the canopy, increasing the fine fuel loads and changing the structure of the vegetation.

These changes to the fuel persist and there remains an increased fire risk in this area. QFES staff from northern and central regions are coordinating risk identification and hazard mitigation activities to address the increased risk. This work will prove valuable to decision makers for the fire season. As a result of this, further work is being undertaken in preparation.

Drought declarations are still in force in 32 local government areas, with a further three under partial drought declaration.

In collaboration with other fire and land management agencies, the Carpentaria Land Council Aboriginal Corporation and landowners, the bushfire potential for the fire season has been assessed as follows:

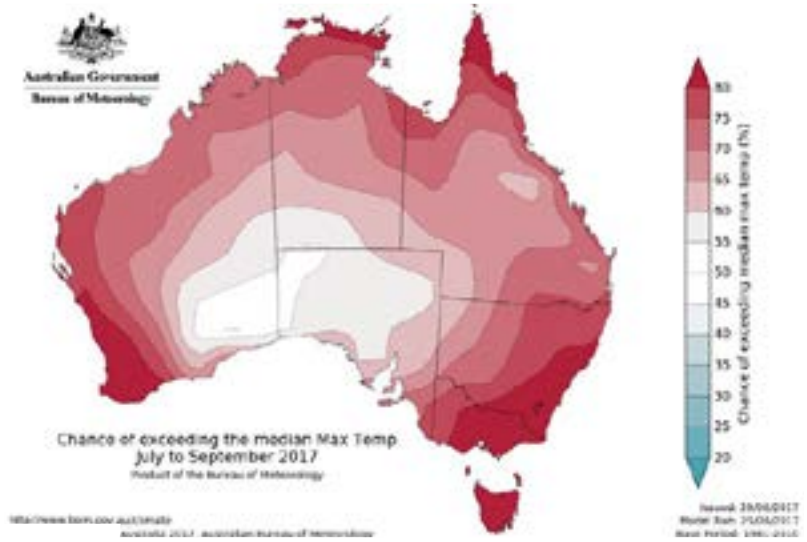
- Above normal fire potential is expected in the coastal ranges from Gladstone, to north of Bowen.
- High fuel loading in Cape York has resulted in above normal fire potential in areas not subject to early season hazard mitigation burning.
- Parts of Etheridge and Croydon shires received good summer rain and consequently have high fuel loads. Due to reduced livestock numbers the high fuel loads will persist into the fire season.
- Woodlands and grasslands around the Mount Isa region, Boulia east to Julia Creek, north to Normanton and west to near the Northern Territory border have above normal fire potential.
- Normal fire potential is predicted for all other areas north of latitude S25°. Regions of south east and western Queensland south of latitude S25° will be assessed for the *Southern Australia Seasonal Bushfire Outlook 2017*, to be published in September.

NORTHERN TERRITORY

Substantial rainfall recorded across the Northern Territory in September 2016 eased the threat to landholders to respond to late season bushfires last fire season. Rainfall has since varied in quantity, extent and timing, though all regions have received at least the average rainfall.

This has resulted in strong fuel growth in varying quantities across the Territory. Pasture conditions have also been observed to be of high quality.

Significant mitigation burns across the Territory have been conducted by agencies, landholders and carbon farming projects. These have provided good results, minimising the potential for fire risk later in the year. Finer scale burning close to populated areas was restricted due to the lengthy wet season. This, in conjunction with the delayed curing of gamba grass, had a negative effect on fire management.



▲ **Figure 4:** THE PROBABILITY OF EXCEEDING THE MEDIA MAXIMUM TEMPERATURE, JULY TO SEPTEMBER 2017.

Central regions

Above average rainfall over the past two years throughout much of central Australia has contributed to increased fuel loads. Areas of high buffel grass distribution have significantly increased the bushfire risk due to the high rainfall, particularly within drainage areas and water courses.

The effectiveness of mitigation efforts has varied depending on land tenure. Landscape scale aerial prescribed burning was trialed within the MacDonald and Burt Plains regions on pastoral estates, but had limited success due to minimal weather opportunities and landowner take-up. Mitigation efforts within the Tanami region have been widely successful.

Top End (excluding areas prevalent with gamba grass)

Consistent and regular rain fell from November through to April across all regions north of the 20th parallel.

The significant rainfall promoted good grass growth, with fuel loads reported as high and needing to be assessed and managed by landholders to minimise threats. Overall the west of the Territory has cured earlier than the east. Mitigation efforts have varied depending on tenure, land value or management objectives of landholders. Where burning has taken place, good results have been achieved. Burning continues in many eastern regions.

Gamba grass prevalent area

Gamba grass continues to spread across the Top End, increasing fuel loads and changing fire management practices on new properties each year. While the September 2016 rain provided welcome relief, it also provided an additional germination period on areas that had been burnt in 2016, providing additional fuel for the 2017 fire season

The retention of above average soil moistures through to April have hampered on-ground mitigation programs, and the onset of strong winds have had an impact on the ability to undertake aerial mitigation prescribed burning. Where burning has taken place, good results have been achieved. Early strong winds, combined with wet conditions, have led to difficulties in containing and controlling early season management practices.

NORTHERN WESTERN AUSTRALIA

A very much above average wet season across northern Western Australia has resulted in significant pasture growth and delayed curing for parts of the Kimberley, the southern half of the Pilbara and the central Gascoyne.

Taking into consideration the recent weather, fires both planned and unplanned over the past wet and dry seasons, and the amount of available fuels, above normal fire potential is expected in parts of the Ord Victoria Plain and Dampierland Regions of the Kimberley. These conditions have also led to above normal fire potential across the southern half of the Pilbara and central parts of the Gascoyne Regions.

The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

HAZARD **NOTE**

bushfire&natural HAZARDSCRC

ISSUE 32 JUNE 2017
TOPICS IN THIS EDITION | FORECASTING | LAND MANAGEMENT | SEVERE WEATHER | SOIL MOISTURE

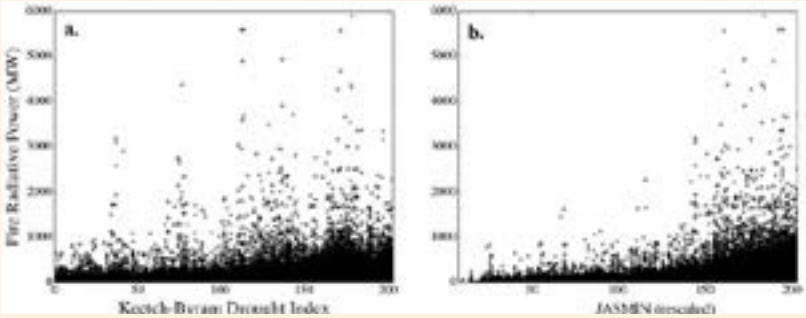
SOIL MOISTURE PROTOTYPE IMPROVES FORECASTS

ABOUT THIS PROJECT

This research was conducted as part of the *Improving land dryness measures and forecasts* project, which is developing more accurate and detailed measurements to improve the management and warnings for bushfires and floods.

AUTHORS

Dr Vinodkumar, Dr Imtiaz Dharssi, Bureau of Meteorology; Alex Holmes, Monash University.



▲ **Above:** FIGURE 1. SCATTER PLOT DEPICTING MODIS FRP PRODUCT AGAINST A) KBDI, AND B) RESCALED JASMIN PRODUCT. THE DATASETS SPAN FROM JANUARY 2013 TO DECEMBER 2013.

SUMMARY

This research has developed a prototype, high-resolution soil-moisture analysis system called JASMIN, which is a significant improvement in accuracy compared to currently used models. It is based on research that examines the use of land surface models, remotely sensed satellite measurements and data assimilation techniques to improve the monitoring and prediction of soil dryness. The new information will be calibrated for use within the existing fire prediction systems. This retains the accuracy, temporal and spatial resolution of the new product without changing the overall climatology of Forest Fire Danger Index and other calculations based on soil moisture.

Immediate benefits for emergency and land management agencies will be improvements to the fire danger rating and warning system, fire behaviour and flood prediction models, which will flow on to emergency warnings issued to the public. The project's long-term goal is to integrate JASMIN's outputs into the new National Fire Danger Rating System.

CONTEXT

This project is addressing a significant limitation in the ability to accurately estimate soil moisture, a key parameter in the prediction of bushfire, flood and heatwave danger. Accurately predicting potential danger directly supports pre-event planning and hazard forecasting, core elements of a resilient community.

BACKGROUND

The current operational forest fire danger rating system uses very simple, outdated models for estimating soil dryness. These models either oversimplify or neglect critical factors that influence soil moisture dynamics. This leads to large uncertainties in the predicted soil dryness, undermining the quality of operational fire warnings. The project aims to develop a high-resolution, soil-moisture analysis system based on satellite measurements and advanced physics-based models, for use in fire danger prediction systems.

BUSHFIRE AND NATURAL HAZARDS CRC RESEARCH

This research is producing a more accurate soil dryness estimation system than the current, simple models used in fire prediction. The benefits of this new product will also extend to landscape management by assisting with planning for fuel-reduction burns, improvements to water resource management, weather and seasonal forecasts, and hydrological monitoring.

The project's significant progress is demonstrated by the development of a prototype, high-resolution soil-moisture analysis system that is a significant improvement in skill compared to currently used models. The system is based on the Joint UK Land Environment Simulator land surface model (JULES LSM) and is called JULES-based Australian Soil Moisture Information (JASMIN). Work is well advanced to re-scale the new system to produce a product that the fire agencies can directly use in place of the current ones without changing any of their existing infrastructure.

RESEARCH FINDINGS

This study suggests that analyses of soil moisture can be greatly improved by using physically based land-surface models, remote sensing measurements and data assimilation. A prototype of the JASMIN system has been developed with a spatial resolution of five kilometres. JASMIN can predict surface soil moisture, which is closely related to dead-fuel moisture content, and also root-zone soil moisture that provides information on live-fuel moisture content. Verification against ground-based soil moisture observations shows that this prototype system is significantly more skilful than the traditional models.

For ease of use within existing operational fire prediction systems, the new system has been calibrated to have the same dynamic range and statistics as the old models. The researchers investigated four variants of

END-USER STATEMENT

The results so far are both encouraging and tantalising. Fire danger forecasting and operational fire-behaviour prediction is limited by the relatively crude soil moisture modelling we commonly use. The availability of the advanced, fine-scale, multi-layer soil-moisture information arising from this project will be a boon to fire behaviour analysts everywhere in Australia, even though the richer data will be a challenge for us to understand, exploit and communicate.

– Mark Chladil, Fire Management Planning Officer, Tasmania Fire Service

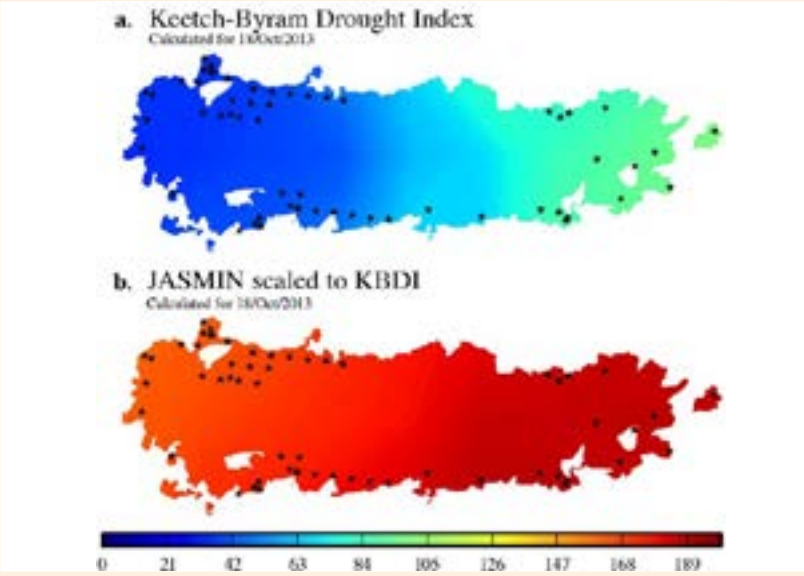
calibration approaches. The correlation with ground observations indicates that all matching techniques have similar skill. Evaluation of the soil dryness products against Moderate Resolution Imaging Spectroradiometer (MODIS) fire radiative power data shows that the JASMIN rescaled product is generally drier than the traditional models (Figure 1, page 1).

HOW COULD THIS RESEARCH BE USED?

The new, more accurate soil dryness analysis system, JASMIN, has been calibrated to enable immediate adoption within the current infrastructure.

The rescaled outputs will be evaluated using many case studies, including past bushfires and fuel reduction burns. These documented case studies are selected and evaluated with the help of end-users and could be used as training documentation by fire agencies.

A pilot project is being initiated, where rescaled outputs from routine JASMIN runs with daily updates will be published in registered user webpages for fire agencies to assess. The routine updates will also be disseminated to the Bureau of Meteorology's extreme weather desk, where the severe weather forecasters can assess the product using the forecasting tools (for example, the Bureau of Meteorology's Visual Weather product) available to them. Also, fire agencies using Visual Weather will be able to use the outputs directly.



▲ **Above:** FIGURE 2. (A) THE KEETCH-BYRAM DROUGHT INDEX AND (B) RESCALED JASMIN SOIL DRYNESS FOR THE STATE MINE FIRE IN NEW SOUTH WALES. THE KBDI IS EXPRESSED AS A SCALE FROM 0–200, WHERE THE NUMBER REPRESENTS THE AMOUNTS OF RAINFALL (IN MILLIMETRES) TO RETURN THE SOIL TO SATURATION. THE PLOT IS VALID FOR 18 OCTOBER 2013. THE SHAPE OF THE PLOT REPRESENTS FINAL FIRE BOUNDARY. THE BLACK STARS DEPICT HOT SPOTS DETECTED BY THE MODIS INSTRUMENT.

KBDI VERSUS JASMIN

One of the cases being studied as part of evaluation is the State Mine Complex fire, which occurred in New South Wales in October 2013. Figure 2a depicts the operationally used Keetch-Byram Drought Index (KBDI) calculated at five-kilometre resolution for 18 October 2013. The JASMIN product for the same date is given in figure 2b. The black stars show hot spots detected by the MODIS instrument. The JASMIN product is far drier compared to the traditionally used KBDI. The KBDI here may be under-predicting the soil dryness, as verifications have shown that it generally has a large wet-bias.

FUTURE DIRECTIONS

Future work will explore the downscaling of JASMIN outputs to a spatial resolution of one kilometre using remotely sensed measurements of land-surface temperature. The NASA Land Information System will be used to increase the number of remotely sensed measurements used by the JASMIN system. Longer term work will integrate JASMIN outputs into the new National Fire Danger Rating System.

FURTHER READING

Vinodkumar, Dharssi I, Bally J, Steinle P, McJannet D, and Walker J (2017), Comparison of soil wetness from multiple models over Australia with observations, *Water Resources Research* **53**, pp. 633-646, doi:10.1002/2015WR017738.

Vinodkumar and Dharssi I (2017), Evaluation of daily soil moisture deficit used in Australian forest fire danger rating system, Bushfire and Natural Hazards CRC.

The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

HAZARD **NOTE**

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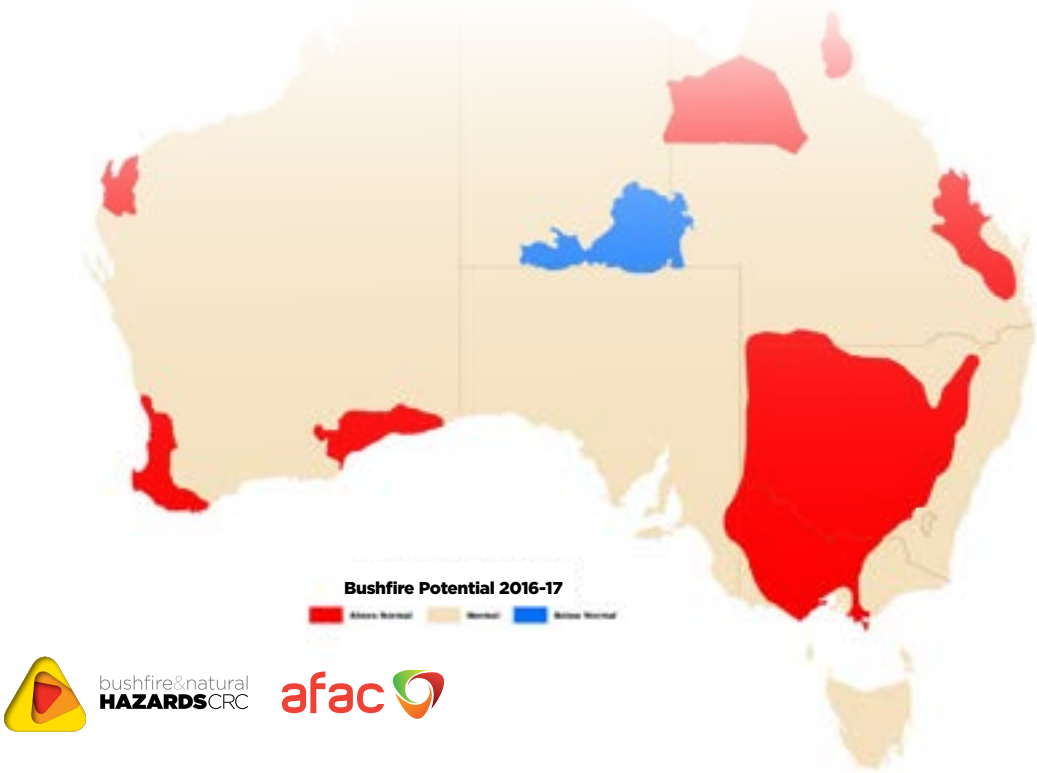
ISSUE 023 NOVEMBER 2016

TOPICS IN THIS EDITION | FIRE WEATHER | FUEL MANAGEMENT

SOUTHERN AUSTRALIA SEASONAL BUSHFIRE OUTLOOK 2016-17: NOVEMBER UPDATE



bushfire&natural HAZARDSCRC afac

OVERVIEW

The bushfire seasonal outlook for 2016-2017 has been re-examined for southern Australia due to a combination of weather factors. Following on from a wet winter across large parts of southern Australia (the second wettest winter on record for the country), September saw further rainfall, with more records broken in parts of central and western New South Wales, western Victoria, eastern South Australia and western Queensland (Figure 1, page 2). Further rainfall is expected to be average to below average in most areas, and when this is coupled with summer temperatures that are forecast to be average to above average, more areas are now expected to experience above normal fire conditions. This risk is predominantly in grassland areas of Victoria and New South Wales, with above average rainfall leading to ideal growing conditions. As temperatures warm, this grass will dry, increasing the risk.

These conditions have resulted in an update to the Southern Australia Seasonal Bushfire Outlook. This new edition, released as *Hazard Note* 23, replaces the previous Outlook, published as *Hazard Note* 19 in August 2016. While Victoria, NSW and Queensland are the areas to receive an update to the map, all states and the ACT are warning of increased grass fire danger, particularly as the fire season progresses.

Other changes to the fire potential are in Western Australia, where the fire risk in the South Western Gascoyne has been reassessed as normal due to the predicted increase in grass fuel loads not eventuating, with soil moisture returning to normal during spring. In Victoria's east, normal fire conditions are now predicted due to a drying of fuels since the August outlook. This area was previously classified as below normal fire potential.

The above map reveals the updated bushfire outlook for 2016-2017 for southern Australia, and has been combined with the outlook for the northern fire season, released as *Hazard Note* 18 in July 2016. It is important to remember that normal fire conditions can still produce fast running and large fires.

HAZARD **NOTE**

DEFINITIONS

Bushfire potential: The chance of a fire or number of fires occurring of such size, complexity or other impact (such as biodiversity or emissions) which requires resources (from both a pre-emptive management and suppression capability) beyond the area in which it or they originate. Bushfire potential depends on many factors, including weather and climate, fuel abundance and availability, recent fire history and firefighting resources available in an area.

Rainfall decile: A decile is a statistical technique that ranks sorted observations into 10 equal groups. A decile rainfall map will show whether the rainfall is above average, average or below average for the chosen time period and area.

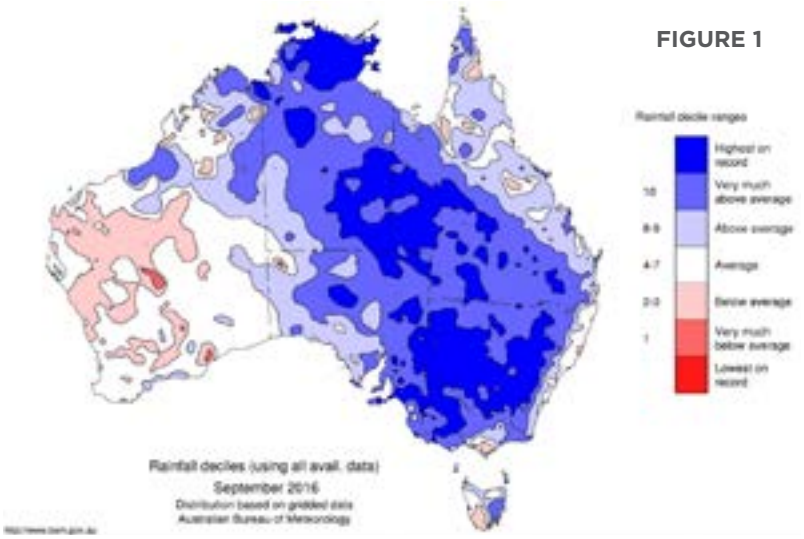


FIGURE 1

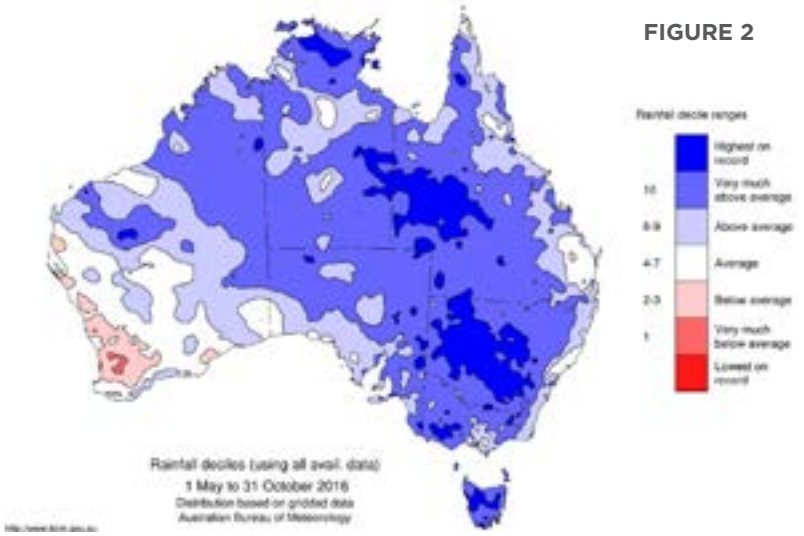


FIGURE 2

RECENT CONDITIONS

The six months from May to October 2016 were the wettest on record for Australia (Figure 2, page 2). However, several regions did miss out on this rainfall, including the coastal strip of New South Wales, eastern Queensland and south west Western Australia. In the areas that did receive it, the high rainfall has contributed to substantial vegetation growth. Maximum and minimum temperatures were cooler than average across large parts of Australia throughout this period, particularly during September and October.

The combination of a strong negative Indian Ocean Dipole and some La Niña-like patterns in the Pacific Ocean have been the key climate influences since autumn. However, these drivers have now returned to a neutral state, which has seen many areas revert to warmer and drier conditions during November, particularly across south west Western Australia and areas east of the Great Dividing Range. More recently, hot and dry conditions have triggered dangerous fire weather conditions across parts of Western Australia, South Australia, Victoria and New South Wales.

UPDATED CLIMATE OUTLOOK

The climate outlook for the coming months through to February 2017 is influenced by warm ocean patterns both in the western Pacific and eastern Indian Oceans, as well as an anomalous northward shift in the prevailing subtropical westerly winds to the south of Australia (known as a negative Southern Annular Mode, or SAM). The outlook for eastern Australia is much drier than earlier forecasts as a result of the decline of the Indian Ocean Dipole, and this northward shift in the westerly winds (Figure 3, page 3). In the tropical Pacific, most indicators of the El Niño–Southern Oscillation are well within neutral bounds. In recent weeks, sea surface temperatures in the central tropical Pacific have warmed, dampening the chances of La Niña development.

In the shorter term, a northerly shift in the average position of westerly winds and high pressure systems (SAM) is forecast for December. When this shift occurs in summer months, it prevents the flow of tropical moisture into southern and eastern Australia, increasing the chances for drier than usual conditions. For December, the outlook indicates it is likely to be drier across much of the continent, particularly for the eastern mainland and parts of southern Western Australia. The summer outlook shows that it is more likely to be drier across eastern mainland Australia.

Temperatures during summer are likely to be above average in large areas of eastern Australia (Figure 5, page 4). Probability shifts in December are strongest across much of eastern Australia, where there is a greater than 80% chance of warmer than average maximum temperatures (Figure 6, page 4). For the

summer period, probability shifts are strongest across southern Queensland and much of New South Wales, with each having a greater than 70% chance of a warmer than average summer.

REGIONAL SUMMARIES

QUEENSLAND

Much of inland Queensland had record or very much above average rainfall from April to September, and as a result there has been significant pasture growth, with grassland curing rates lower than average for this time of year.

Forests were generally wetter than average, with the exception of areas west of the Great Dividing Range, from around Bundaberg, south to the New South Wales border and particularly around Biggenden, Gayndah and Kingaroy.

Since September rainfall has been below average or average, and forest fuel availability continues to increase. With the high likelihood of a dry and hot summer, in particular December, the bushfire potential for areas of south east Queensland is now above normal.

NEW SOUTH WALES

Spring grass growth in the NSW southern border regions has resulted in an amended outlook for this area, with above normal fire potential now indicated. As indicated in the August outlook (see *Hazard Note* 19), a majority of central NSW has above normal fire potential, with prolific grass growth experienced during the spring, and a forecast tending towards above average temperatures for summer. These temperatures are likely to result in accelerated grass curing and increased fire danger.

ACT

With a forecast trend towards hotter and drier weather for the next few months, there is now some potential for conditions conducive to wildfires to develop. Given the wet spring, these conditions are unlikely before January for forests and grasslands. The main operational concern is the raised grassland fuel loading, and the resulting increase in potential fire behaviour. As summer develops, conditions will be closely monitored, particularly if the change to drier conditions occurs earlier than is currently expected.

VICTORIA

An above normal bushfire season is likely across most of Victoria. A departure from longer term drying trends is countered by close to ideal growing conditions for crops and pasture. Severe long term rainfall deficiencies remain in many parts of western Victoria and West and South Gippsland, and may increase the fire risk in forests mid-season. This risk may be pronounced where recent rainfall has not been abundant, such as in West and South Gippsland. In these areas forest fire risk is likely to increase early in summer, along with grass fire risk.

Above to very much above average rain across the state over the last six months has yielded above average or well above average grass fuel, with prolific grass growth in the state's north. In some central and south western areas growth has been limited until now by cooler than normal conditions.

The emergence of widespread fire risk from grass curing is likely to occur later than usual. This may mean crop harvesting in northern and western areas coincides with more severe or extreme fire danger, while expected milder temperatures and available soil moisture near to the south west coast may see curing delayed until February.

The advancement of curing and fire risk is likely to progress quickly across Victoria once temperatures begin to warm and a trend of strong drying in the far east has emerged with an increasing

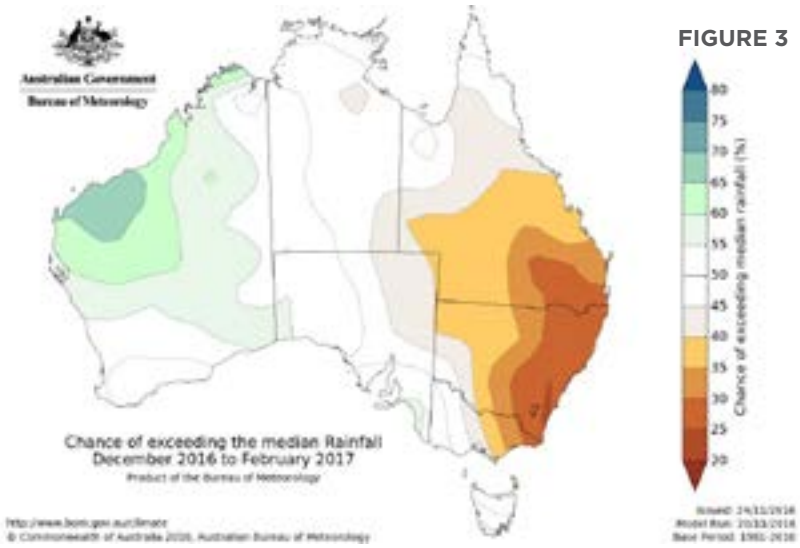


FIGURE 3

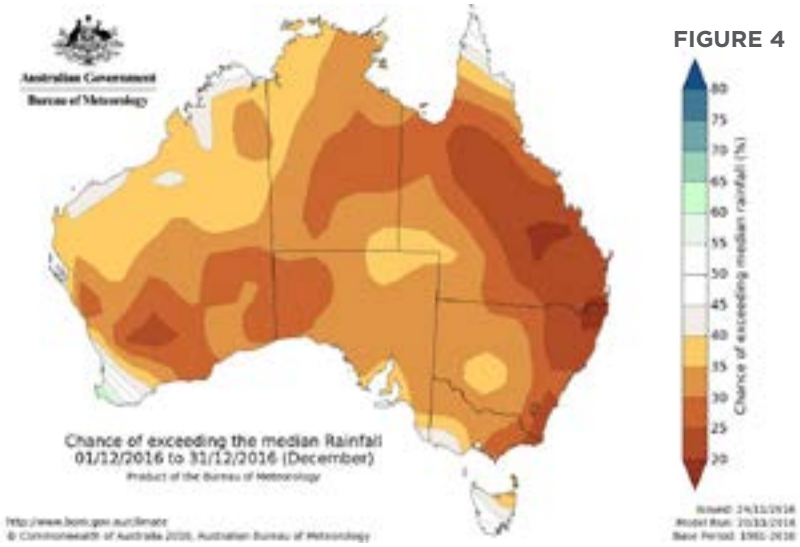


FIGURE 4

dominance of westerly winds. This area has normal fire potential, and the emergence of forest fire risk is expected to consolidate around Christmas. These areas will be closely monitored for further emerging trends throughout summer.

TASMANIA

The fire season continues to be delayed with few vegetation fires to date, and the influence of high soil moisture levels dominates. November rains have reduced threat levels and December rains will determine the commencement of a more normal fire season. Significantly dry conditions in early summer will increase threat levels considerably for February onwards.

Vegetation less influenced by soil moisture such as moorlands, heaths and scrubs have a normal bushfire potential, while forest fuels have normal to below normal bushfire potential. Grassland fuels have a below normal potential until the end of summer, when they may provide a significant threat once they are cured. Opportunities for planned burning will be very limited at least until autumn.

SOUTH AUSTRALIA

The updated outlook conditions for South Australia indicate the majority of the state may experience normal levels of fire activity. The exception to this are parts of the Upper South East, Murraylands and Riverland, which are likely to see above normal fire potential due to significant rainfall deficits in recent years. Whilst the rainfall received across the state during spring will assist with growth, field observations have resulted in the fire danger season commencing on the traditional dates. Normal to above normal fire activity may see the need for firefighting resources deployed over a longer period of time, together with a longer time for mop up post-fires. The areas where there is potential for above normal activity may pose resourcing issues should an above normal level of activity be experienced.

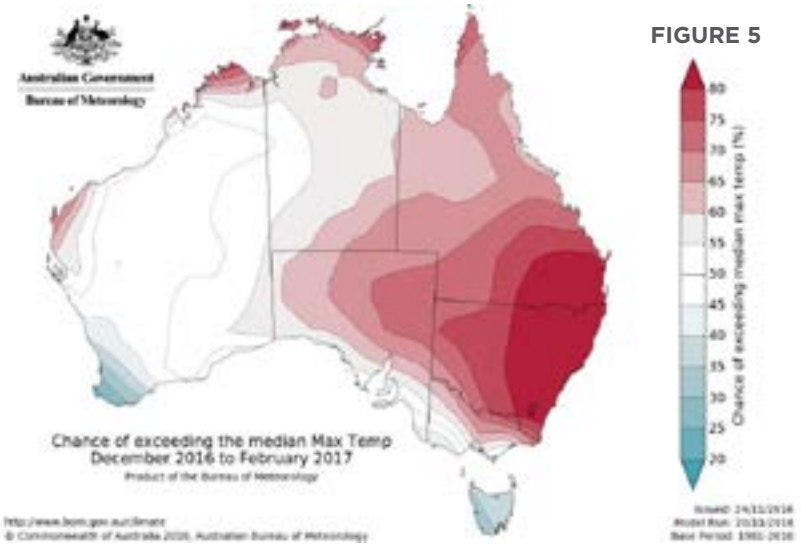


FIGURE 5

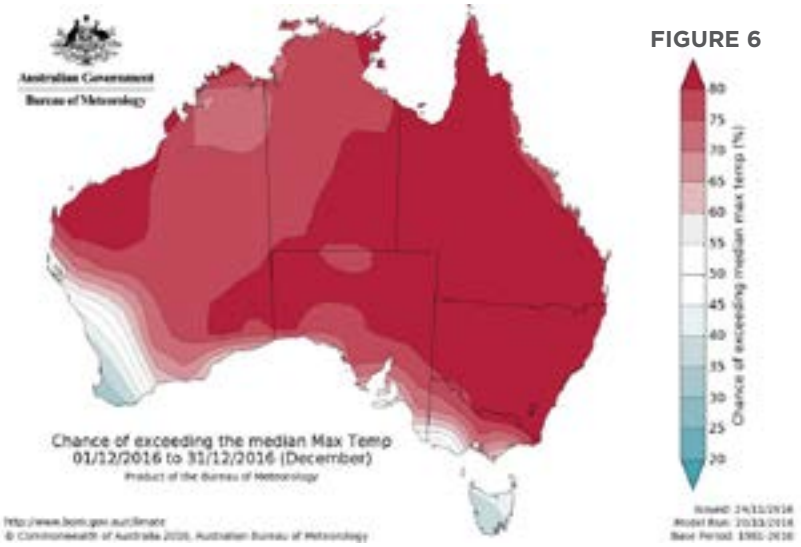


FIGURE 6

WESTERN AUSTRALIA

In the Gascoyne, Murchison, Goldfields, Central West and Desert areas, there is normal bushfire potential due to average rainfall and grass growth. In the Western Pilbara region there is above normal fire potential as a consequence of higher than average grass fuel loads as a result of above average soil moisture. Note that the above normal prediction for the South Western Gascoyne as detailed in *Hazard Note* 19 has been reassessed as the predicted increase in grass fuel loads due to higher than normal late winter soil moistures did not persist into spring. The Eucla and South West areas remain classified as above normal fire potential as described in *Hazard Note* 19.

The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

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HAZARD **NOTE**

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ISSUE 21 OCTOBER 2016
TOPICS IN THIS EDITION | FIRE SEVERITY | FIRE WEATHER | FIRE IMPACTS

NEXT GENERATION FIRE MODELLING

ABOUT THESE PROJECTS

This is an overview of the *Next generation fire modelling* cluster of Bushfire and Natural Hazards CRC research projects. This cluster has four linked studies:

1. **Fire spread across fuel types –** A/Prof Khalid Moinuddin, Dr Duncan Sutherland, Prof Graham Thorpe, Rahul Wadhwani, Victoria University; Prof Andrew Ooi, Dr Daniel Chung, Michael MacDonald, Nitesh George, University of Melbourne. Contact khalid.moinuddin@vu.edu.au
2. **Fire coalescence and mass spotfire dynamics –** A/Prof Jason Sharples, University of New South Wales; Dr Andrew Sullivan, Dr James Hilton, CSIRO. Contact j.sharples@adfa.edu.au
3. **Coupled fire-atmosphere modelling –** Dr Jeff Kepert, Dr Mika Peace, Bureau of Meteorology. Contact j.kepert@bom.gov.au
4. **Determining threshold conditions for extreme fire behaviour –** Dr Trent Penman, Dr Thomas Duff, A/Prof Kevin Tolhurst, Alex Filkov, University of Melbourne. Contact trent.penman@unimelb.edu.au

CONTEXT

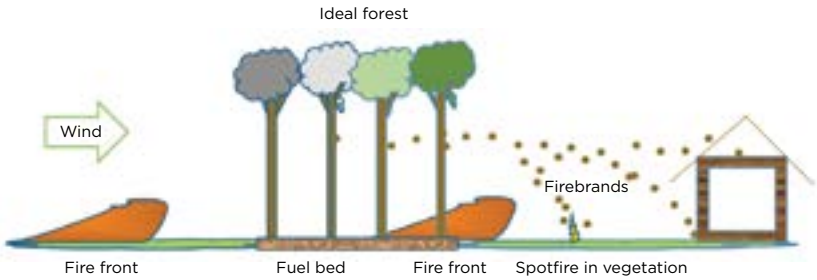
This research cluster is helping to bridge the gap between fire danger prediction systems based on the science of the 1950s and 1960s and those that exploit current research and technology. These projects take a long-term view towards developing more sophisticated fire behaviour models. All of these projects are contributing to the science that will underpin national bushfire predictive services into the future.

FIRE SPREAD PREDICTION ACROSS FUEL TYPES

BACKGROUND

This project is applying physics-based approaches to an ideal fire scenario (represented in Figure 1, right).
The project attempts to simulate the fire with unprecedented detail and in the process obtain useful application tools for end-users.

To address existing gaps in the mathematical and computational modelling of bushfire dynamics, the scenario shown in Figure 1 is subdivided into four parts. Part one is exploiting new observations about the geometric characteristics of trees and forests to determine how fire-spread rate is affected by forested areas compared with open terrain. Part two has designed and built an ember generator to investigate how embers and firebrands travel ahead of bushfires. Improved computational methods that address issues such as the turbulence around bushfires are a key focus of part three. Part four aims to develop simple-to-use formulae that will help fire behaviour analysts to calculate the flow and heat transfer over various surface features, such as buildings.



▲ **Above:** A SCHEMATIC OF FIRE SPREAD MECHANISM IN THE IDEAL FOREST SHOWING SPOTTING IN VEGETATION AND A MODEL HOUSE.

RESEARCH ACTIVITY

Modelling wind speed through tree canopies

The rate of spread of a bushfire depends both on fuel types and the wind velocity profiles at ground and tree canopy levels. Ground cover, tree trunks, branches and leaves all affect the velocity profile. This particular aspect of the project aims to understand the velocity profile within the tree canopy in order to predict the wind reduction factor, which is present in some empirical models of fire spread. This work will improve the modelling of wind-driven fire behaviour as it enters, traverses and leaves a wooded area.

Spread and distribution of firebrands

Embers and firebrands carried ahead of the main fire front often dominate the rate of spread of bushfires. The team is harnessing its expertise in aerodynamics to design, construct and operate a firebrand generator to accurately quantify how embers disperse. Along with wind speed, bushfire spread rates strongly depend on the physical and chemical properties of vegetative materials, such as grasses, wood and leaves. To prepare for experiments using the generator, the team invested in equipment and training for measuring properties such as thermal conductivity, specific heat, density, heat of pyrolysis, heat of combustion and reaction rate constants.

Improving computational methods

Physics-based models of bushfires must consider phenomena that occur on length scales that range from a fraction of a millimetre (e.g. flame thickness) up to several hundred metres (e.g. in terrain). The researchers have addressed this challenge by considering how the average of the small-scale phenomena would affect large-scale phenomena, such as the length and intensity of flames.

Bushfire-driven airflow over surface features
This aspect of the study applies the principles of engineering science to calculate bushfire-generated airflows above buildings, structures and forests. The aim is to quantify the behaviour of airflow and heat transfer in order to calculate how the wind profiles above the surface features of variable heights changes. The approach is to calculate details of the flow and heat transfer to produce highly accurate solutions, from which simple-to-use equations are extracted for operational use.

RESEARCH OUTCOMES

Modelling wind speed through tree canopies
This aspect of the study has successfully predicted the wind velocity profiles through a set of idealised, rectangular canopies of dense vegetation, and the researchers are refining the analysis to account for sparse vegetation. The simulations demonstrate the variation in the wind reduction factor over the canopy and the presence of vortices downstream of the canopy, and will be used to assess idealised models for the wind reduction factor. Further work is required to understand the effect of canopy variability and models for non-ideal canopies over varying terrain.

Spread and distribution of firebrands
The prototype firebrand generator has been designed using computational fluid dynamics software. It projects firebrands at near-uniform velocities, which assists in the analysis. Experiments of the dispersion of cubical and cylindrical particles have been conducted, with early results showing qualitatively similar findings. Bench-scale experiments have also been undertaken to investigate the thermo-physical, flammability and kinetic properties of grasses and litter fuels. These studies will assist in understanding the propensity of grasses and litter fuels to ignite from firebrands.

Improving computational methods
The team has filtered out the small-scale phenomena from the equations that govern bushfire behaviour. This has led to the development of a rigorous, accurate and robust model of buoyancy-driven flows that show great promise for bushfire modelling.

Bushfire-driven airflow over surface features
This part of the study is well advanced and utilisation work to extract simple-to-use equations for operational use is underway.

▲ **Above:** RESEARCH IS INVESTIGATING HOW TO ACCURATELY PREDICT BUSHFIRE BEHAVIOUR WHEN MULTIPLE FIRES ARE BURNING IN CLOSE PROXIMITY. PHOTO: NEW ZEALAND FIRE SERVICE.

FIRE COALESCENCE AND MASS SPOTFIRE DYNAMICS

BACKGROUND

This project addresses a significant knowledge gap about how to model the behaviour of mass bushfire spotting and the interactions of multiple fires adjacent to each other. The inability to accurately predict fire behaviour in these circumstances can exacerbate the risk to firefighters and communities. Research is investigating the processes involved in the coalescence (or convergence) of free-burning fires under experimentally controlled conditions, and quantifying their physical mechanisms. It also investigates the geometric drivers of fire-line propagation, with the aim of developing a physically simplified proxy for some of the more complicated dynamic effects.

RESEARCH ACTIVITY

As well as developing computationally efficient fire-spread models, the study will conduct a targeted experimental program that analyses experimental fires burning under controlled laboratory conditions and in the field.

The researchers will conduct four categories of experiments using CSIRO's Pyrotron facility:

- Parallel fire line experiments
- V-shaped fire experiments
- Ring fire experiments and
- Multiple spotfire experiments.

The project will also analyse data collected during field experiments, such as the CSIRO-led Project Aquarius, which examined the behaviour of point ignitions set in close proximity to each other.

DEFINITIONS

Coalescence – the process of how nearby fires converge together.

Coupled fire-atmosphere model – a model that combines weather and fire, which takes into account how bushfires influence the atmosphere, and therefore the weather.

Curvature – the degree to which a curve deviates from a straight line. In the case of fire modelling, it is how curved the fire front is.

Firebrand – an object that becomes airborne and has the potential to create a spotfire.

Vorticity-driven lateral spread – the rapid lateral propagation of a fire across a lee-facing slope in a direction approximately perpendicular to the prevailing wind direction.

Numerical simulations involving coupled fire-atmosphere models will be used to better understand the physical mechanisms driving spotfire coalescence, to provide information about the scale dependence of their effects and to support two-dimensional model development. The numerical simulations will also provide information about ember trajectories that are driven by an evolving heat source, which will be used to develop an end-to-end model for spotfire development. These simulations will be supported by the supercomputing facilities at the National Computational Infrastructure at the Australian National University.

RESEARCH OUTCOMES

The modelling and simulation aspects of the project have contributed strongly to understanding the processes that drive fire coalescence and dynamic fire spread.

In particular, the research has addressed the role that fire-line geometry (especially curvature) plays in the dynamic propagation of bushfires. The project team has demonstrated the performance advantages of fire propagation models incorporating curvature dependence when applied to simple wind-driven fires at both laboratory and field scales.

The research has also produced fundamental insights into how the shape of the fire line affects the dynamic behaviour of the fire as a whole. Coupled fire-atmosphere modelling was used to investigate how fire-induced air movements (pyroconvection) can produce significantly enhanced rates of spread for certain fire shapes.

END USER STATEMENT

We need better understanding and modelling of how a fire will progress and when it will impact on communities. Greater precision in predicting the size and timing of bushfires will enable fire agencies to better target their warnings and that will help to save lives. Increasing knowledge of the role and influence of weather and ember dispersion ahead of the main fire front is critical for fire agencies in warning and preparing communities under those extreme events. These projects have many benefits in improving the understanding of these issues and applying the research.

– Dr Simon Heemstra, Manager Community Planning, NSW Rural Fire Service

Above: RESEARCH IS INVESTIGATING HOW LARGE BUSHFIRES INTERACT WITH THE ATMOSPHERE, WHICH CAN LEAD TO EXTREME FIRE BEHAVIOUR. PHOTO: GAIL WRIGHT, DEPARTMENT OF ENVIRONMENT, LAND, WATER AND PLANNING VICTORIA.

COUPLED FIRE-ATMOSPHERE MODELLING

BACKGROUND

Large bushfires release substantial amounts of energy into the surrounding atmosphere. This energy release modifies the structure of the surrounding wind, temperature and moisture profiles in three dimensions. The changes driven by the fire can manifest as winds that are similar in speed but opposite in direction to the prevailing winds, pyroconvective clouds and fire-generated thunderstorms. The dynamic feedback loops produced by the fire-atmosphere coupling process can have a dramatic influence on how a fire evolves.

In current operational fire simulation models, simple wind inputs are inserted into a linear algorithm for fire spread to predict how a fire perimeter will evolve across a two-dimensional landscape. This approach does not incorporate the three-dimensional interactions between the fire and atmosphere and, in many cases, will provide a limited depiction of how a fire may evolve, particularly in a dynamic environment in high terrain where the risk is elevated. This project explores the ability to model fire-atmosphere interactions through use of a coupled model.

RESEARCH ACTIVITY

The project uses the Australian high-resolution weather prediction model ACCESS, coupled to a fire spread model. The ACCESS model has been used to examine several high impact bushfires and has provided detailed insights into the meteorological processes impacting the fire environment. Coupling ACCESS to a fire model builds on previous expertise and provides opportunity for future development and real-time use of coupled modelling in Australia.

Case studies will be run to test and validate the model, with the Waroona fire in Western Australia in January 2016 selected as the first case study. Over a two-day period there were two separate pyroconvective thunderstorms, triggered by different processes during the diurnal cycle. In addition, analysis of Doppler radar data shows detail of the rapid plume development contributing to the ember shower that burnt over Yarloop, causing two fatalities.

RESEARCH OUTCOMES

The coupled fire-atmosphere model ACCESS-Fire will be installed on national Australian computing infrastructure for research application, with future capability for operational use. The model will be used to run a series of case studies. Detailed examination of high impact events and verification against available meteorological and fire behaviour data will highlight the importance of assessing and predicting the likelihood of fire-atmosphere interactions in anticipating fire evolution. The close links of the project team with operational and training activities will provide a clear pathway for implementing research findings.

HAZARD **NOTE**

THRESHOLD CONDITIONS FOR EXTREME FIRE BEHAVIOUR

BACKGROUND

Particular fire phenomena occur only in extreme fire conditions. These include fire tornados, atmospheric coupling (see previous project), ember storms and vorticity-driven lateral spread (see breakout box, page three). Research into such phenomena is limited and there are no operational fire spread models that can accommodate them. The first step towards accounting for these phenomena is to describe them and the conditions under which they occur – this includes fuel conditions, surface weather and atmospheric profiles.

This project will build knowledge of the unique features of extreme fires by a) collating observations of extreme fires in Australia in recent years, and b) analysing fire phenomena in conjunction with accessory information (i.e. weather, fuel and topography).

▲ **Above:** FIRE DATA, INCLUDING OBSERVED BEHAVIOUR, WEATHER FORECASTS AND WEATHER OBSERVATIONS, IS BEING COLLATED TO HELP TO UNDERSTAND UNDER WHAT CONDITIONS EXTREME FIRE BEHAVIOUR CAN OCCUR. PHOTO: NSW RURAL FIRE SERVICE.

RESEARCH ACTIVITY

This project involves three overlapping research activities:

Collating fire behaviour observations

The researchers will create a database of observations of extreme fire behaviour to use in model development and verification. They will work directly with fire and land management agencies to develop reconstructions of past fire events. This will include structuring a database, standardising data formats and processing historic reconstructions. This will involve collating both fire data and accessory data, such as weather observations and forecasts. Existing datasets will be audited, including those developed during the Bushfire CRC and outside the CRC program. This information will be useful for all projects within this cluster.

Understanding extreme fire weather and fire behaviour

This work will determine the thresholds in fire and environmental conditions (weather, fuel, topography) that lead to extreme fire phenomena.

It will use data about past fires to identify processes that lead to extreme phenomena. This will include analysing smoke plume observations from Bureau of Meteorology weather radars, three-dimensional numerical weather predictions and impact maps. These sources will be used to determine fire-related parameters, including the strength of convective winds and spotting patterns.

Factors linked to extreme fire behaviour

This aspect of the study will identify the extent to which extreme fire behaviour occurs in Australia and attempt to develop simple, statistical equations to represent dynamic fire phenomena that may be integrated into existing fire-behaviour models.

The researchers will determine relationships between specific characteristics of extreme fire behaviour and the conditions under which they occur. This will include analysing the conditions on the ground (such as fuel, temperature and relative humidity), fire properties (such as observed flame heights and rates of spread) and atmospheric conditions.

Statistical methods will be used to assess whether there are thresholds for extreme fire activity and to describe its nature when it does occur.

FURTHER READING

Duff T, Penman T, Filkov A (2016), Determining thresholds for extreme fire behaviour: annual project report 2015-2016, Bushfire and Natural Hazards CRC.

Kepert J, Peace M (2016), Coupled fire-atmosphere modelling: annual project report 2015-2016, Bushfire and Natural Hazards CRC.

Moinudeen K, Sutherland D, Thorpe G (2016), Fire spread prediction across fuel types: annual project report 2015-2016, Bushfire and Natural Hazards CRC.

Sharples J, Hilton J, Sullivan A (2016), Fire coalescence and mass spotfire dynamics: experimentation, modelling and simulation annual project report 2015-2016, Bushfire and Natural Hazards CRC.

The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

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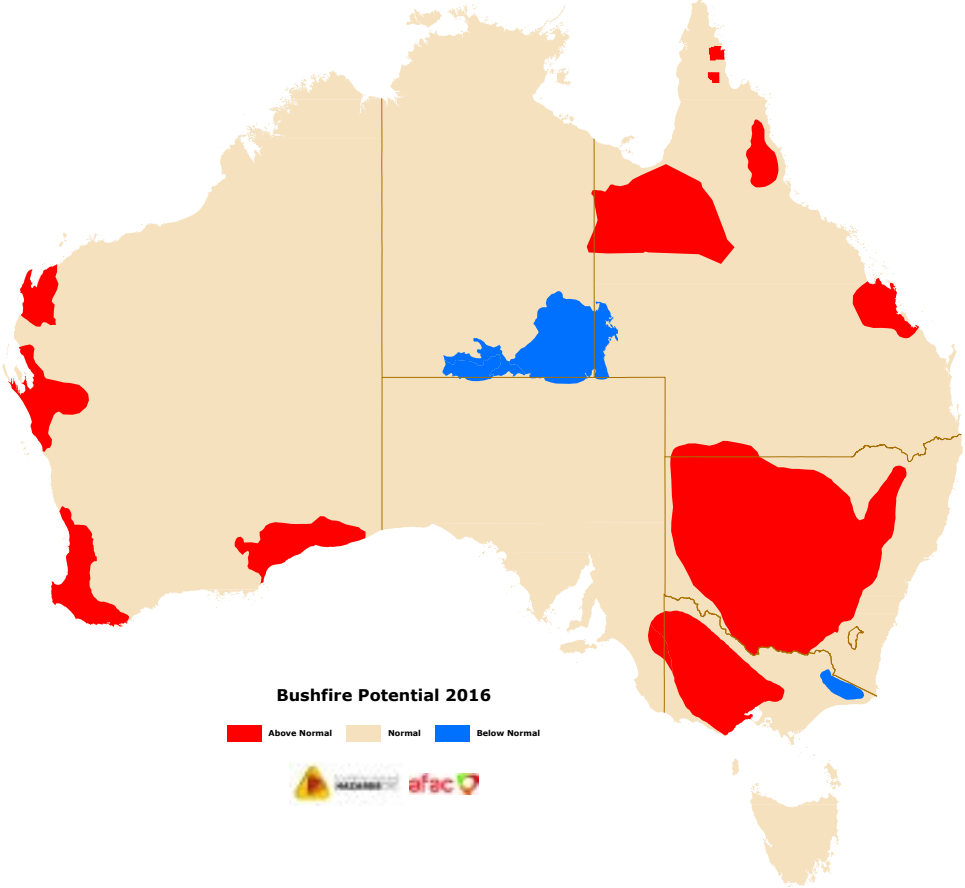
HAZARD **NOTE**

ISSUE 019 AUGUST 2016
TOPICS IN THIS EDITION | FIRE WEATHER | FUEL MANAGEMENT

SOUTHERN AUSTRALIA SEASONAL BUSHFIRE OUTLOOK 2016



OVERVIEW

The Seasonal Bushfire Outlook for southern Australia is used by fire authorities to make strategic decisions on resource planning and prescribed fire management for the upcoming fire season. The outlook is developed at an annual workshop convened by the Bushfire and Natural Hazards CRC and the Australasian Fire and Emergency Service Authorities Council (AFAC).

At the 2016 workshop in Brisbane in August, the Outlook was assessed and a range of broad climate factors were considered.

The above map shows the bushfire outlook for southern Australia through to the end of 2016. This map has been combined with the outlook for the northern Australia bushfire season, which was released at the beginning of July, to show the areas of fire potential for all of Australia. (See *Hazard Note* 18, July 2016). This Outlook will be reviewed towards the end of spring to take into account the impacts of actual temperatures and rainfall in the lead up to summer.

The Southern Seasonal Bushfire Assessment Workshop brought together fire and land managers, climatologists and meteorologists to evaluate the upcoming season for the southern part of Australia.

BUSHFIRE POTENTIAL

Fire season potential depends on several factors. The amount, location and timing of rainfall in the period leading up to the fire season are critically important for estimating fuel loads and dryness. The temperature and rainfall outlooks for the next few months are crucial factors for influencing the development of fire threat.

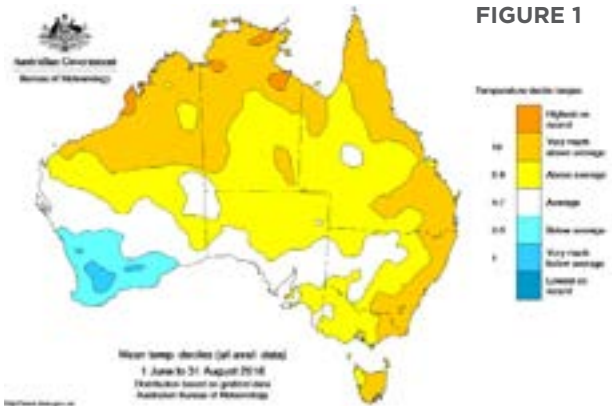


FIGURE 1

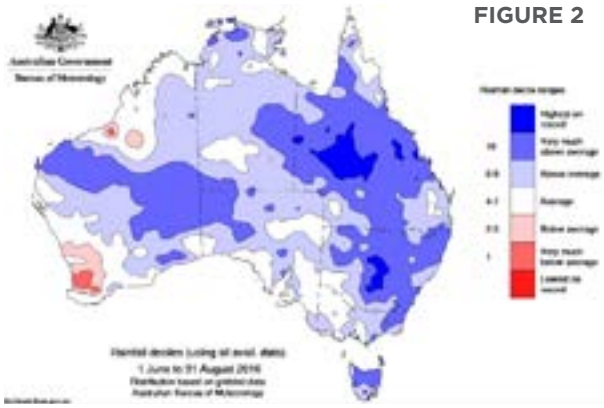


FIGURE 2

Of particular importance are the future tendencies of sea surface temperatures in the Pacific Ocean, associated with the El Niño-Southern Oscillation, and those in the Indian Ocean. These are major drivers of climate over much of Australia. Other factors considered include the distribution of firefighting resources to meet potential threats, as well as previous fire activity and the amount of prescribed burning that can reduce the threat.

The workshop discussed the weather, landscape conditions and cross-border implications leading into summer and determined areas that had the potential for a fire season that was above normal, normal or below normal. Attendees included representatives of the Bushfire and Natural Hazards CRC, AFAC, the Bureau of Meteorology, Queensland Fire and Emergency Services, Tasmania Fire Service, the Australian Capital Territory Emergency Service Agency, the New South Wales Rural Fire Service, South Australia's Country Fire Service, Victoria's Country Fire Authority and Department of Environment Land, Water and Planning, and Western Australia's Department of Parks and Wildlife and the Department of Fire and Emergency Services.

ANTECEDENT CONDITIONS

For every month of 2016 the Australian national mean temperature has been above average. This warmth culminated in the August 2015 to July 2016 period was +1.33 °C above the 1961-1990 average, the largest anomaly for any 12-month period since records began in 1910.

Despite a number of significant cold spells, winter has continued the pattern of above average temperatures, with a mean temperature anomaly of +0.9˚C (Figure 1). The longer term changes are important for the season ahead, noting that summer 2015/2016 marked the fourteenth consecutive warmer than average southern fire season (October to April). These warmer conditions have contributed to elevated fire risk in most years in recent decades.

After a dry second half of 2015, most parts of Australia have seen very good rainfall since mid-autumn 2016 (Figure 2). Nationwide, preliminary analysis shows that winter 2016 saw a national average rainfall of 116mm, the second wettest on record. June and July were both particularly wet months, with June 2016 being the second-wettest June on record, while large areas of the country reported record high rainfall during July. The pattern of heavy rainfall following a strong El Niño is not uncommon and is tied to the warming of ocean waters around Australia.

Winter rainfall was particularly good across Queensland, most of NSW, Tasmania, eastern Victoria and parts of inland and central districts of South Australia and eastern Western Australia. A beneficial result of the above average rainfall has been the removal of short-term rainfall deficiencies, with soil moisture now near or above normal. Rainfall tended closer to average in remaining parts of Victoria and the west coast and Murray Mallee areas of South Australia. The far south west of Western Australia has experienced another winter of below average rainfall, meaning that 15 of the past 16 winters have been below average. In this region the long-term drying of vegetation and the landscape continues in a pattern that became established in the 1970s.

The generally good rainfall and above average temperatures has seen vegetation growth that is above average across much of southern and eastern Australia, particularly through much of New South Wales. With good soil moisture conditions and above average rainfall forecast, this pattern is expected to continue for some months, increasing fuel loads.

Winter 2016 was a period that saw Australia's climate become strongly influenced by a negative Indian Ocean Dipole. This pattern tends to increase winter and spring rainfall for southern and eastern Australia and generally sees cooler than average temperatures. Typically, once a negative Indian Ocean Dipole becomes established in the winter, it is expected to persist through spring and decay rapidly in summer. Meanwhile, ocean temperatures along the equatorial Pacific returned to near average values following the end of the strong 2015/16 El Niño. The range of observations and model forecasts suggest that the tropical Pacific will continue to remain in neutral conditions (though just falling short of a La Niña) or may see the development of a weak La Niña. The Indian Ocean Dipole is expected to persist into spring, and is likely to end around November.

CLIMATE OUTLOOK

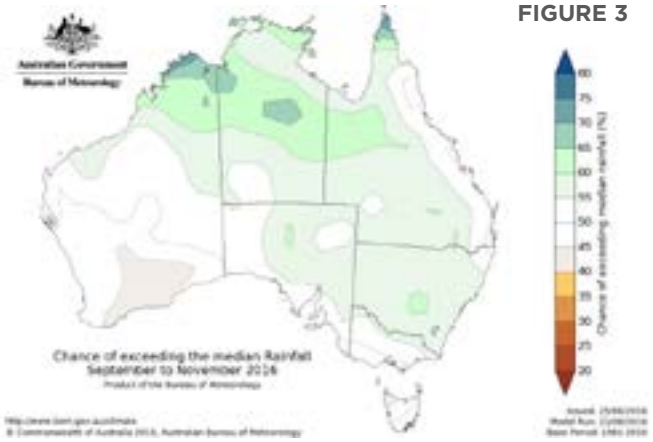
The climate outlook for the coming three months is influenced by both the Pacific and Indian Oceans. The combination of neutral to near La Niña in the Pacific and a negative Indian Ocean Dipole favours wetter than average conditions in many areas. While the natural drivers will tend to reduce temperatures, the overall pattern of well above average global temperatures (i.e., global warming) means that Australian temperatures are expected to be mostly above average.

The outlook for spring rainfall indicates a higher chance of above average rainfall is likely across most of northern and eastern Australia. The probability of above average is typically in the range of 55 to 65 percent, meaning a leaning towards wetter than average conditions. In some contrast, the odds in south west Australia are tending towards below average rainfall. The rainfall odds are close to 50:50 elsewhere.

The outlook for both maximum and minimum temperatures strongly favours above average temperatures across most of Australia. The likelihood of above average temperatures is typically in the range of 60 to 75 per cent, locally exceeding 80 per cent in Tasmania and in some northern areas. This forecast suggests that Australia is likely to experience another warmer than average spring, with summer-like temperatures likely to start earlier in southern Australia than is historically the case.

Updates to forecasts and the outlook for the Indian Ocean Dipole and La Niña are published at www.bom.gov.au/climate/ahead.

FIGURE 3



REGIONAL SUMMARIES

QUEENSLAND

While some parts of inland Queensland have seen record rainfalls, much of the state remains drought affected and grass fuel loads are still sparse to moderate in these areas.

With the exception of the south east corner of the state, forested areas have received above average rainfall in the three months leading up to the start of the fire season. As a result the fire season is likely to see a slower start than usual. The outlook is for lower maximum temperatures and above average rainfall through to October. These two factors, plus the likelihood of an early northern rainfall onset, make the potential of an above normal fire season unlikely across most of Queensland.

Queensland Fire and Emergency Services worked closely with Queensland Parks and Wildlife around Rockhampton to assess the increased risk as a result of Severe Tropical Cyclone *Marcia* in preparation for the 2015 fire season. Mitigation activities guided by these assessments continued in the lead up to the 2016 season. Residual risk remains in the area and this will be a focus again this season.

Soil moisture is relatively dry to the west of the Great Dividing Range, from around Bundaberg, and south to the New South Wales border, particularly around Biggenden, Gayndah, Kingaroy and Dalby. While normal fire potential is expected for this outlook period, it is important to recognise that an active fire season is still probable and more likely in the areas with the underlying soil dryness.

NEW SOUTH WALES

A delayed start to the bushfire season in New South Wales is likely due to above average winter rainfall for much of the state, and a prediction for the chance of above average rainfall over the next three months.

However, a predicted end to the current negative Indian Ocean Dipole and more neutral El Niño-Southern Oscillation conditions in spring could see a shift away from wetter and cooler conditions towards more typical summer conditions. This shift could be exacerbated by the warmer than average temperatures – as part of a global warming trend – that are drying forest and grassland fuels.

It is expected that the significantly higher than average rainfall received over winter in the central and western parts of the state will result in prolific grass growth over spring. This grass growth, combined with a drying phase and summer conditions, could lead to above normal fire potential for central and western grassland areas during summer.

The trend towards significantly exceeding average rainfall totals was less pronounced adjacent to the south western and western boundaries of the state. As a result, the prediction here is for normal bushfire potential as the likelihood of prolific growth is not considered high.

The Sydney Basin and the Greater Hunter have followed the trend for above average rainfall over winter and are likely to see a delayed start to the bushfire season. However, the prediction for conditions to shift towards more typical conditions over summer could see fuel availability coinciding with the peak of summer, leading to the prediction for normal bushfire potential.

Forested areas south of Sydney have also received above average rainfall over winter. A late start to the fire season is common for these areas and, therefore, fire potential is expected to follow a normal season pattern.

Recent rainfall in northern New South Wales has reduced the potential from the early predictions of an above normal season, to a season that is likely to follow a more normal pattern.

ACT

After three wet months the upper soils in the Australian Capital Territory are wetter than average for this time of year. The forecast changes of the Pacific and Indian Oceans, towards climatically neutral conditions, are expected to bring near average rainfalls and temperatures through to at least November.

This could encourage an early and vigorous growth of grasses. It will also boost the recovery of the high country forests that have been affected by large fires since 2003. These higher fuel loads may be offset by the effects of rainfall on fuel flammability.

High levels of grassland curing may not be seen until mid-summer at the earliest. The amount of flammable fine fuels in the forest areas is also expected to remain low until mid-summer.

As a result, the bushfire potential for this outlook period is assessed as normal.

As summer approaches, conditions will be closely monitored, particularly if there is an earlier than currently expected change to drier conditions.

VICTORIA

East Gippsland has a mostly below normal fire potential this year. It has received very much above average rain in the short and long term, and the temperature outlook is not likely to support strong late spring drying in the forests. The fire season in East Gippsland is expected to begin later than normal on these current signals. The marginal chances of above average rain along the Murray River and in Far East Gippsland raise the possibility of a delayed start to the fire season in those areas. This also means the Murray

Valley is likely to have normal fire potential despite underlying dryness in some areas.

In west and south Gippsland, parts of Victoria's Central Highlands, including Melbourne's water catchments, and across most of south west Victoria, the slight chance of above average rain coupled with a high probably (80 percent) of above average temperatures, plus existing severe rainfall deficits, indicates strong late spring drying is likely in forested areas. This could see rapidly escalating fire behaviour later in summer.

Most soils in the extensive western grass plains and their forests have saturated upper layers this year, in many areas evidenced by accumulations of surface water; but a dryness remains at deeper levels, and the current weak signal for spring rain is likely to mean good overall grass growth in these areas, with insufficient available water to soak deeper into the soil to reduce the fire risk in the forests. Melbourne's water catchments have not yet been saturated and now have a long history of underlying dryness. Forest fuels have increased since the 2009 fires, so there is once again potential for fire. Similarly, the eastern Otway Range, Brisbane Ranges, Wombat Forest, and drier forest types bordering Victoria's box ironbark belt also have a long history of dryness. These areas have above normal fire potential.

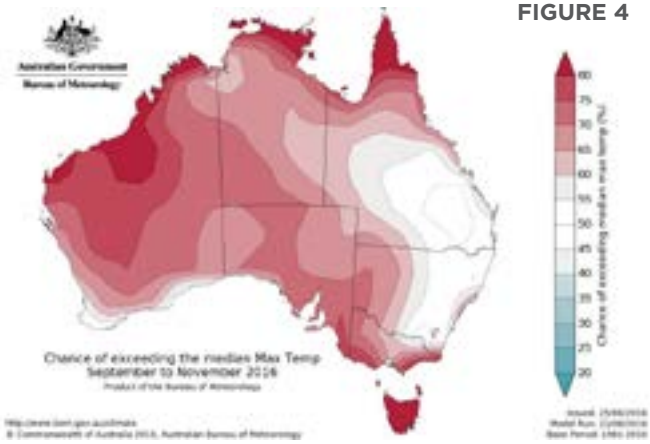
TASMANIA

The start of the fire season in Tasmania will be delayed as long as top up rains continue, which is expected to at least October and possibly later.

Fuels less influenced by soil moisture such as moorlands, heaths and scrubs, have a normal bushfire potential, while forest fuels have normal to below normal bushfire potential. Grassland fuels have a normal to below normal potential, but will provide a significant threat in the New Year when they are cured. Given the wet outlook for the next few months, opportunities for planned burning will be very limited, at least until autumn.

By early summer, without top up rain, most fuels will have a normal potential in terms of ignitability. Fire weather conditions are likely to be average or even subdued. However, if rainfall is above average the fire season potential will be below normal at least until the New Year, when grasslands will cure. Overall, the state has normal bushfire potential.

FIGURE 4



SOUTH AUSTRALIA

South Australia has experienced a wetter than average winter, resulting in the current Soil Dryness Index being below the 10-year average across the state. The potential for slightly above average rain is forecast to continue through September and into October, which may lead to the fire season starting later than in recent years.

This puts the outlook in line with the more traditional South Australian fire season, and as a result, current indications are that most parts of the state can expect a normal fire season. Good rainfall will promote growth, particularly in pastoral areas; however, many of the forested areas have received good soaking rains and will not burn as early as they have in previous years. The exception is parts of the Mallee and Upper South East of the state, which have experienced significant rainfall deficits in recent years. As a result, and despite recent rainfall, these areas are assessed as above normal fire potential.

WESTERN AUSTRALIA

The bushfire outlook for Western Australia has been derived from several information sources including the relative root zone moisture availability, pasture biomass, recent bushfire and prescribed burning history and forecasted weather conditions.

In the Eastern Gascoyne, Murchison, Goldfields, Central West and Desert areas, there is normal bushfire potential due to average rainfall and grass growth.

In the Western Gascoyne and Pilbara regions there is above normal fire potential as a consequence of higher than average grass fuel loads in response to above average soil moisture.

The Wheatbelt and Great Southern regions have above average grass fuel loads for this time of the year due to good rainfall. However, this is not expected to result in above average fuel loads at the end of the growing season, given the impacts of crop harvesting and grazing.

In the Eucla, east of Norseman, above average soil moisture and subsequent pasture growth, combined with pre-existing mature fuels, have resulted in the expectation of higher than normal bushfire potential.

In the South West, despite early and close to average rainfall, there is an underlying long-term deficit in the soil moisture. Recent bushfires and prescribed burning have reduced fuel loads in localised areas. However, on the landscape scale, the current high loads of forest fuels have resulted in above normal fire potential.

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HAZARD **NOTE**

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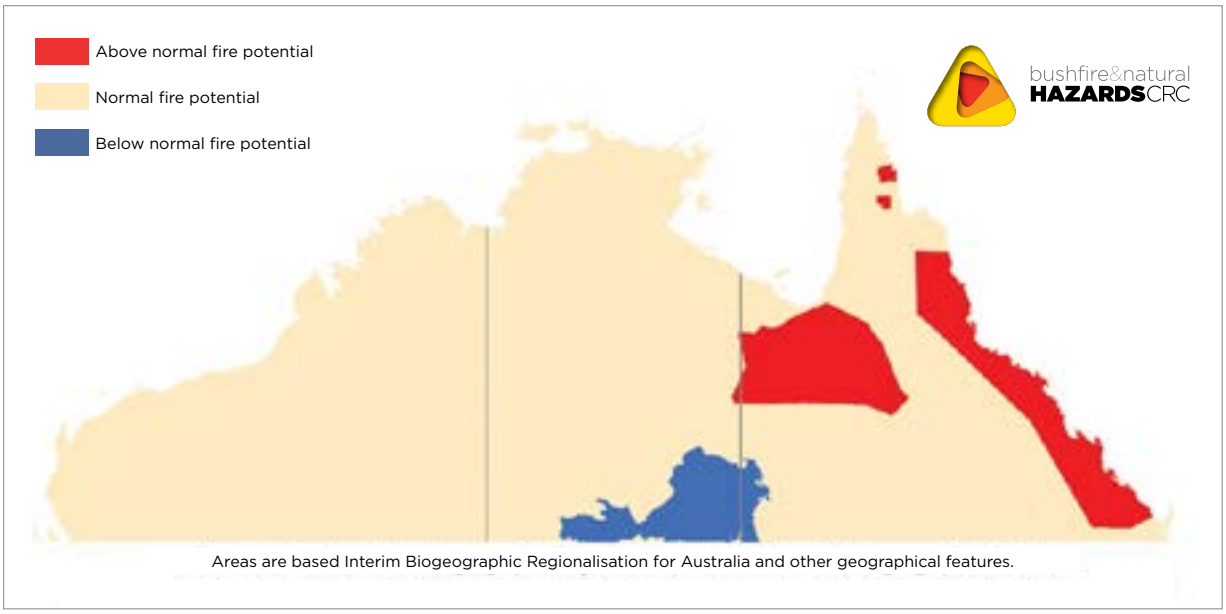
ISSUE 18 JULY 2016

TOPICS IN THIS EDITION | FIRE WEATHER | FUEL MANAGEMENT

NORTHERN AUSTRALIA SEASONAL BUSHFIRE OUTLOOK 2016



BUSHFIRE POTENTIAL

This *Northern Australia Seasonal Bushfire Outlook* provides information to assist fire and land management agencies in making strategic decisions such as resource planning and prescribed fire management to reduce the negative impacts of bushfire.

A *Seasonal Bushfire Outlook* for southern Australia will be distributed in early September, and will include an update on the northern fire season.

Bushfire potential depends on many factors. In northern Australia, conditions are determined by the nature of the previous wet season. The volume, location and timing of rainfall are critically important when estimating fuel volumes and growth. They also affect the timing of the drying of the fuel.

The climate outlook for the next few months is also a crucial factor. Of particular interest are the future tendencies of Pacific sea surface temperature associated with the El Niño-Southern Oscillation, a major climate driver over Australia. Other less quantifiable factors, such as the distribution and readiness of firefighting resources, are also considered.

The annual Northern Australian Fire Managers' Group Forum, chaired by Bushfire and Natural Hazards CRC CEO Richard Thornton, met in Alice Springs in June. During the two-day proceedings the Forum discussed the seasonal outlook for the imminent fire season, enabling the production of this *Hazard Note*. All other presentations from the Forum are online at www.bnhcrc.com.au.

Forum attendees included representatives of Bushfires NT, NT Fire and Rescue Service, Parks and Wildlife Commission of the NT, Queensland Fire and Emergency Services, Queensland Parks and Wildlife Service, WA Department of Fire and Emergency Services, WA Department of Parks and Wildlife, the Bureau of Meteorology, AFAC, Charles Darwin University and the Central Land Council.

ANTECEDENT CONDITIONS

The 2015-2016 northern wet season was affected by one of the strongest El Niño events on record. The El Niño remained strong throughout the summer, before weakening in autumn. Neutral conditions have recently become established, and there remains a significant chance that a La Niña will develop in the coming months. The Pacific warmth (El Niño) has coincided with near-record warm ocean conditions across almost the entire Indian Ocean.

As a result of the strong El Niño, wet season rainfall was patchy, tropical cyclone activity suppressed and temperatures at record warmth. Most coastal areas had below average rainfall for October to April. In contrast, an area of above average rainfall occurred in a belt from near Katherine to the Alice Springs region. The bulk of this rainfall fell in a couple of weeks around Christmas Day and early January, associated with a slow-moving

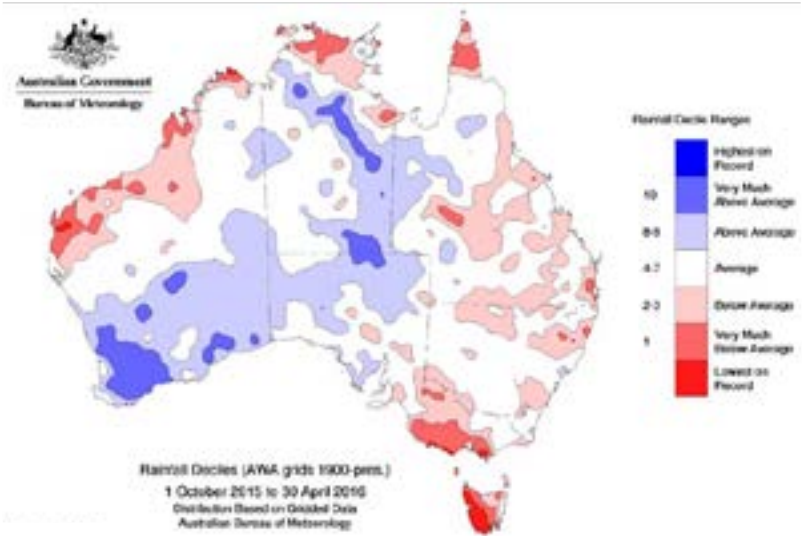
HAZARD **NOTE**

DEFINITIONS

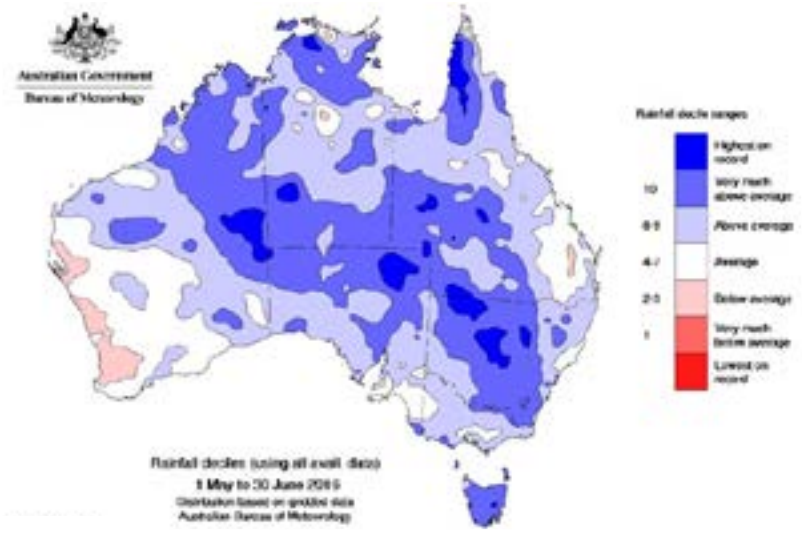
Bushfire potential: The chance of a fire or number of fires occurring of such size, complexity or other impact (such as biodiversity or global emissions) that requires resources (from both a pre-emptive management and suppression capability) beyond the area in which it or they originate. Fire potential depends on many factors including weather and climate, fuel abundance and availability, recent fire history and firefighting resources available in an area.

Rainfall decile: A decile is a statistical technique that ranks sorted observations into 10 equal groups. A decile rainfall map will show whether the rainfall is above average, average or below average for the chosen time period and area.

IBRA: Interim Biogeographic Regionalisation for Australia. Australia's landscapes are divided into 89 large geographically distinct bioregions based on common climate, geology, landform, native vegetation and species information.



▲ **Figure 1:** RAINFALL DECILES FOR 1 OCTOBER 2015 TO 30 APRIL 2016.



▲ **Figure 2:** RAINFALL DECILES FOR 1 MAY TO 30 JUNE 2016.

monsoon depression. In Queensland, March saw some heavy rainfall, particularly near the Northern Territory border and southern Cape York Peninsula, with patchy areas of above average rainfall along the coast.

Weaker than normal monsoonal activity in the north meant that much of Queensland continues to suffer substantial rainfall deficits over periods of three to four years (dating back to late 2012). These deficiencies are reflected in agricultural drought declarations that currently affect more than 80% of Queensland. In the Northern Territory and Western Australia long-term deficiencies are patchier and less severe in intensity.

A notable feature of the past 12 months has been record heat. Mean temperatures for the 12 months ending June 30 were some +1.3°C above the 1961-1990 average across northern Australia, beating the previous record of +0.9°C set in 2013/2014. Records were also set for both maximum and minimum temperatures over the same period.

The return to neutral El Niño-Southern Oscillation (ENSO) conditions in April and warming in the eastern Indian Ocean (a precursor to a likely negative Indian Ocean Dipole) has triggered a shift in Australia's climate toward favouring wetter conditions. Above average to locally record high May-June rainfall has fallen across almost all of northern Australia (see Figure 2, above), with some areas such as the central west of Queensland having more rainfall during this period than in the whole of 2015. The combination of a relatively poor wet season (and very poor second half), followed by unseasonal dry season rainfall is highly unusual.

Vegetation across northern Australia has dried rapidly in response to the record warm and dry second half to the northern wet season, despite the unusual rainfall in May and June.

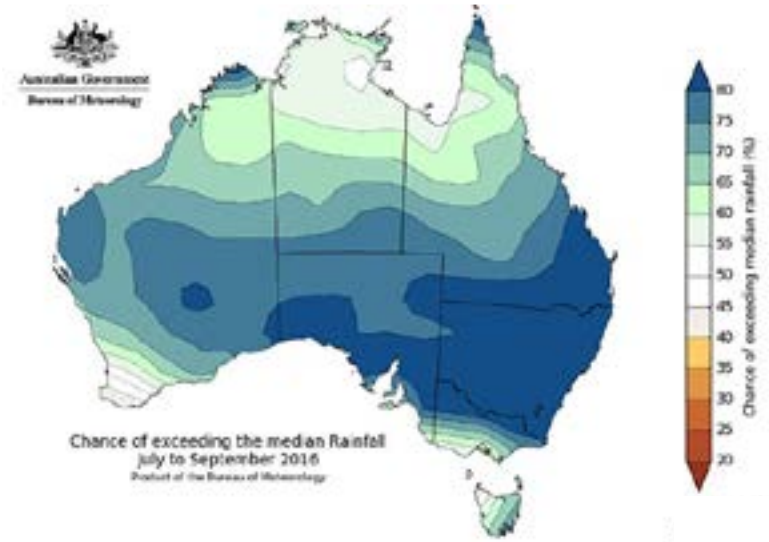
CLIMATE OUTLOOK

The Pacific Ocean is currently experiencing neutral ENSO conditions, with the Indian Ocean remaining at near-record warmth. While there remains some uncertainty around future developments, it is likely that a negative Indian Ocean Dipole will develop in the coming weeks, while neutral to weak La Niña conditions are expected in the Pacific. There remains the possibility that a more significant La Niña could develop later in 2016, but this is assessed as being less likely. The combination of these climate drivers means that an early start to the wet season is now likely for northern Australia, which might bring an early end to the fire season.

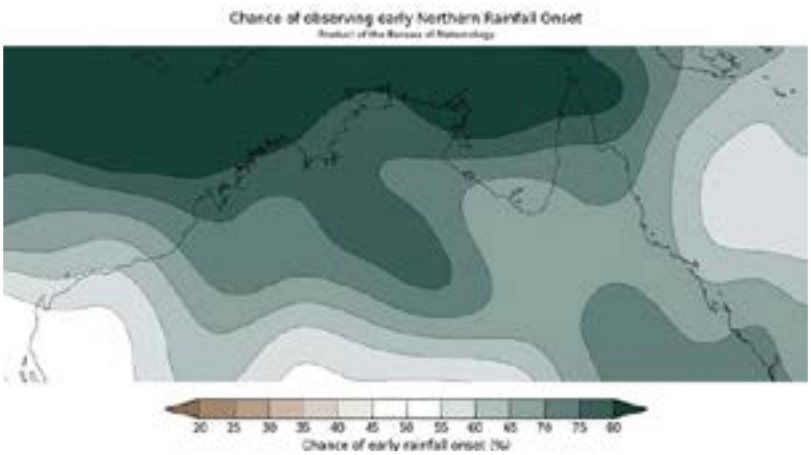
The July to September period is normally dry for northern Australia, with low rainfall except near the tropical Queensland coast. This means that the impact of rainfall in the coming months, even if it is above average, will tend to be quite modest. For Australia as a whole (Figure 3, right), rainfall moderately to strongly favours above median rainfall. The probability of above median rainfall is greater than 70% in central Australia and typically 55 to 65% in tropical Australia. These probabilities suggest that the higher rainfall seen in May and June may be expected to continue through until September, although rainfall over northern Australia is typically low during this period. Historical outlook accuracy for July to September is moderate over most of northern Australia, except around the border of Western Australia and the Northern Territory, and areas surrounding the Gulf of Carpentaria, where accuracy is low.

July to September is likely to bring above average maximum temperatures to tropical parts, with conditions likely to be cooler than average further south. The overall pattern is similar for minimum temperatures, with the probability of above median typically in the range of 70% or higher in tropical parts, and somewhat less than 50% in parts of central Australia. Maximum temperature accuracy is moderate to high over most of Australia for this time of year. Minimum temperature accuracy is moderate over the northern half of Australia for this time of year.

The climatic conditions and the climate outlook overall presents quite mixed signals for the fire season. For this reason, the state and amount of available fuels, and the predicted earlier onset of northern rainfall, is probably the best guide to the fire season ahead in many parts.



▲ **Figure 3:** THE PROBABILITY OF ABOVE MEDIAN RAINFALL FOR JULY TO SEPTEMBER.



▲ **Figure 4:** THE PROBABILITY OF EARLY NORTHERN RAINFALL ONSET (ACCUMULATION OF 50+MM FROM 1 SEPTEMBER 2016).

REGIONAL SUMMARIES

NORTHERN QUEENSLAND

The bushfire season across northern Queensland is primarily influenced by geographic location, the relationship between climate and vegetation, and long-term, seasonal and short-term climatic conditions. The 2015/2016 wet season did not produce much rain, with the main falls coming in May and June, outside the normal period. The impact of this more recent rain is unclear at this time.

Following three years of drought, much of western and central Queensland has been destocked. This year's rain has led to increased fuel loads in some of these areas. However due to both the high price and shortage of store cattle they remain either destocked or lightly stocked. This has created higher than normal fuel loads that will carry into this northern Queensland fire season.

In February 2015 Severe Tropical Cyclone *Marcia* (see *Hazard Note* 8 July 2015 for information on the impact of *Marcia* on fuel levels) caused significant damage to the vegetation around Rockhampton. Very strong winds stripped leaves from the canopies and this increased the fine fuel loads and changed the structure of the vegetation.

These changes to the fuel persist and there remains an increased fire risk along the Capricorn Coast. Task Force Marcia was created to manage this increased risk and this work proved valuable to decision makers last fire season. As a result of this success, further work is being undertaken in preparation for this fire season.

Drought declarations are still in force in 36 local government areas, with a further six under partial drought declaration. These areas have limited fuel loads.

In collaboration with other fire and land management agencies, the Carpentaria Land Council Aboriginal Corporation and landowners, the bushfire potential for the fire season has been assessed as follows:

- Above normal fire potential is expected in the coastal ranges from Bundaberg north to around Cooktown.

- Woodlands and grasslands around the Mount Isa region, east to Richmond, north to Normanton and west to near the Northern Territory border have been assessed as having above normal fire potential.
- Isolated patches in Cape York can expect above normal fire potential.
- Below normal fire potential is expected north of Cameron Corner adjacent to the Northern Territory border.

Normal fire potential is predicted for all other areas north of latitude S25°. Regions of south east and western Queensland south of latitude S25° will be assessed during the Southern Australia Bushfire Seasonal workshop in August 2016.

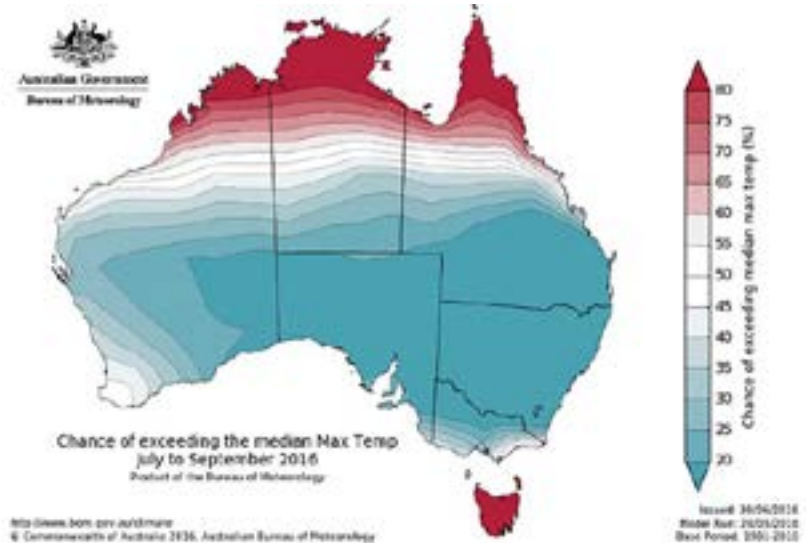
NORTHERN TERRITORY

Overview

Weather events have been quite diverse over the previous six to eight months and inconsistent with previous years. Areas across the pastoral estate have received record rainfall, whilst other areas on the Arnhem Coast have received the lowest rainfall on record. Conditions in Central Australia continue to advance towards another fire season of significant intensity. Pasture conditions and growth also fluctuate across the Territory, with fire potential classified as normal in all areas except the south east, with a level of confidence that it will not exceed into above normal.

Western Top End

The Darwin coastal and Darwin IBRA regions have experienced average to well below average rainfall since October 2015. This rainfall, including late rains in May, was still sufficient, and coupled with sunny days, has been enough to produce average growth of vegetation. The concerning factor was that the unseasonal May rain hampered, and in some cases put a halt on, mitigation burning. This rain also led to regrowth of already burnt areas, impacting on the effectiveness of the completed burns, and delayed planned mitigation work, affecting fire management outcomes.



▲ **Figure 5:** THE PROBABILITY OF ABOVE MEDIAN MAXIMUM TEMPERATURE FOR JULY TO SEPTEMBER.

Southern Top End

Inconsistent rain during the 2015/2016 wet season has resulted in average fuel growth across these regions. Areas of the Daly basin received the highest rainfall totals on record, whilst other areas have seen the lowest rainfall on record.

Late 2015 saw a large number of bushfires across this area which reduced a large quantity of fuel for the 2016 fire season. Normal fire potential is expected for the 2016 fire season in these areas.

Central Regions

Conditions have been normal over north and north western areas of central Australia, with carbon farming initiatives and other mitigation activities taking place. These regions maintain normal fire potential.

Parts of the Mitchell Grass Downs IBRA region in the Territory received the highest rainfall on record during the wet season. Continuing rainfall over more recent months has reduced curing, and this combined with the intensiveness of the grazing in this region, should restrict the likelihood of the fire season exceeding normal conditions.

Below normal fire potential has been identified as occurring in the south and south eastern area of the Territory. Rain in recent months, along with delayed curing, provides a level of confidence with this assessment. These areas are likely to return to normal fire potential by the end of the year.

WESTERN AUSTRALIA

A drier than average wet season in the East Kimberley and Pilbara has resulted in the lowest autumn rainfall on record, with normal to reduced grass fuel loads in these regions. With expansive areas of reduced fuel loads as a result of a mosaic of dry season fire scars and late wet season burning across 2015/2016 in the Central and West Kimberley, the risk of above normal grass fuel loads from an above average wet season for this region has been mitigated. The result of the combination of weather and mitigation influences across the north of Western Australia has resulted in normal to reduced grass fuel loads across the region, with the expectation of a normal fire season.

Note: no above normal areas indicated in Western Australia.

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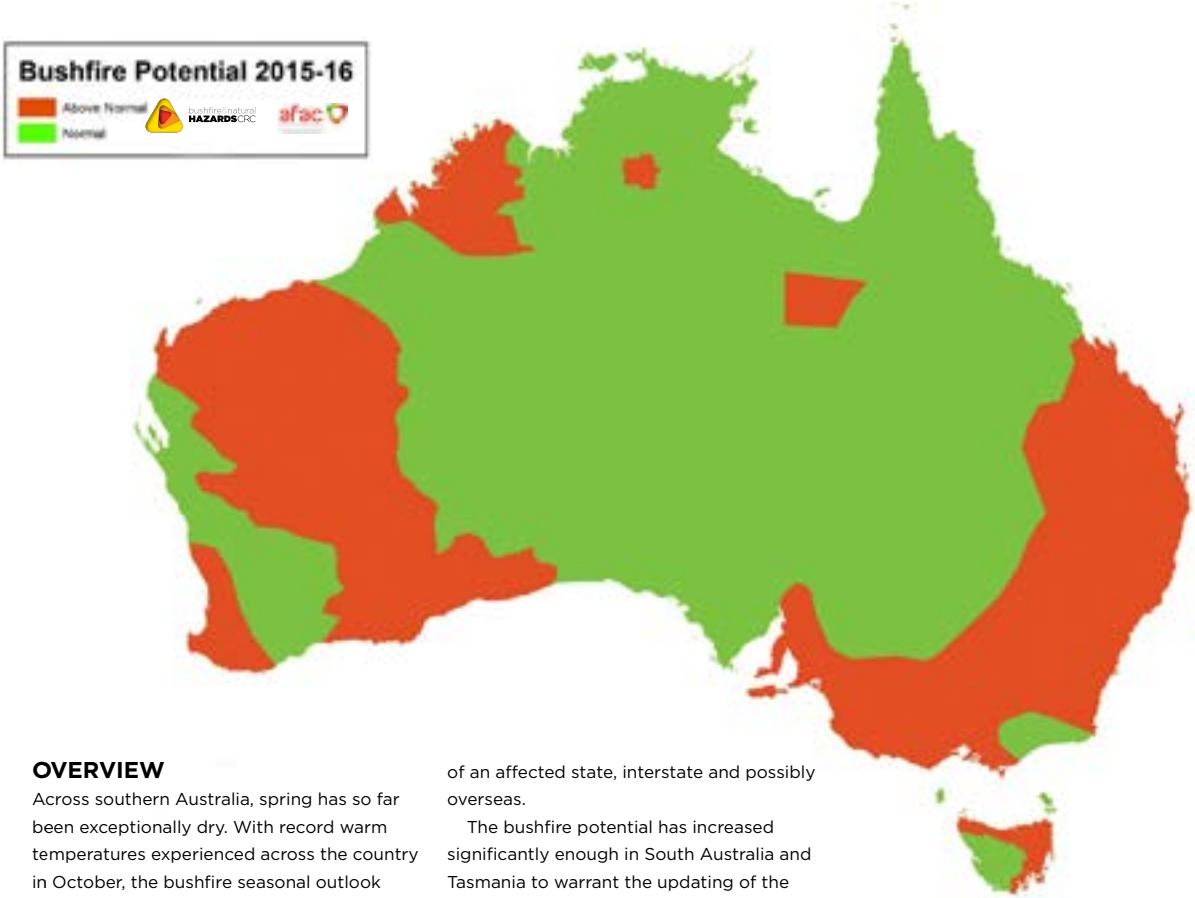
ISSUE 12 NOVEMBER 2015

TOPICS IN THIS EDITION | FIRE WEATHER | FUEL MANAGEMENT

SOUTHERN AUSTRALIA SEASONAL BUSHFIRE OUTLOOK 2015-16: NOVEMBER UPDATE



OVERVIEW

Across southern Australia, spring has so far been exceptionally dry. With record warm temperatures experienced across the country in October, the bushfire seasonal outlook for 2015-16 has been re-examined for South Australia and Tasmania.

This has resulted in an update to the *Southern Australia Seasonal Bushfire Outlook*. This new edition, released as *Hazard Note* 12, replaces the previous Outlook for these two states, published as *Hazard Note* 10 in September 2015.

The significant change in this Outlook is that more parts of south eastern Australia are now expected to experience above normal fire conditions. In these areas, it is more likely that the resources required to fight bushfires from within a region will be insufficient, with resources required from other areas of an affected state, interstate and possibly overseas.

The bushfire potential has increased significantly enough in South Australia and Tasmania to warrant the updating of the national perspective. The above map reveals the updated bushfire outlook for southern Australia through to 2016.

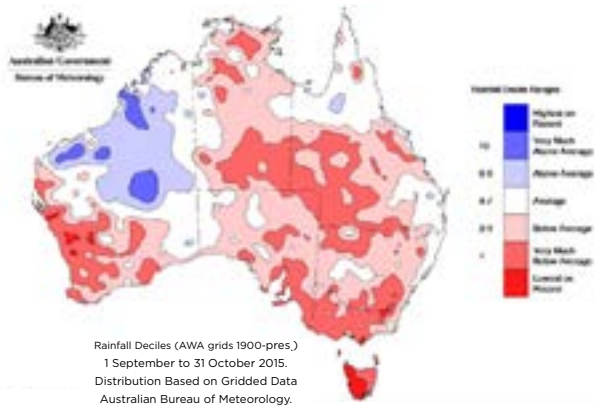
This map has been combined with the outlook for the northern fire season, released in July 2015, to show the areas of fire potential for all of Australia in 2015-16 (see *Hazard Note* 7).

RECENT CLIMATE CONDITIONS

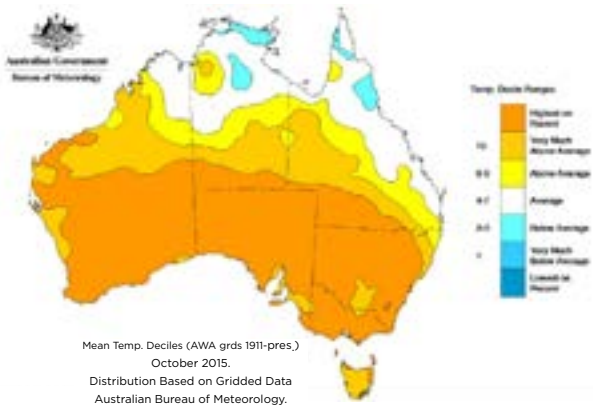
September and October have been exceptionally dry months for much of Australia (Figure 1, next page) with large areas recording less than 20% of their average rainfall. Rainfall has been particularly low in Tasmania, South Australia, southern Western Australia, Victoria, and much of New South Wales west of the Great Dividing Range. The low rainfall has contributed to a rapid and early drying of vegetation.

Accompanying the low rainfall has been record high temperatures (Figure 2, next page). Following a slightly warmer than average September for Australia (mean temperature anomaly of +0.2°C), October has seen record warm temperatures across the country (mean Australian anomaly of +2.89°C, well above the previous October record of +2.14°C in 1988).

HAZARD **NOTE**



Rainfall Deciles (AWA grids 1900-pres.)
1 September to 31 October 2015.
Distribution Based on Gridded Data
Australian Bureau of Meteorology.



Mean Temp. Deciles (AWA grds 1911-pres.)
October 2015.
Distribution Based on Gridded Data
Australian Bureau of Meteorology.

DEFINITION

Bushfire potential: The chance of a fire or number of fires occurring of such size, complexity or other impact (such as biodiversity or emissions) which requires resources (from both a pre-emptive management and suppression capability) beyond the area in which it or they originate. Bushfire potential depends on many factors, including weather and climate, fuel abundance and availability, recent fire history and firefighting resources available in an area.

It was also the warmest October on record in Tasmania, South Australia, Western Australia, Victoria and New South Wales. The combination of record heat and very dry conditions means that the 2015-16 southern fire season has commenced early in some locations.

The combination of an El Niño-linked drought, long-term rainfall deficiencies, drying in southern Australian over nearly 20 years, as well as warming global and Australian temperatures, sets the scene for above normal fire potential in large parts of southern Australia.

UPDATED CLIMATE OUTLOOK

The climate outlook for November to January is influenced by both the Pacific and Indian oceans. A strong El Niño remains in the Pacific Ocean, which is expected to peak around the start of summer, and then subsequently decline. The Indian Ocean retains its record warmth, while a positive Indian Ocean Dipole event has started to decay. This combination suggests that rainfall is likely to improve in coming months.

The rainfall outlook for November to January (not shown) suggests some areas may experience above average rainfall, but many of these areas are seasonally dry and therefore unlikely to see a significant reduction in the antecedent fire danger. In the south east of the country (including Tasmania), average to drier than average conditions remain likely.

Temperatures leading into summer (not shown) are likely to be above average during November. Probability shifts are stronger in southern areas, where both maximum and minimum temperatures are likely (>80%) to be warmer than average.

The decline of both the positive Indian Ocean Dipole event and El Niño favours an improving rainfall outcome for Australia. However it is currently too early to determine how extensive this rainfall relief will be, and whether rainfall will fall in sufficient amounts to ease the fire season severity.

REGIONAL SUMMARIES

South Australia

As part of the ongoing monitoring and reviewing of conditions across South Australia, the updated outlook conditions indicate the most likely scenario is for above normal fire potential in parts of the Flinders, Mid North, Yorke Peninsula, Mt Lofty Ranges, Murraylands, Riverland, Kangaroo Island, Upper South East and Lower South East. These areas have experienced rainfall deficiencies with very dry soil moisture, resulting in very dry fuels and earlier than average curing of grasslands.

Normal to above normal fire potential may see the need for firefighting resources over a longer period of time, together with a longer time for mop up post-fires. The districts where there is potential for above normal activity may pose resourcing issues during this fire danger season, should an above normal level of activity be experienced.

Tasmania

The potential for bushfire has been assessed as above normal across northern and eastern Tasmania, as well as in the Midlands and the South East. This is a significantly larger area than the September assessment. The bushfire potential in the remainder of the state is currently normal.

The first half of spring has seen very low rainfall for almost all of Tasmania, especially in the west. Above-average daytime temperatures have increased evaporation rates, which further increases fuel dryness. The fire season has commenced in the eastern half of the state, with many fires proving difficult to control because of the dryness of fuels.

Other states and territories

In New South Wales, the ACT, Victoria, Western Australia and Queensland, the *Southern Australia Seasonal Bushfire Outlook* remains as described in September's *Hazard Note* 10.

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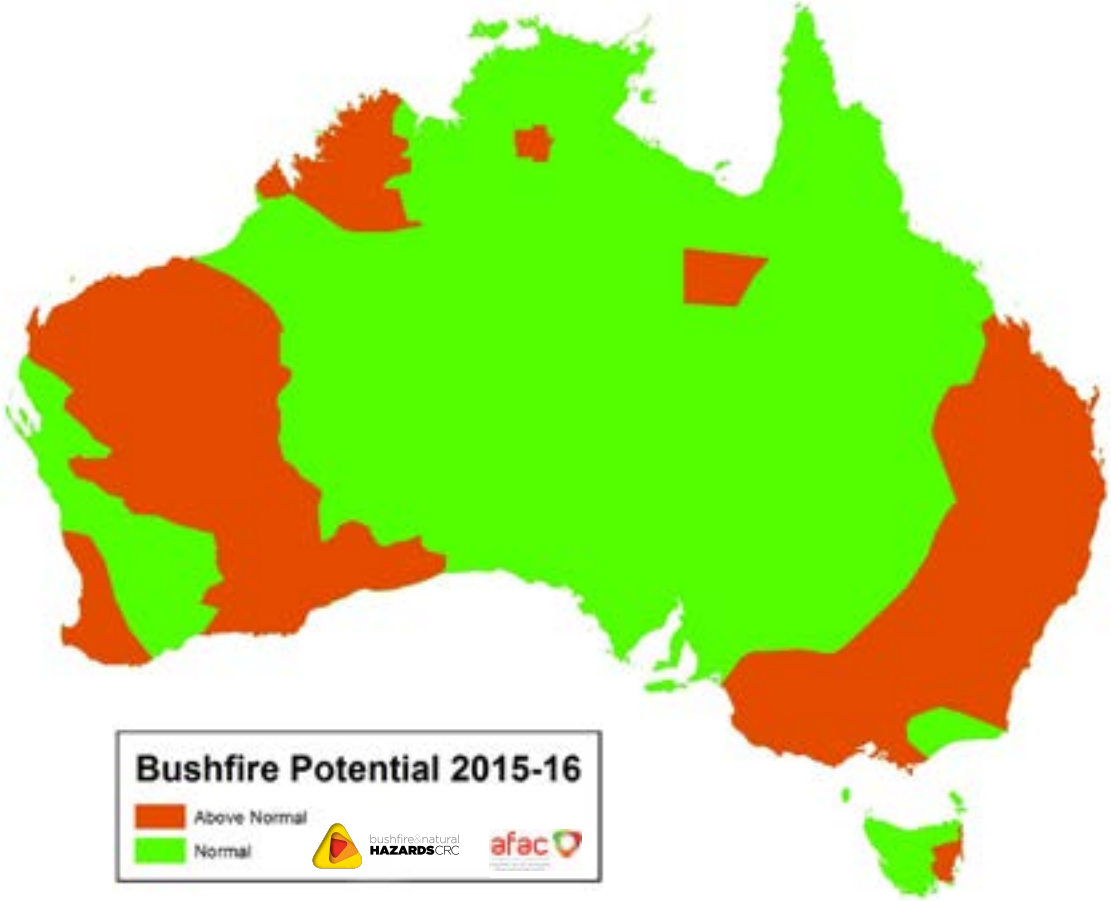
ISSUE 010 SEPTEMBER 2015

TOPICS IN THIS EDITION | FIRE WEATHER | FUEL MANAGEMENT

SOUTHERN AUSTRALIA SEASONAL BUSHFIRE OUTLOOK 2015-16



OVERVIEW

The Seasonal Bushfire Outlook for southern Australia is used by fire authorities to make strategic decisions on resource planning and prescribed fire management for the upcoming fire season. The outlook is developed at an annual workshop convened by the Bushfire and Natural Hazards CRC and the Australasian Fire and Emergency Service Authorities Council (AFAC).

At the 2015 workshop in Perth in August, the outlook was assessed and a range of broad climate factors were considered.

In assessing the bushfire potential for any given year, it is important to take into account not only the amount of rainfall in the immediately preceding months but the long-term rainfall deficit across southern Australia.

Leading into this year, many areas have consistently received below average annual rainfall across successive years. This has produced a cumulative reduction in soil moisture levels and increasingly dry forests and grasslands.

In addition to these long-term trends, other climate drivers, such as the currently strengthening El Niño-Southern Oscillation event across the Pacific and the warmer waters associated with the Indian Ocean Dipole, may further increase the severity and duration of the upcoming fire season.

Such impacts will challenge the limited resources of the fire and land management agencies and have created the situation where each fire season is likely to be more demanding than the last, both in economic and human costs.

The above map shows the bushfire outlook for southern Australia through to 2016. This map has been combined with an updated outlook for the northern Australia bushfire season, which was first released in mid July, to show

the areas of fire potential for all of Australia in 2015-16. (See *Hazard Note* 7, July 2015).

The Southern Seasonal Bushfire Assessment Workshop was hosted by the Department of Parks and Wildlife in Perth on 20–21 August. The workshop, supported by the Bushfire and Natural Hazards CRC and AFAC, brought together fire and land managers, climatologists and meteorologists to evaluate the upcoming season for the southern part of Australia.

BUSHFIRE POTENTIAL

Fire season potential depends on several factors. The amount, location and timing of rainfall in the period leading up to the fire season are critically important for estimating fuel loads and dryness. The temperature and rainfall outlooks for the next few months are crucial factors for influencing the development of fire threat.

Of particular importance are the future tendencies of sea surface temperatures in the Pacific Ocean, associated with the El Niño-Southern Oscillation, and those in the Indian Ocean. These are major drivers of climate over much of Australia. Other factors considered in the analysis of fire potential include the distribution of firefighting resources to meet potential threats, as well as previous fire activity and the amount of prescribed burning, which can reduce threat.

The workshop discussed the weather, landscape conditions and cross-border implications leading into the fire season and determined areas that had the potential for a fire season that was above normal, normal or below normal. Attendees included representatives of the Bushfire and Natural Hazards CRC, AFAC, the Bureau of Meteorology, Tasmania Fire Service, the Australian Capital Territory Emergency Service Agency, the New South Wales Rural Fire Service, South Australia's Country Fire Service, Queensland Fire and Emergency Services, Victoria's Country Fire Authority and Department of Environment, Land, Water and Planning, and Western Australia's Department of Parks and Wildlife and the Department of Fire and Emergency Services.

ANTECEDENT CONDITIONS

The 2015-16 southern fire season comes against a backdrop of long-term drying, record warmth in the Indian Ocean and the continued development of a major El Niño event in the Pacific. Across southern Australia a pattern of drier southern wet seasons (April to October) has continued for more than 10 years leaving substantial rainfall deficits (Figure 1). The below average rainfall has been accompanied by above average temperatures, with the past decade being the warmest on record in many areas. The pattern of long-term below-average rainfall and above-average temperatures means that conditions such as soil moisture and fuels are prone to rapid drying with the approach of summer.

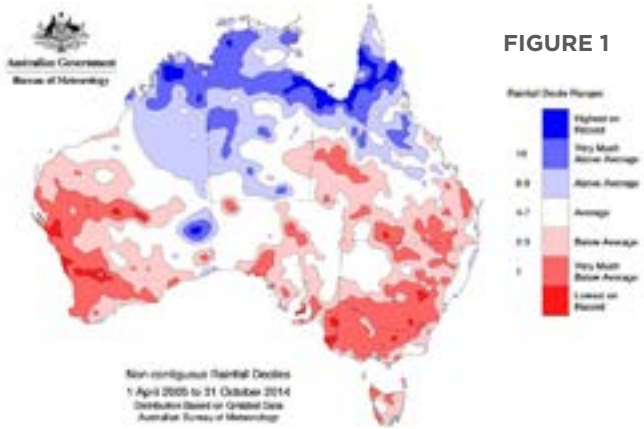


FIGURE 1

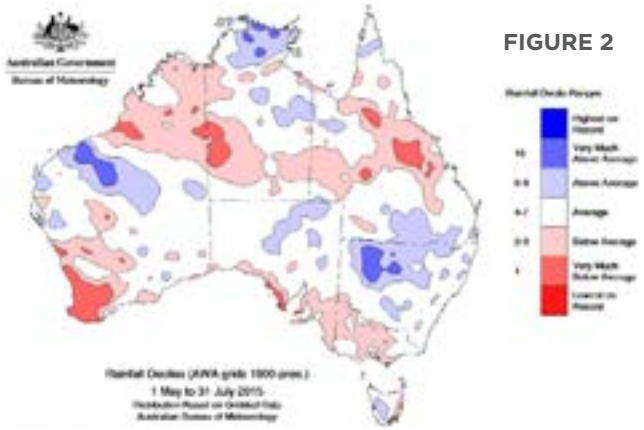


FIGURE 2

Fire conditions in summer are affected by rainfall in the preceding cool season, as well as conditions during the summer itself. Since the start of autumn, rainfall has been mixed over Australia as a whole, though tending to be below average across southern areas. Rainfall from May to July 2015 (Figure 2) has been below average in south west Western Australia, southern parts of South Australia, much of Victoria, and the east coast of Tasmania. Relatively good rainfall has occurred for most of New South Wales, with small areas of above average rainfall. Inland Western Australia south of the tropics has been mostly wetter than average as a result of unseasonal rainbands.

Soil moisture reflects the net balance between rainfall and evaporation, and includes the impact of warmer or cooler temperatures. Lower-level ("root zone") soil moisture is below average across south west Australia, central and western Victoria, almost all of Queensland, south east South Australia and parts of eastern Tasmania. It is these regions that are most likely to see an early drying of fuels leading into summer. Elsewhere, soil moisture is average to above average, particular across inland areas.

SEASONAL CLIMATE OUTLOOK

Seasonal outlooks in 2015 are being influenced by significantly warmer than normal sea surface temperatures in both the tropical Pacific and Indian Oceans. Since an El Niño was declared by the Bureau of Meteorology in May, the event has become well-established and is currently tracking as one of the strongest on record as measured by sea surface temperatures in the central Pacific. All

international climate models surveyed by the Bureau of Meteorology suggest the 2015 El Niño will continue to strengthen and last into (at least) early 2016.

While there are significant existing long-term rainfall deficiencies in the western half of Victoria, southern South Australia and parts of south west Western Australia, the 2015 El Niño has not been associated with significant rainfall deficiencies across the winter months across much of southern Australia. This pattern may have been influenced by unusually warm waters in the Indian Ocean to Australia's west, which are generally favourable to rainfall in southern parts of Australia. Rainfall, however, has been below average south of the Murray River, in far south west Western Australia and south east Queensland. Each of these regions also have longer-term deficiencies.

The climate outlook (Figure 3) indicates that the direct impact of El Niño may continue to be modest over spring, with likely above average rainfall over most of western and central Australia. Rainfall shifts are modest for eastern parts of Australia, with small areas favouring below average rainfall.

The outlook for maximum temperatures (Figure 4) for the coming spring shows that above average temperatures are most likely in the east and the far south west. Elsewhere, forecasts probabilities favour cooler than normal maximum temperatures, though probability shifts are relatively modest. The below average maximum temperatures are related to the (likely) increased rainfall coming out of the Indian Ocean.

It is worth noting that the temperature forecasts use a 1981-2000 base period, which means that even average conditions will be above the historical longer-term normal (for 1910 to present). This highlights the difficultly in defining what is meant by average temperatures in a warming climate.

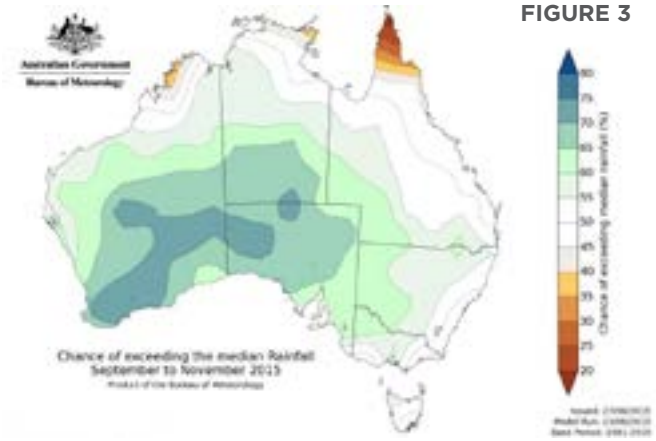
The climate outlook will be updated by the Bureau of Meteorology around the end of each month leading into summer, providing new insights on the likely upcoming seasonal conditions.

REGIONAL SUMMARIES

ACT

Most of the Australian Capital Territory has wet soil, which is typical for this time of year (out of drought), and this moisture will form a base for vigorous grass growth leading into spring. Some of the more rugged regions will not dry out until at least November, when the higher sun will penetrate into these areas.

FIGURE 3



The forecast is for a dry spring and this could lead to early curing of the landscape and an elevated grass fire danger.

If the predicted hot summer occurs, and especially if it is accompanied with heatwaves, this could lead to a significant drying of the forest litter and the non-surface fuels. The forest fire danger will be even higher if wind and humidity conditions deteriorate.

In the ACT, major El Niño events tend to lead to hot and dry conditions until at least early autumn, suggesting preparations need to consider a prolonged period of fire danger.

TASMANIA

There is an above normal potential for bushfire across a large part of the east coast of Tasmania, extending from the coastal strip around St Helens southwards, and extending across the Fingal Valley, the North and Southern Midlands and the Eastern Tiers down to Sorell and the Forestier Peninsula.

The likelihood of an early fire season is high in these areas but the amount of spring rain will ultimately determine overall fire activity in the eastern half of the state. The potential for bushfires in the remainder of the state is currently expected to be normal. However, the long-term lack of rain right across Tasmania may lead to more lengthy campaign fires due to the deep level of dryness.

QUEENSLAND

Much of Queensland remains drought affected and as a consequence has very low grass fuel loads.

The soil is relatively dry along parts of the north tropical coast and south east coast. If the El Niño conditions bring low rainfalls, the flammability of the forest fuels will increase as they continue to dry.

South and west of Rockhampton, areas around Inglewood, the Sunshine Coast, Brisbane and the Gold Coast, have had above average rainfall in the lead up to this bushfire season. The higher grass fuel loads in these areas have increased the bushfire potential.

Severe Tropical Cyclone *Marcia* crossed the central Queensland coast on 20 February and the associated winds caused extensive but variable damage across that landscape. The cyclone-damaged vegetation, particularly around Rockhampton, has significantly increased the bushfire potential in that area.

Queensland Fire and Emergency Services has worked with Queensland Parks and Wildlife Services and many other stakeholders to conduct prescribed burns that have reduced fuel loads but the bushfire potential for this area remains high. This increase in bushfire potential has been communicated to the community.

In the north western part of the state above normal fire potential is expected in the greater Mt Isa area, including around Sedan Dip, The Monument, Urandangi and Camooweal.

SOUTH AUSTRALIA

In South Australia the outlook conditions indicate the most likely scenario is for normal fire potential across most of the state, but with above normal fire potential in the Lower South East, Upper South East and parts of the Murraylands.

These districts have received below average rainfall for the past six months, following on from a dry spring and early hot summer in 2014. This rainfall deficit has the potential to result in fuels in forested and scrub areas to be drier than average and be available to burn sooner and more readily than normal.

A normal to above normal fire potential may see the need for firefighting resources over a longer period of time, together

with a longer time for mop-up after the fires. The districts where there is potential for above normal activity may pose resourcing issues during this fire season, should an above normal level of bushfire activity be experienced.

VICTORIA

A preliminary investigation of factors affecting the fire season outlook for 2015-16 point to an above normal season across most of Victoria.

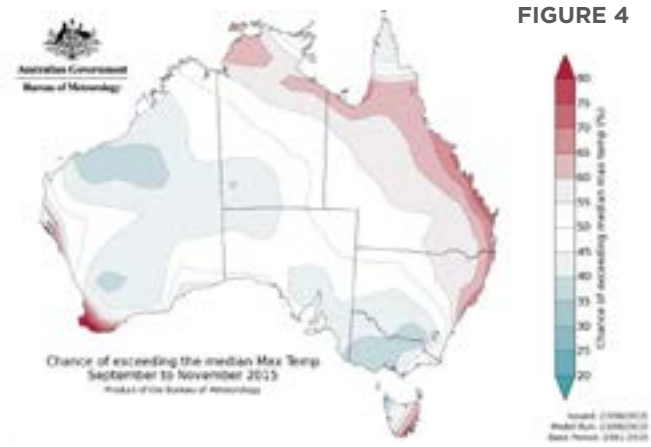
Key indicators of above normal fire potential are currently in place. They include an extended rainfall deficit, drying conditions in eastern central Australia that affect north westerly air patterns, and rain that dampens but doesn't soak soil profiles. Drier conditions in key areas of the continent that affect Victoria's weather, when combined with the normal course of spring warming and increasing day length, lead to a strong liklihood that the season will begin early.

Areas with long-term rainfall deficits extend in a broad band from the South Australian border to the north east foothills, and includes some areas of Gippsland. There are local occurrences of lowest-on-record rainfall in the west of the state.

Short-term rainfall deficits exist across much of the state, with the exception of the south west coast and Far East Gippsland. Crop and pasture growth has been highly variable across the state in response to autumn rainfall patterns. The exact pattern of factors affecting grass growth and curing is not yet clear, though an increased outlook for spring rain may indicate increased grass growth in some areas. Agencies will monitor conditions and the emerging weather outlook closely in the lead up to summer.

Historically, the August to October period is the wettest time of the year in Victoria, and it sets the scene for fuel growth and fuel conditions over the summer. Current climatic signals indicate a slightly better than average chance of above average rainfall and below average daily maximum temperatures across most of the state, leading to an improved outlook for grass growth. However, given the long-term rainfall deficits, significant rain would be required over the spring period to alter the outlook for an above normal fire potential for most of Victoria.

FIGURE 4



NEW SOUTH WALES

The effects of the current strong El Niño event are being offset by warmer than normal temperatures in the Indian Ocean. However, the three-month climate outlook suggests drier than average conditions are favoured in north east New South Wales and the far south coast combined with increased chances of warmer conditions in the north east and along the coast. This outlook, coupled with the traditional El Niño risk of higher than average temperatures, could result in a rapid drying of forest fuels and lead to above normal fire potential in the forested eastern parts of the state.

Winter rainfall totals have been near the long-term average over central inland areas. The three-month climate outlook is suggesting further average rainfall. As a result, high grass growth could be a concern when the soils begin to warm in spring. An above normal fire season is expected in these areas.

The western half of New South Wales has generally received useful winter rainfall, close to or above the long term average. However, a normal fire season is expected as there has not been enough rain for significant grass growth.

WESTERN AUSTRALIA

In Western Australia, for the Western Gascoyne and Central West, there is normal fire potential due to average rainfall and grass growth.

In the Murchison, Goldfields and Desert areas, there is above normal fire potential as a consequence of high fuel loads from above average rainfall.

The Wheatbelt and Great Southern regions have average grass fuel loads as a result of average to below average rainfall, leading to normal fire potential.

In the South West, a lack of rainfall, a long-term deficit in the soil moisture and high fuel loads have led to above normal fire potential.

In the South East, higher-than-average rainfalls east of Norseman have created higher fuel loads, leading to above normal fire potential.

Although the El Niño continues to strengthen, the correlation between El Niño and rainfall and temperature patterns is weaker for Western Australia than it is for the eastern states. In an average El Niño, daytime temperatures across the southern half of the state are higher and the wet season onset typically occurs later in the season.

However, every event is different and El Niño is not the only influence on rainfall and temperature; other factors, such as warmer-than-average sea surface temperatures to the north of Australia and in the Indian Ocean, will also affect the climate, and hence, bushfire potential across Western Australia.

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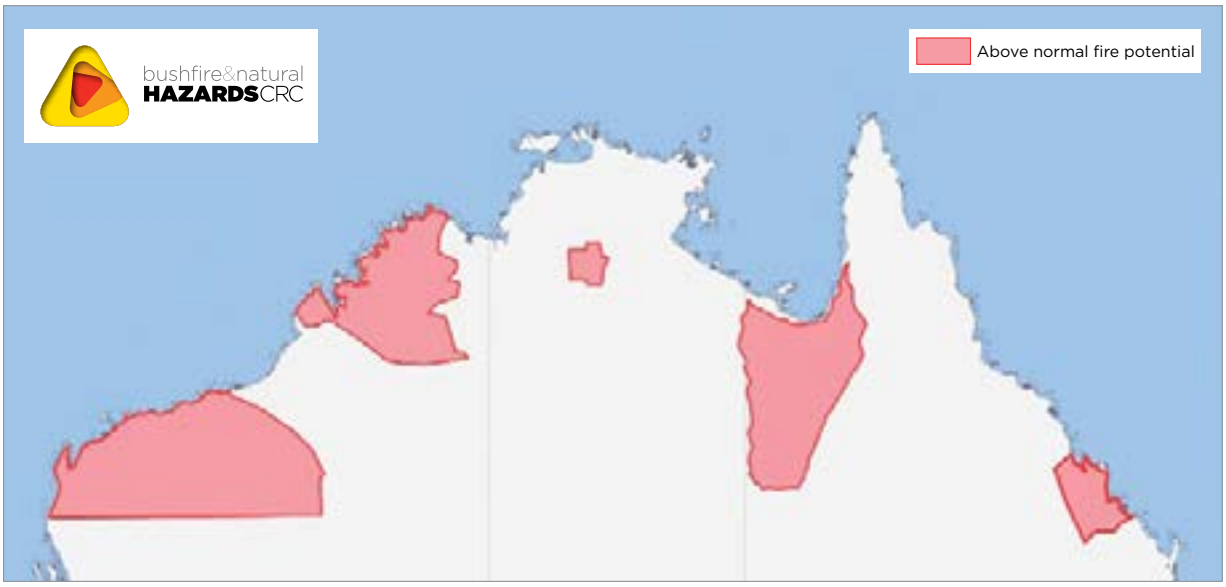
HAZARD **NOTE**

bushfire&natural HAZARDSCRC

ISSUE 007 JULY 2015

TOPICS IN THIS EDITION | FIRE WEATHER | FUEL MANAGEMENT

NORTHERN AUSTRALIA SEASONAL BUSHFIRE OUTLOOK 2015



BUSHFIRE POTENTIAL

This *Northern Australia Seasonal Bushfire Outlook* provides information to assist fire authorities in making strategic decisions such as resource planning and prescribed fire management, and to reduce the negative impacts of bushfire.

A *Seasonal Bushfire Outlook* for southern Australia will be distributed in early September, and will include an update on the northern fire season.

Bushfire potential depends on many factors. In northern Australia, conditions are determined by the nature of the previous wet season. The volume, location and timing of rainfall are critically important for fuel volumes and growth. They also affect the timing of the drying of the fuel.

The climate outlook for the next few months is also a crucial factor. Of particular interest are the future tendencies of the Pacific and Indian Ocean sea surface temperatures associated with the El Niño-Southern Oscillation and the Indian Ocean Dipole, which are major climate drivers over Australia. Other less quantifiable factors, such as the distribution and readiness of firefighting resources, are also considered.

The annual Northern Australian Fire Managers' Forum, chaired by Bushfire and Natural Hazards CRC CEO Dr Richard Thornton, met in Cairns in June. During the two-day proceedings the Forum discussed the seasonal outlook for the imminent fire season, enabling the production of this *Hazard Note*. All other presentations from the Forum are available at www.bnhcrc.com.au

Forum attendees included representatives of the Bureau of Meteorology, Queensland Fire and Emergency Services, Queensland Parks and Wildlife Service, Bushfires NT, the NT Fire and Rescue Service, the WA Department of Fire and Emergency Services, the WA Department of Parks and Wildlife, Charles Darwin University, AFAC, Rural Fire Brigades Association Queensland, Cape York Sustainable Futures, Carpentaria Land Council Aboriginal Corporation, Landgate, the Aboriginal Carbon Fund and the federal Department of Defence.

ANTECEDENT CONDITIONS

The 2014–2015 northern wet season saw borderline El Niño conditions in the Pacific Ocean, which reached peak intensity towards the end of the calendar year. After a brief weakening over summer, warming recommenced in the Pacific in autumn and an El Niño was declared in May 2015. The El Niño is expected to persist through the remainder of 2015, with some further strengthening likely during spring. The Pacific warmth coincides with warm ocean conditions across the Indian Ocean, which has been linked to increased rainfall across the subtropics in recent months.

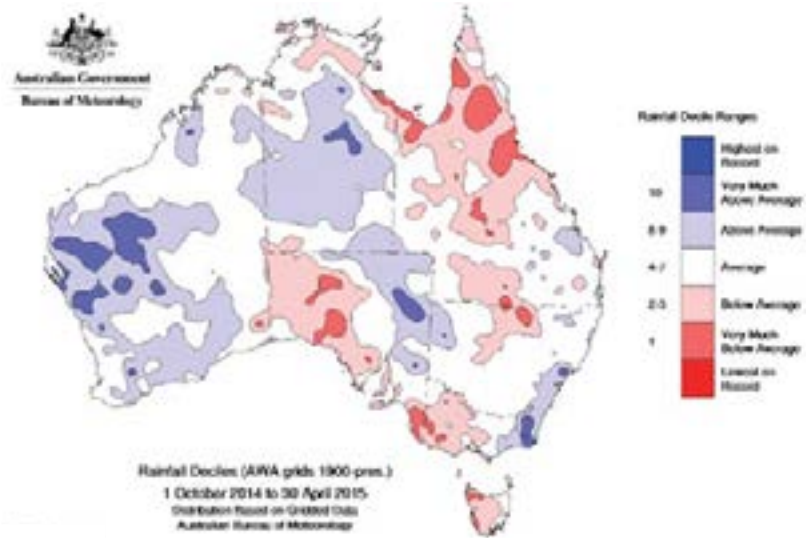
HAZARD **NOTE**

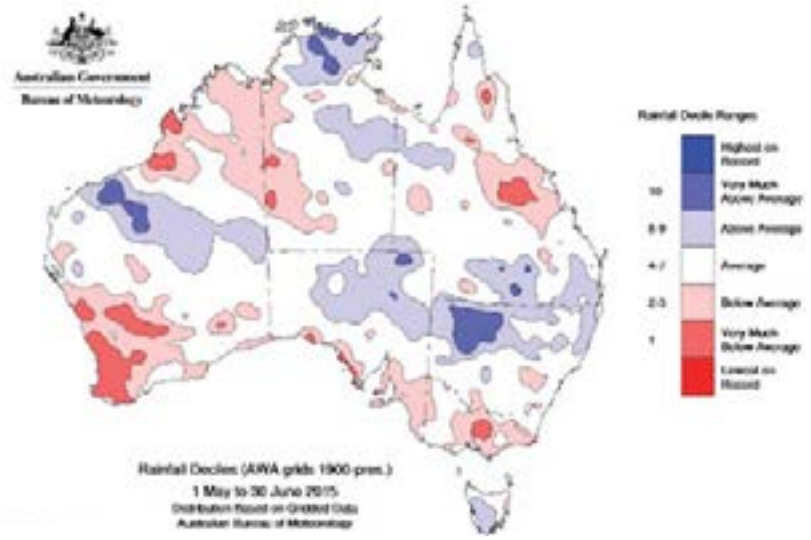
DEFINITIONS

Bushfire potential: The chance of a fire or number of fires occurring of such size, complexity or other impact (such as biodiversity or global emissions) that requires resources (from both a pre-emptive management and suppression capability) beyond the area in which it or they originate. Fire potential depends on many factors, including weather and climate, fuel abundance and availability, recent fire history and firefighting resources available in an area.

Rainfall decile: A decile is a statistical technique that ranks sorted observations into 10 equal groups. A decile rainfall map will show whether the rainfall is above average, average or below average for the chosen time period and area.

IBRA: Interim Biogeographic Regionalisation for Australia. Australia's landscapes are divided into 89 large geographically distinct bioregions based on common climate, geology, landform, native vegetation and species information. The Bushfire Outlook map is based on the IBRA regions for northern Australia.





Consistent with the near El Niño conditions, the build-up months of October and November 2014 saw very much below average rainfall for many northern areas, with unusually warm daytime temperatures. The monsoon onset at Darwin occurred later than usual (officially observed on 31 December 2014). The arrival of the monsoon saw widespread heavy rainfall into January, with particularly good falls occurring in a north west-south east belt from the north of Western Australia and the Top End of the Northern Territory, down into south east Australia. Unfortunately the outbreak of heavy rainfall was short-lived; dry and locally record-warm temperatures affected most of northern Australia for the remainder of the wet season.

The bulk of Queensland experienced a relatively poor wet season, the third in as many years, with rainfall widely below to very much below average. Severe Tropical Cyclone *Marcia* brought locally heavy rainfall to the central coast of Queensland and adjacent inland areas in February, was associated with cyclone-strength winds over a large area of vegetation and caused significant damage to several towns. At the same time, Severe Tropical Cyclone *Lam* brought locally heavy falls to the eastern Top End of the Northern Territory and parts of the Cape York Peninsula in Queensland. While both cyclones were locally significant, they left only a modest signal on seasonal rainfall totals.

Currently, about 80% of Queensland is drought declared, with vegetation and soil moisture affected by the protracted rainfall deficiencies. Southern drought-affected areas have seen poor vegetation growth for a number of years, which translates into low fuel loads.

Rainfall during February, March and April was generally below average over Queensland, meaning that the wet season effectively ended early. The combination of a poor finish to the wet season and above average temperatures has led to an early curing (drying) of vegetation, with vegetation greenness values very low for March. In May 2015, only the immediate tropical coast of Queensland and a small area of the Northern Territory corresponding to heavy rainfall during January remained green for the time of year.

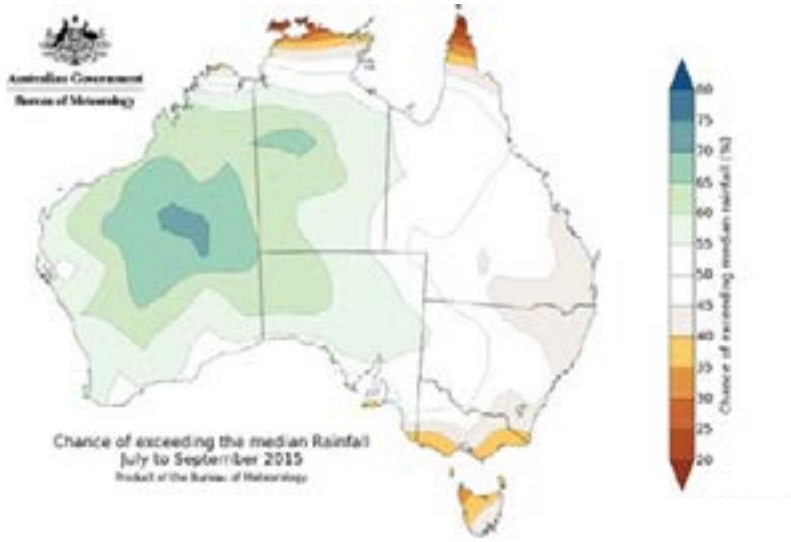
CLIMATE OUTLOOK

The 2015 El Niño continues to strengthen and will be an important driver of climate for the remainder of the year. Central and eastern tropical Pacific Ocean sea surface temperature indices are more than one degree above average, levels not seen since 1997 (the last strong El Niño). El Niño is typically associated with above average daytime temperatures and a delay in the start of the northern wet season, suggesting that an early end to the fire danger season is unlikely. The Bureau's new Northern Rainfall Onset outlook, which takes into account influences from the Pacific and Indian oceans, suggests that the onset of the rainy season is likely to be delayed, and particularly so about the most northerly parts of the tropics.

The July to September period is dry for northern Australia (see right), with very low rainfall except near the tropical Queensland coast. The climate outlook shows that there is an increased chance of a wetter than usual July to September over central and northern Western Australia, as well as adjacent areas of the Northern Territory. Rainfall is likely to be below average across the far north. The current outlook reflects abnormally warm sea surface temperatures in the Indian Ocean and El Niño in the Pacific. The Bureau's historical climate outlook accuracy for July to September is moderate over most of northern Australia, except around the border of Western Australia and the Northern Territory, and areas surrounding the Gulf of Carpentaria, where accuracy is lower.

July to September days are likely to be warmer than average across large parts of northern Australia (see page 4), continuing the pattern of recent months. Overnight temperatures are likely to be warmer than average for most of northern Australia. Significantly warmer-than-average sea surface temperatures in the Indian Ocean, and in waters around Australia, are likely influencing the warmer overnight temperatures expected for much of the country. The Bureau's maximum temperature accuracy is moderate to high over most of Australia for this time of year, while minimum temperature accuracy is moderate over the northern half of Australia for this time of year.

The combination of above average temperatures, dry fuel and low rainfall suggests that fire weather is likely to be elevated during the northern fire season.



REGIONAL SUMMARIES

NORTH QUEENSLAND

The bushfire season across northern Queensland is primarily influenced by geographic location, the relationship between climate and vegetation and long-term seasonal and short-term climatic conditions. During the 2015 wet season, Queensland experienced two severe weather events. While Severe Tropical Cyclone *Marcia* provided much needed rainfall to the coastal areas of the central region, and likewise Tropical Cyclone *Nathan* north of Cooktown, the remainder of north and central Queensland experienced well below average rainfall for the wet season. A neutral El Niño-Southern Oscillation was replaced by an official El Niño declaration, with El Niño conditions expected to strengthen.

As of 1 July 2015, over 80% of Queensland had been drought declared. Over the past 12 months, rainfall has generally been average to below average across most of northern and central Queensland. Although record rainfall along the north tropical coast in June has lessened deficiencies in some coastal areas, the remainder of the region around Townsville, central and western Cape York Peninsula, the southern coast of the Gulf of Carpentaria and inland from central Queensland near Longreach continue to have severe rainfall deficiencies. With average to below average rainfall forecast, and temperatures expected to be above average over much of Queensland into early spring, conditions are unlikely to improve.

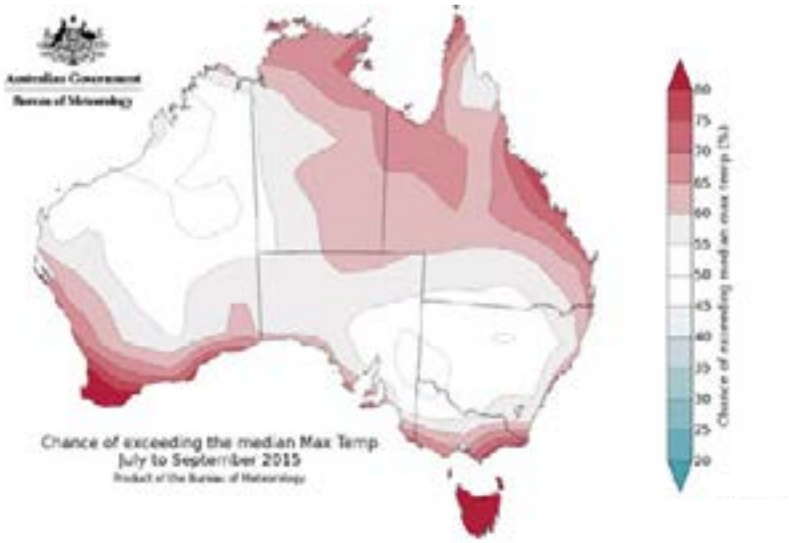
Pasture conditions and grass fuel loads vary considerably, and with the onset of the dry season the condition of the vegetation is generally declining, especially across inland and northern inland areas. Winter frosts over inland areas have added to the denigration of grassland conditions and due to the increasing drought conditions many landowners are now focused on protecting existing pasture, which in turn increases the risk of fire in some regions.

In collaboration with other fire and land management agencies, the Carpentaria Land Council Aboriginal Corporation and landowners, the bushfire potential for the fire season has been assessed as follows:

- In the northern and north western part of the state, above normal fire potential is expected across the Gulf Country from the Northern Territory border, east to around Normanton and north towards Kowanyama; south towards Prospect and south west to south of Boulia and west to the Northern Territory border, encompassing the Barkly Tableland and greater Mount Isa area.
- In the central region, above normal fire potential is expected in the impact areas of Severe Tropical Cyclone *Marcia*, from the coastal fringe west into the Callide Valley.
- Normal bushfire potential is expected from north west of Theodore, north towards Collinsville and into

western Cape York near Kowanyama, south towards Julia Creek and south east to the northern Central Highlands, the Desert Uplands and south east to Alpha and north towards Charters Towers.

Normal fire potential is predicted for all other areas north of latitude S25°. Regions of south east and western Queensland south of latitude S25° will be assessed during the Southern Australia Bushfire Season workshop in August 2015.



NORTHERN TERRITORY

Overview

The Northern Territory has experienced inconsistent rain over the past six to eight months, where regular rain (every three-five days) ceased at the end of January, with limited monsoonal activity apart from cyclone activity across a large portion of the Territory. This has led to a variety of curing development with some IBRA regions (Victoria Bonaparte and Gulf Falls Uplands) being far more advanced than others. The three-month forecast looks to support this, with limited rain predicted for the remainder of the dry season after higher than average rainfall occurring from mid-May until the end of June.

Western Top End

The Darwin coastal and Darwin IBRA regions have experienced average rainfall, which has resulted in usual growth patterns of vegetation. As in previous years, the presence and density of Gamba Grass continues to have a high impact on this region, greatly increasing the complexity and potential risk associated with managing bushfires. The reduced length of the wet season has allowed for more mitigation work to take place, resulting in a normal assessment of the fire season throughout the western Top End in 2015.

Southern Top End

An above normal fire season was experienced in 2014 due to several large bushfires, followed by a wet season that saw good initial rain in December but limited rainfall after January, leading to average pasture growth. Early curing has allowed for mitigation works to occur, which has complemented 2014 fire scars and grazing programs by pastoralists, leading to an estimated normal assessment of the 2015 fire season across the majority of the southern Top End.

The exception to this is the central area of the Sturt Plateau IBRA region. This area has been subjected to above average rainfall, with 1600mm falling in some places, resulting in significant pasture growth and delayed curing. There has been limited mitigation due to properties utilising the increased vegetation as pasture. This indicates an above normal fire potential in comparison to the neighbouring IBRA regions.

Central Regions

Rain has been present across the Tanami, MacDonnell Ranges and Burt IBRA regions, which put an end to the 2014 summer fire season in February. This rainfall has led to increased pasture levels. With planned mitigation works and landholder grazing plans, the fire potential is anticipated as being normal. This may change with consistent winter rains and relevant curing in the coming months.

WESTERN AUSTRALIA

The Kimberley and Pilbara are fire-prone landscapes and it is normal for bushfires to occur each year.

Kimberley

Overall, there is a normal bushfire potential in the central region of the Kimberley and the area adjacent to the Northern Territory border. The exception to this is the areas to the west and parts of the north east of the central zone, which are of above normal potential. This assessment is taking into account the prescribed burning that has been undertaken, as well as what is planned, across the region.

Pilbara/Northern Goldfields

Rainfall across the Pilbara has been average or above average. Due to the rainfall patterns there is an above normal bushfire potential in the western region. The central and eastern regions have a normal bushfire potential.

The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

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HAZARD **NOTE**

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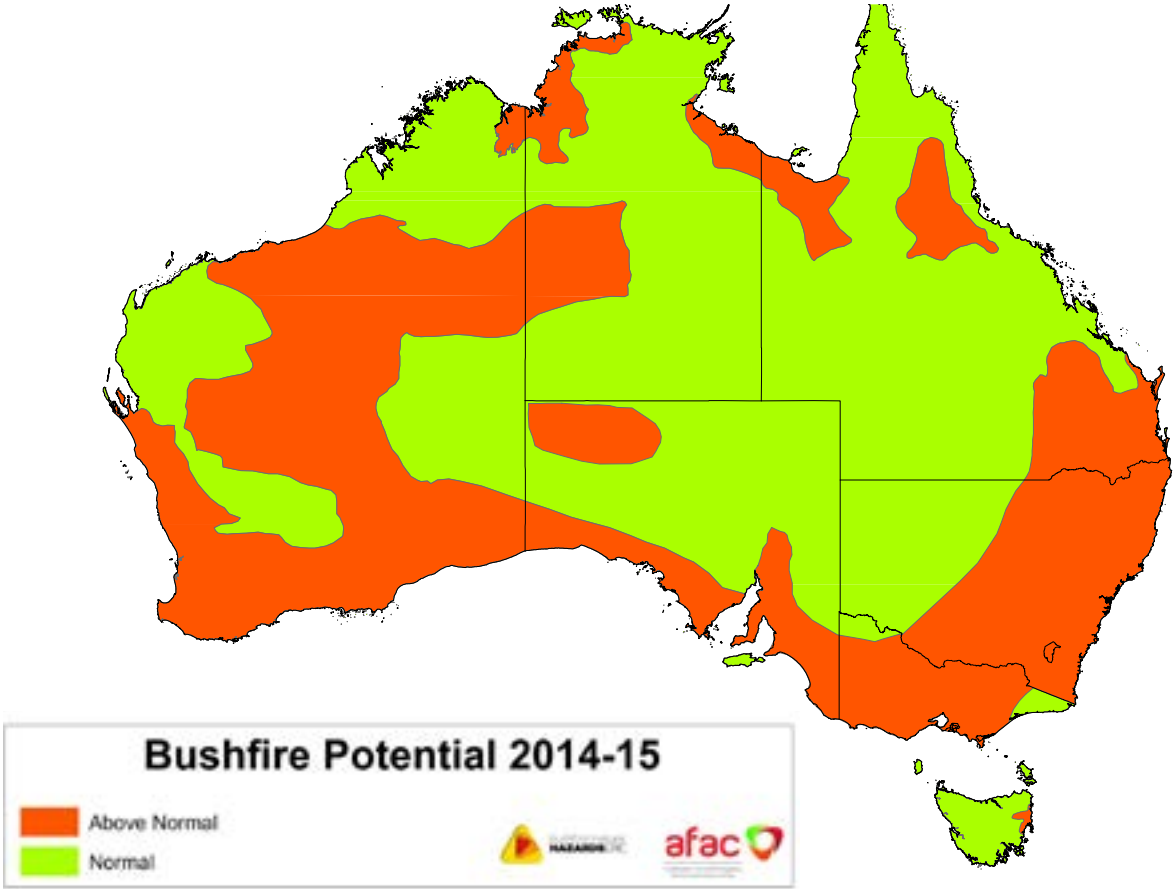
ISSUE 003 NOVEMBER 2014

TOPICS IN THIS EDITION | FIRE WEATHER | FUEL MANAGEMENT

SOUTHERN AUSTRALIA SEASONAL BUSHFIRE OUTLOOK 2014-15: NOVEMBER UPDATE



OVERVIEW

Across south eastern Australia, spring has been unseasonably dry and with the expectation of a hot and dry summer the bushfire seasonal outlook for 2014-15 has been re-examined for Victoria, South Australia and Tasmania.

This has resulted in an update to the *Southern Australia Seasonal Bushfire Outlook*. This new edition, released as *Hazard Note* 003, replaces the previous Outlook for these three states, published as *Hazard Note* 002 in September 2014.

The significant change in this Outlook is that more parts of south eastern Australia are now expected to experience above normal fire conditions. In these areas, it is more likely that the resources required to fight bushfires from within a region will be insufficient, with resources required from other areas of an affected state, interstate and possibly overseas.

Record October warmth across much of southern Australia has caused a rapid drawing of moisture from the landscape which is raising expectations of high fire danger in the south eastern states.

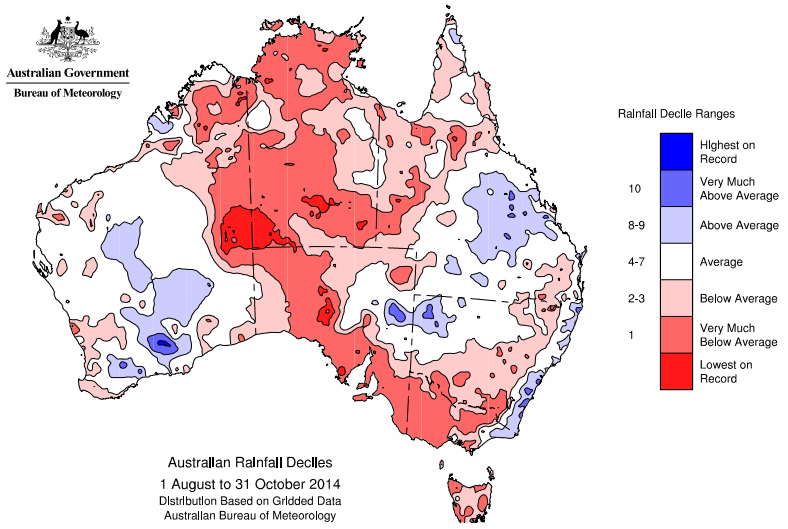
This has increased the bushfire potential in Victoria, South Australia and Tasmania sufficiently to warrant the updating of the national perspective. The above map reveals the updated bushfire outlook for southern Australia through to 2015. This map has been combined with the outlook for the northern fire season from July 2014, to show the areas of fire potential for all of Australia in 2014-15 (see *Hazard Note* 001).

HAZARD **NOTE**

SEASONAL CLIMATE OUTLOOK

Rainfall since August has been below average to very much below average across most of Victoria, South Australia and Tasmania, with South Australia recording its driest October on record.

Climate models suggest current conditions will either persist or strengthen, with at least a 70% chance of El Niño occurring. Regardless of whether El Niño fully develops, warmer-than-average tropical Pacific Ocean temperatures, combined with cooler waters currently to the north of Australia, increase the chance of some El Niño-like impacts. For many parts of Australia, this suggests below average rainfall and above average temperatures in the months ahead.



REGIONAL SUMMARIES

Victoria

The expectation of an above normal fire season for 2014-15 has extended in Victoria. The outlook has changed to a potentially major fire season.

All Victorian districts except the Mallee and East Gippsland may expect above normal fire potential. The continuation of dry conditions in all districts except East Gippsland, coupled with an increased likelihood of an earlier start to the season, has extended the above normal outlook beyond the geographic extent advised in September (see *Hazard Note* 002).

Longer term rainfall deficits have emerged across much of the state, including key areas along the Great Dividing Range. Critical shorter term deficits in coastal and southern Victoria coincide with areas of tall forest with no recent history of fire. Critical deficits also coincide with vulnerable areas in the Great Dividing Range where forests have been killed by fire in the past 10 years.

New additions include Wyperfeld, the Far South West, the Otway Range, the eastern Melbourne region, forests in the Great Dividing Range as far east as the Tongio Plateau and the Cobberas Range, Melbourne's water catchments, the foothills of South Gippsland, Wilsons Promontory and the Latrobe Valley.

Climatic signals indicate the continuation of warmer and drier than average conditions. Significant or widespread above average rainfall is not forecast. Rainfall of 30-50mm may occur in places, but its effectiveness will be limited due to the antecedent conditions.

South Australia

In South Australia the outlook conditions indicate the most likely scenario is for above normal fire potential in many parts of the state.

In the North West Pastoral, West Coast, Eastern Eyre Peninsula, Flinders and Mid North districts, the above normal fire potential is due to accumulated growth from previous growing seasons and above average rainfall earlier in 2014.

The Yorke Peninsula, Mount Lofty Ranges, Upper South East and Lower South East districts are experiencing rainfall deficiencies, with very dry soil moisture resulting in very dry fuels.

The area adjacent to the Northern Territory border (north of the APY Lands) has normal fire potential, in line with the normal potential indicated by the Northern Territory.

Normal to above normal fire potential may see the need for firefighting resources over a longer period of time, together with a longer time for mop up post-fires. The districts where there is potential for above normal activity may pose resourcing issues during this fire danger season, should an above normal level of activity be experienced.

Tasmania

The extraordinary run of above average monthly maximum and minimum temperatures continues, while dry conditions in September and October were only relieved by significant rain in the last week of October.

Difficult fires have already occurred; on 28 September Tasmania experienced the earliest total fire ban since 1987. The central part of the east coast extending into Fingal continues to have above normal fire season potential.

Without an improvement in conditions, the area from St Helens down to Marion Bay and through the Midlands and lower Derwent Valley are all likely to have above normal potential at the beginning of summer.

Other states and territories

In New South Wales, the ACT and Western Australia, the *Southern Australia Season Bushfire Outlook* remains as described in September's *Hazard Note* 002.

The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government in the Cooperative Research Centre (CRC) Program. It was formed in 2013 in partnership with the fire, land and emergency service management agencies in Australia and New Zealand for an eight year program to undertake end-user focused research.

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HAZARD **NOTE**

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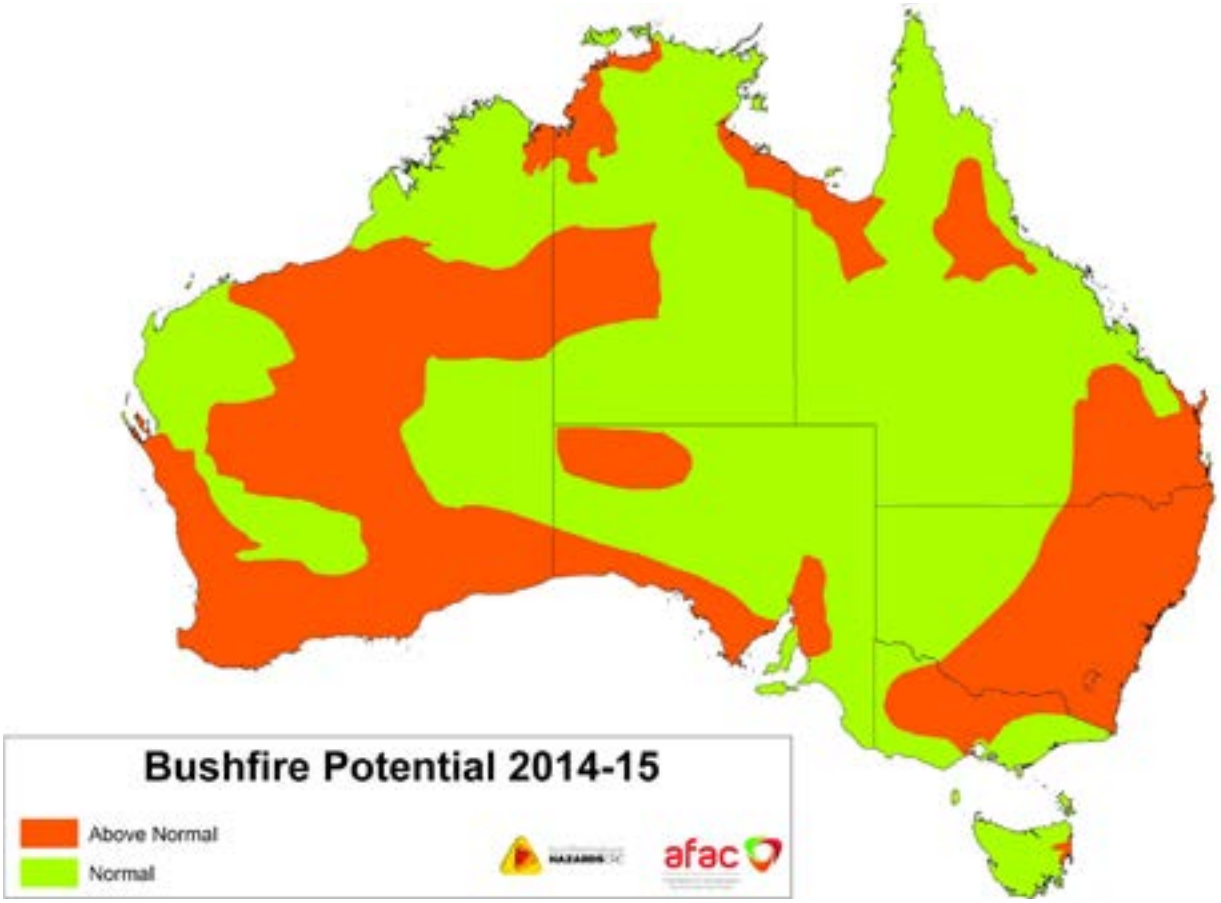
ISSUE 002 SEPTEMBER 2014

TOPICS IN THIS EDITION | FIRE WEATHER | FUEL MANAGEMENT

SOUTHERN AUSTRALIA SEASONAL BUSHFIRE OUTLOOK 2014-15



OVERVIEW

The *Southern Australia Seasonal Bushfire Outlook* is used by fire authorities to make strategic decisions on resource planning and prescribed fire management for the upcoming fire season. The outlook is decided at an annual workshop convened by the Bushfire and Natural Hazards CRC and the Australasian Fire and Emergency Service Authorities Council (AFAC).

At the 2014 workshop in Hobart in August, the outlook was assessed and a range of broad climate factors were considered.

Australia is predicted to experience a trend towards an increasing number of bad fire weather days in its southern and eastern states with fire seasons that begin earlier and last longer than in earlier decades (*Be Prepared: Climate Change and the Australia Bushfire Threat*, Climate Council 2013).

As benign fire seasons are predicted to become the exception, the concept of an average or normal fire season becomes less meaningful as historical long-term averages are surpassed by fire seasons that are regularly above average in either duration, area burnt or in the total number of fires. Costs to the community for firefighting and damage are already steadily rising.

Fire severity across southern Australia has been consistently worse than the long term averages would suggest. This is partly driven by an increase in temperatures as well as an increased dryness of soils and vegetation.

HAZARD **NOTE**

DEFINITIONS

Bushfire potential: The chance of a fire or number of fires occurring of such size, complexity or other impact (such as biodiversity or emissions) which requires resources (from both a pre-emptive management and suppression capability) beyond the area in which it or they originate. Bushfire potential depends on many factors including weather and climate, fuel abundance and availability, recent fire history and firefighting resources available in an area.

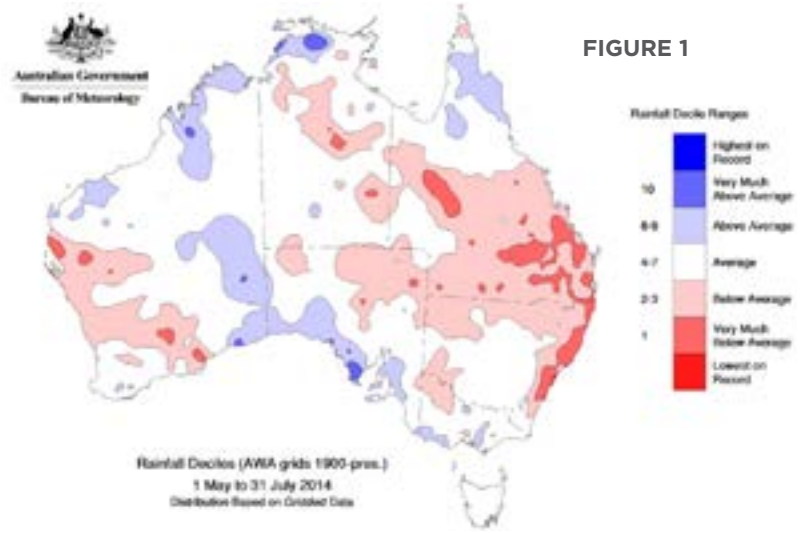


FIGURE 1

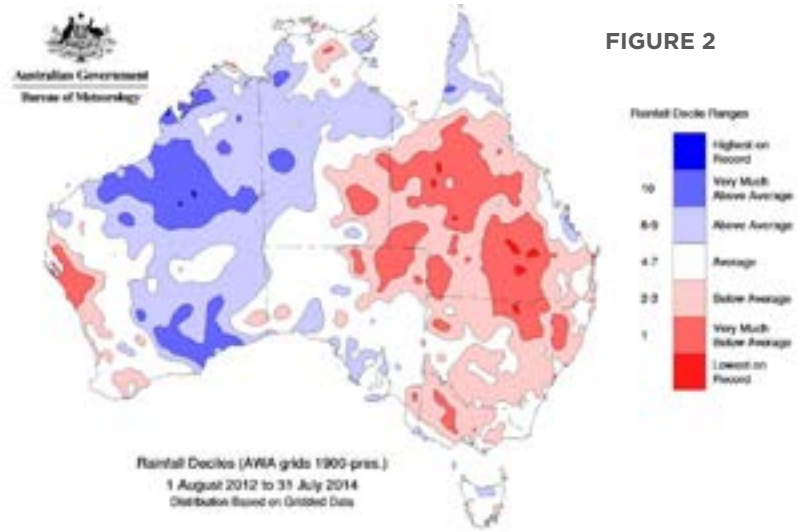


FIGURE 2

In assessing the bushfire potential for any given year, it is important to take into account not only the amount of rainfall in the immediately preceding months but the long-term rainfall deficit across southern Australia.

Leading into this year, many areas have consistently received below average annual rainfall over successive years. The effect of this has been a cumulative reduction in soil moisture levels and increasingly dry forests and grasslands.

In addition to these long-term trends, other climate drivers, such as the El Niño-Southern Oscillation and the Indian Ocean Dipole, can further increase the severity and duration of the fire seasons.

Such impacts are challenging the limited resources of the fire and land management agencies and have created the situation where each fire season is demanding both in economic and human costs.

The page 1 map reveals the bushfire outlook for southern Australia through to 2015. This map has been combined with the outlook for the northern Australia bushfire season, which was released at the beginning of the northern fire season in July, to show the areas of fire potential for all of Australia in 2014-15 (see *Hazard Note 001*, July 2014).

BUSHFIRE POTENTIAL

Fire season potential depends on several factors. The volume, location and timing of rainfall in the period leading up to the fire season are critically important for estimating fuel loads and dryness. The temperature and rainfall outlooks for the next few months are crucial factors for fire behaviour.

Of particular importance are the future tendencies of Pacific sea surface temperatures associated with the El Niño-Southern Oscillation, a major driver of climate over much of Australia. Other factors, such as the distribution of firefighting resources, previous fire activity and the amount of prescribed burning, are also considered in the analysis of fire potential.

The Southern Seasonal Bushfire Assessment Workshop was hosted by the Tasmania Fire Service in Hobart on 21 August. The workshop, supported by the Bushfire and Natural Hazards CRC and AFAC, brought together fire and land managers, climatologists and meteorologists to evaluate the upcoming season for the southern part of Australia.

The group discussed the weather, landscape conditions and cross-border implications leading into summer and determined areas that had the potential for a fire season that was above normal, normal or below normal. Attendees included representatives of the Bushfire and Natural Hazards CRC, AFAC, the Bureau of Meteorology, Emergency Management Australia, Tasmania Fire Service, the Australian Capital Territory Emergency Service Agency, the New South Wales Rural Fire Service, South Australia's Country Fire Service, Victoria's Country Fire Authority and Department of Environment and Primary Industries, and Western Australia's Department of Parks and Wildlife and the Department of Fire and Emergency Services.

The *Southern Australia Seasonal Bushfire Outlook* and the earlier *Northern Australia Seasonal Bushfire Outlook* provide information to assist fire authorities in making strategic resource and planning decisions leading into the fire season.

ANTECEDENT CONDITIONS

Rainfall since May has tended to be below average across most of Queensland, northern and eastern New South Wales, northern South Australia and much of south west Western Australia (figure 1, page 2). A particularly dry August has affected most parts of southern Australia, meaning that the extent of deficiencies will substantially expand beyond those evident at the end of July across Victoria, southern South Australia and Tasmania. On time scales of 12 to 24 months (figure 2, page 2), below-average rainfall has dominated almost the entirety of eastern Australia as well as the south western areas of Australia, meaning that long-term substantial deficits persist in these areas. The underlying dry conditions mean that any surface moisture will quickly decline with warmer temperatures and reduced rainfall over summer.

2013 was Australia's warmest year since comparable records began in 1910, and persistent warm conditions have continued to affect Australia during 2014 (figure 3, above). These above average temperatures have been a feature across almost the whole country, and particularly affected the eastern states in 2014, including the major eastern capital cities. This combination of underlying rainfall deficits, with persistently above average temperatures and near El Niño conditions in the Pacific, means that the antecedent conditions favour an early and above normal fire season in many areas.

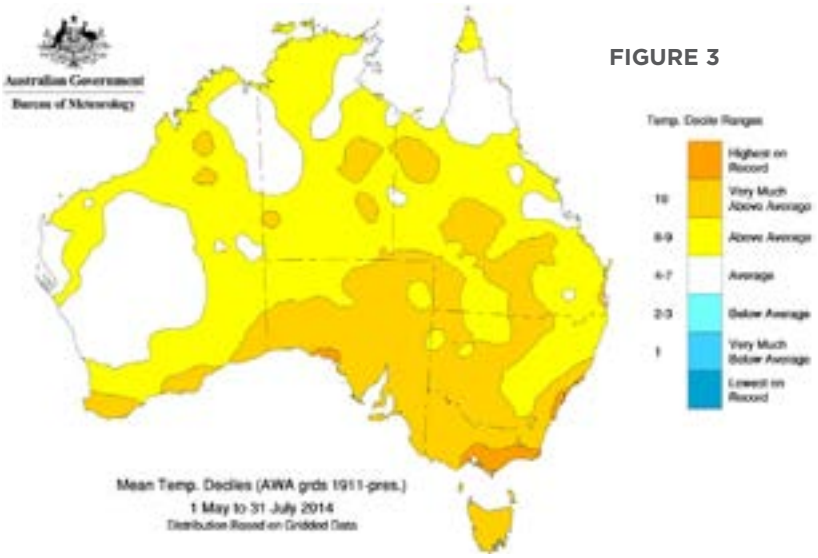


FIGURE 3

SEASONAL CLIMATE OUTLOOK

The past few months have seen near El Niño conditions in the Pacific, with a negative Indian Ocean Dipole (IOD); a highly unusual combination. The consensus of model forecasts from various international centres suggests that the coming months are likely to see the IOD return to neutral values. The outlook for the El Niño remains somewhat uncertain, with above average temperatures likely to continue across much of the tropical Pacific Ocean. Conditions approaching El Niño or weak El Niño conditions are the most likely scenarios.

With the El Niño-Southern Oscillation still not making the shift into El Niño territory just yet and the negative IOD returning to neutral, the seasonal climate outlook for September to November does not show a strong bias toward below average or above average rainfall over most of southern Australia. The main exception is southern NSW and central Victoria, where a dry season is most likely (figure 4, page 4).

The outlook for temperatures in spring shows that above average temperatures are most likely across southern and eastern Australia (figure 5, page 4). Historically, El Niño has brought more frequent hot days to south eastern Australia. It is not clear whether this will occur this season. However, even without the effects of an El Niño, there will be hot days during the coming fire weather season.

REGIONAL SUMMARIES

ACT

While the ACT does not have a strong signal for the severity of the coming summer, there are several reasons for expecting above normal fire potential. These include:

- Strong grass growth into early winter.
- Forecast for above average temperatures into summer.
- A reduction in rainfall in recent months, with heavy rains falling only in adjacent central areas of NSW.

NEW SOUTH WALES

Much of NSW experienced well below average rainfall in the three months leading up to August. Temperatures have also been above average or very much above average for all of this time. This has resulted in significant drying of the heavy fuels in the forests. Reduced rainfall has also resulted in reduced growth and lower grass fuel loads through much of the west of the state.

The next three months are forecast to have average rainfall over much of the state except the southern border areas, which are forecast to have reduced rainfall. The temperatures are forecast to remain above average for much of the state. Under these conditions the drying trend will continue and it is expected to result in above normal fire activity for the coastal table lands and central slopes of the state while the risk of significant fire in the west of the state will be normal.

WESTERN AUSTRALIA

In Western Australia, the Wheatbelt region has below average grass fuel loads as a result of average and below average rainfall totals across the region.

In the South West reduced rainfall, a long term deficit in the soil moisture and high fuel loads has led to above normal fire potential.

Conversely, across the Mid West and Desert, it is the high fuel loads as a consequene of above average rainfall totals that warrant the expectation of an above normal fire season. Rainfalls in the area has led to high fuel loads. The higher rainfall across the Nullarbor, east of the Fraser Range, has also led to an above normal fire potential.

SOUTH AUSTRALIA

In South Australia the outlook conditions indicate the most likely scenario is for near normal fire potential across southern agricultural areas of the state, with parts of the North West Pastoral, West Coast, Eastern Eyre Peninsula, Lower Eyre Peninsula, Flinders and Mid North districts likely to be above normal fire potential.

All these areas of above normal fire potential have had above average rainfall in the period leading up to the fire season, resulting in above average fuel loads. The

North West Pastoral and Flinders regions also have abundant fuel loads that have been building up from previous seasons.

The area adjacent to the Northern Territory border (north of the APY Lands) has normal fire potential, in line with the normal potential indicated by the Northern Territory.

A normal to above normal fire potential may see the need for firefighting resources over a longer period of time, together with a longer time for mop-up post fires. The districts where there is potential for above average activity may pose resourcing issues during this fire season, should above level of activity be experienced.

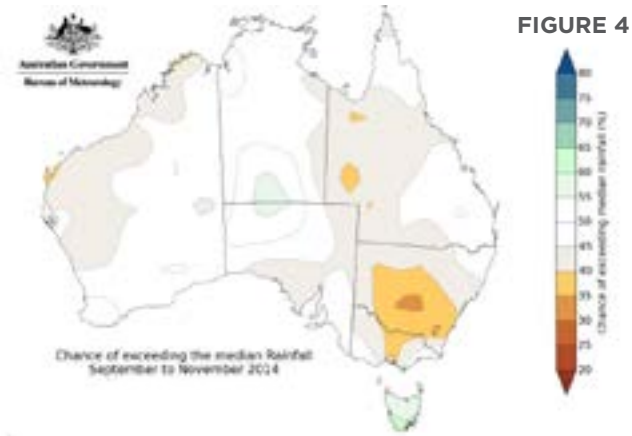


FIGURE 4

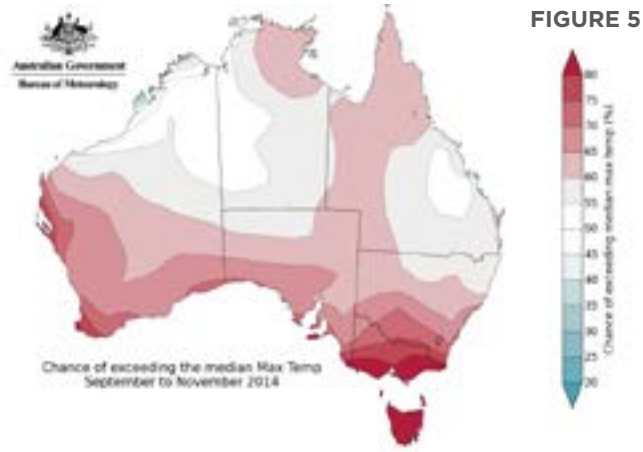


FIGURE 5

QUEENSLAND

The overview for the state is that generally grass fire potential is reduced as a result of the drought. Forest fuels continue to dry out, making more of the fine fuels available for the upcoming fire season.

Recent wet seasons have failed to deliver widespread rains resulting in significantly reduced rainfall particularly in inland areas. More than 75 percent of Queensland is now drought declared. Rainfall from tropical cyclones was patchy and as a result the pasture growth is varied across the state.

In general, grassland fuel loads are significantly less than the average and curing across much of the state is ahead of the same time last year.

Above normal fire potential has been assessed for much of south east Queensland, from Bundaberg south west to Gayndah, north west to Biloela, south to Miles, across to Roma and down the Carnarvon Highway to the NSW border.

TASMANIA

Overall, normal fire season potential is expected over most of the state and on the Bass Strait Islands in the period to the end of December. There is above normal potential in the central part of the east coast between Swansea and St Helens and extending around Fingal. The south of the state is relatively moist, including the Derwent Valley and the Southern Midlands. Forest fires are expected to be relatively normal up to December in the eastern half of the state. while forest fire activity in the west will be suppressed. Similarly, moorland and scrub fuels are expected to be relatively normal while grassland fire activity will be low during spring and early summer.

VICTORIA

A preliminary investigation of factors affecting the fire season outlook for 2014-15 point to an above normal season in many areas of central, north and western Victoria. Key factors are an overall rainfall deficit coupled with the potential for an earlier start to the season.

Areas with long-term rainfall deficits run from the west of Melbourne to the central Wimmera and also north through central Victoria into the Mallee. Another band exists extending from the north east of Melbourne to the northern slopes of the Great Dividing Range.

Shorter term deficits are emerging in a broad band across much of the state's north, extending south to the northern rises of the Great Dividing Range. Similar deficits are emerging in coastal and southern Victoria, though the exact pattern in these areas is not yet clear.

Climatic signals indicate a likely return to warm conditions in spring. There is no strong signal on rainfall, and agencies will be closely monitoring rainfall amounts across the state.

Widespread above average rainfall conditions are not likely, but even in the event they occur, Victoria may still expect, given the antecedent conditions, a fire season slightly more active than 2013-14.

The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government in the Cooperative Research Centre (CRC) Program. It was formed in 2013 in partnership with the fire, land and emergency service management agencies in Australia and New Zealand for an eight year program to undertake end-user focused research.

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HAZARD **NOTE**

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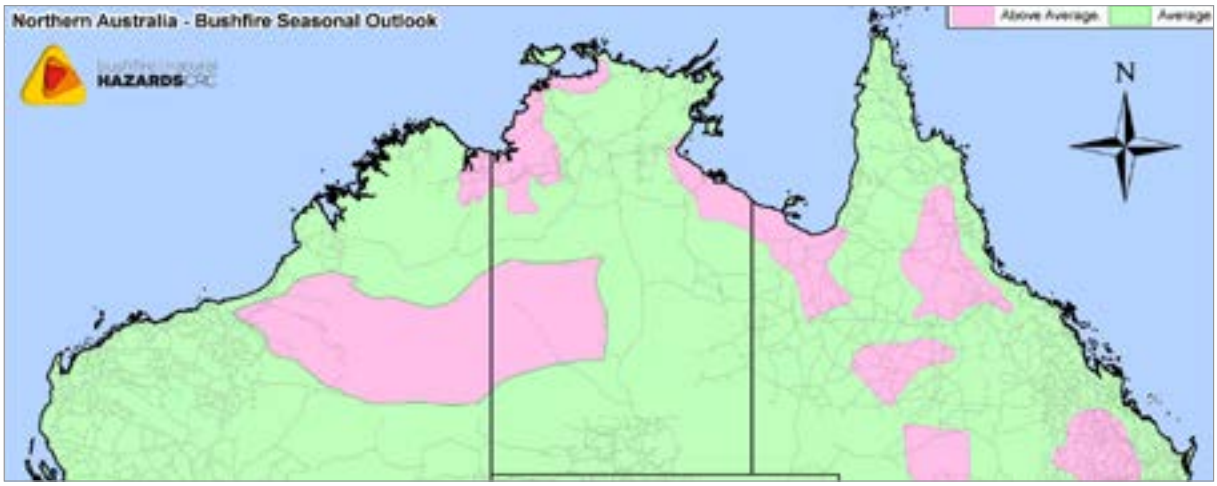
ISSUE 001 JULY 2014

TOPICS IN THIS EDITION | FIRE WEATHER | FUEL MANAGEMENT

NORTHERN AUSTRALIA SEASONAL BUSHFIRE OUTLOOK 2014



BUSHFIRE POTENTIAL

This *Northern Australia Seasonal Bushfire Outlook* provides information to assist fire authorities in making strategic decisions such as resource planning and prescribed fire management, and to reduce the negative impacts of bushfire.

The Bushfire and Natural Hazards CRC is continuing the role begun by the Bushfire CRC as the convener of the meetings to discuss the seasonal outlooks and as the distributor of the final outlook.

A *Seasonal Bushfire Outlook* for southern Australia will be distributed in early September, and will include an update on the northern fire season.

Bushfire potential depends on many factors. In northern Australia, conditions are determined by the nature of the previous wet season. The volume, location and timing of rainfall are critically important when estimating fuel volumes and growth. They also affect the timing of the drying of the fuel.

The climate outlook for the next few months is also a crucial factor. Of particular interest are the future tendencies of Pacific sea surface temperature associated with the El Niño-Southern Oscillation, a major climate driver over Australia. Other less quantifiable factors, such as the distribution and readiness of firefighting resources, are also considered.

The annual Northern Australian Fire Managers' Group Forum, chaired by Bushfire and Natural Hazards CRC CEO Richard Thornton, met in Broome in July.

During the two-day proceedings the Forum discussed the seasonal outlook for the imminent fire season, enabling the production of this *Hazard Note*. All other presentations from the Forum are online at www.bnhcrc.com.au

Forum attendees included representatives of the Bureau of Meteorology, Bushfires NT, the NT Fire and Rescue Service, the WA Department of Fire and Emergency Services, the WA Department of Parks and Wildlife, Queensland Rural Fire Service, Charles Darwin University, University of Western Australia, Carpentaria Land Council Aboriginal Corporation and Kimberley Land Council.

ANTECEDENT CONDITIONS

The 2013-2014 northern wet season saw neutral ENSO conditions (neither La Niña nor El Niño) in the Pacific along with generally warmer than average sea surface temperatures (SSTs) in the eastern Indian Ocean. With the major climate drivers in a neutral phase and generally not favouring wet or dry conditions over northern Australia, shorter-term weather features contributed to the seasonal variability.

The position of the northern Australian monsoon and the movement of tropical lows delivered above average rainfall to large areas of northern Australia, except for the southern two-thirds of Queensland, which experienced an extended period of drier than normal conditions.

A typical build-up period was followed by one of the earliest monsoon onsets on record at Darwin. The last week of November saw an active monsoon trough over the Top End and included the impact of tropical cyclone *Alessia*. A second burst in monsoon activity began around Boxing Day and brought rainfall mostly to northern Western Australia and included severe tropical cyclone

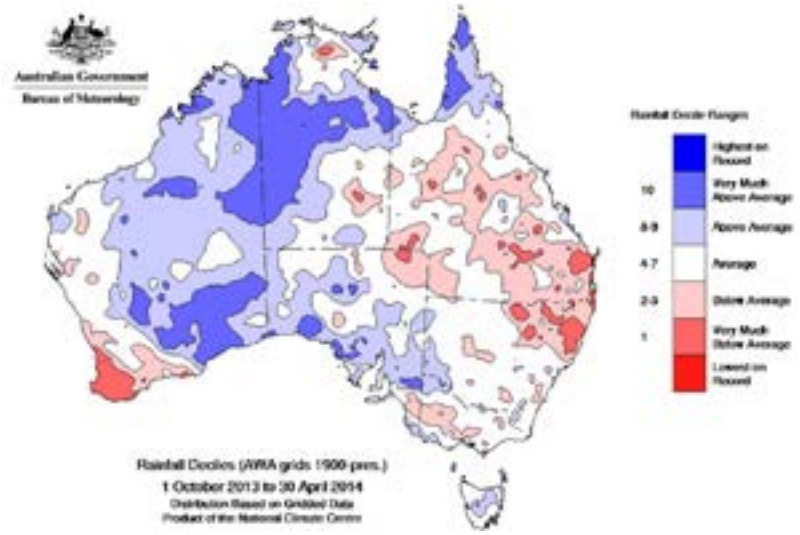
HAZARD **NOTE**

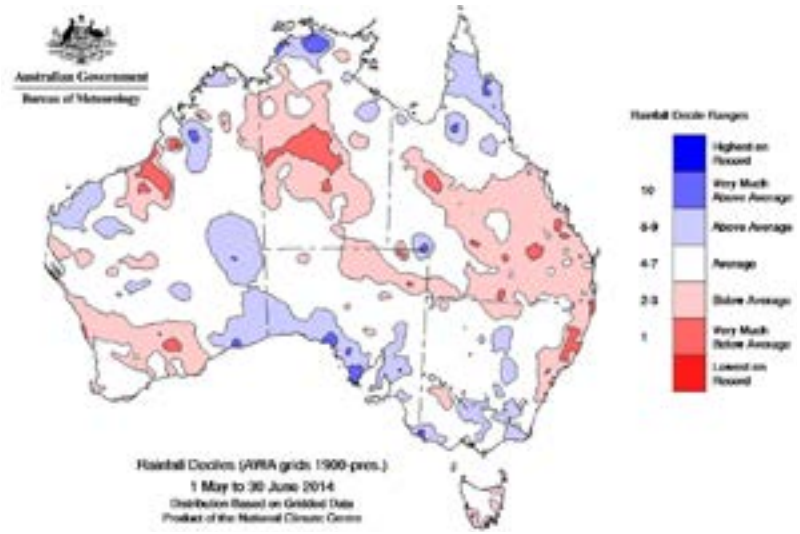
DEFINITIONS

Bushfire potential: The chance of a fire or number of fires occurring of such size, complexity or other impact (such as biodiversity or global emissions) which requires resources (from both a pre-emptive management and suppression capability) beyond the area in which it or they originate. Fire potential depends on many factors including weather and climate, fuel abundance and availability, recent fire history and fire-fighting resources available in an area.

Rainfall decile: A decile is a statistical technique that ranks sorted observations into 10 equal groups. A decile rainfall map will show whether the rainfall is above average, average or below average for the chosen time period and area.

IBRA: Interim Biogeographic Regionalisation for Australia. Australia's landscapes are divided into 89 large geographically distinct bioregions based on common climate, geology, landform, native vegetation and species information. The Bushfire Outlook map is based on the IBRA regions for northern Australia.





Christine, which made landfall near Karratha, WA, on 30 December 2013. While WA received above average rainfall, Queensland had its third driest December on record.

Early January saw high temperatures and a few January temperature records set across northern Australia. In mid-January another active monsoon period began that lasted nearly five weeks and included ex-tropical cyclone *Fletcher* in the Gulf of Carpentaria and two other tropical lows that moved across the Northern Territory and the Kimberley region. The monsoon produced continual, and at times heavy, rainfall across the Top End, Victoria River District and the Barkly, parts of the Pilbara and Interior WA.

In Queensland, however, the monsoon did not move far enough south to produce significant rainfall over northern Queensland except for coastal regions around the Gulf, including Cape York. Most of interior Queensland was the driest since 2003 for January and received near average rainfall for February, which was not enough to make up for several months of dry conditions.

Following an exceptionally wet January and February, March was relatively dry for most of northern Australia with no large-scale monsoon patterns for the month. The wet season ended with a series of small rainfall events that continued until the end of April, with April rainfall totals being near average for most of the tropical north. A northwest cloudband in late April brought welcome rainfall to the Kimberly, Interior WA, the Alice Springs District and parts of Southern Australia, with some locations setting new April rainfall records.

CLIMATE OUTLOOK

The tropical Pacific Ocean surface temperature has been at levels typically associated with a weak El Niño since May. However, waters below the surface have cooled and atmospheric patterns have only recently shown some response to the warm ocean temperatures. These changes would need to persist for several weeks in order for an El Niño to become established, and it remains possible they are simply related to shorter-term weather variability.

Most climate models surveyed by the Bureau of Meteorology along with recent observations continue to indicate El Niño is likely (70 per cent chance) to develop later this year.

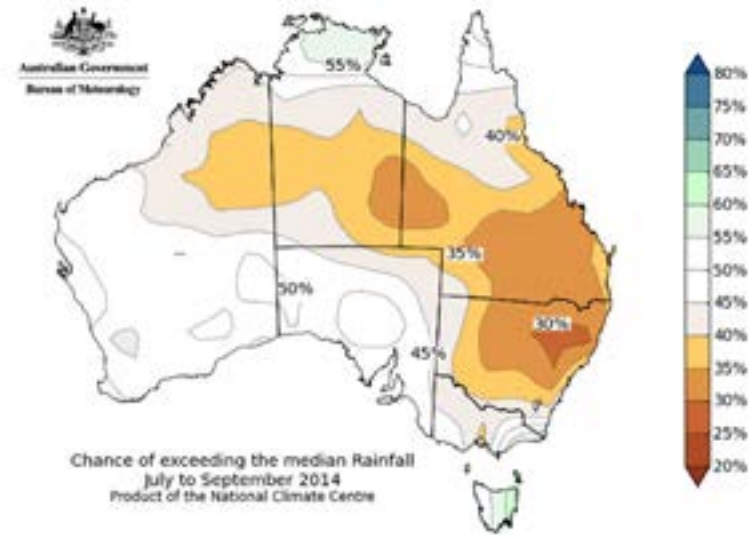
El Niño is often associated with below normal rainfall across large parts of inland eastern Australia during the second half of the year. The recent Seasonal Climate Outlook suggests a northern Australian

rainfall pattern may have some features typical of El Niño periods. Parts of northern Queensland are likely to experience drier than normal conditions for the remainder of the northern dry season. During an El Niño, the northern wet season and monsoon typically arrive later than normal, with northern Australia tending to have lower than usual rainfall from September through January. There is not a strong correlation between El Niño and rainfall across northern WA.

The Indian Ocean Dipole (IOD) typically has influence on Australian climate from about May to November. So far, the IOD has been neutral for most of the year. In mid-June, the sea surface temperature pattern across the tropical Indian Ocean tended towards a weak negative dipole pattern (warmer in the east than the west). However, some model outlooks suggest this may be a short-term shift, and the IOD may return to a neutral pattern for the rest of the year. Negative IOD events are typically associated with average to above average rainfall for central Australia from August to November.

Warmer than normal sea surface temperatures have surrounded northern Australia for most of the dry season. These warmer waters can provide more moisture to the atmosphere, which in favourable weather conditions (for example, interactions with fronts or northwest cloudbands) may result in increased rainfall.

The temperature outlook for Australia favours warmer than normal maximum and minimum temperatures for the remainder of the dry season across northern Australia. This could be partially caused by the warmer than average waters across mid-latitude Indian and south Pacific oceans – air masses moving over Australia need to travel over a large swathe of warmer than average ocean.



REGIONAL SUMMARIES

NORTHERN TERRITORY

Overview

Significant rain events across a large part of the Northern Territory over the past six to nine months, together with longer range forecasts from Bureau of Meteorology and an expectation of a long and hot fire season, allow for the following observations on bushfire potential in the Northern Territory.

Top End

The Darwin Coastal and Darwin IBRA regions had average rainfall totals over the wet season and this has resulted in significant growth of vegetation. In addition, the range and density of Gamba Grass continues to have an impact on this region, greatly increasing the complexity and potential risk associated with managing bushfires. The relatively late curing of the vegetation in the coastal area and limited opportunities to undertake mitigation efforts means that the assessment for the Darwin Coastal region is for Above Average bushfire potential, and an Average potential remains in the neighbouring regions.

Southern Top End

Rainfall totals and associated vegetation growth in the far north including the Victoria Bonaparte IBRA region. Broad scale efforts at mitigating late bushfires have been partially successfully with the high fuel loads somewhat reduced. However, an above average bushfire potential is evident in this region.

On the eastern side of the Northern Territory, significant rain and good vegetation growth has resulted in well above average levels of fuel on the coastal region, including the Gulf Upper Coast. The work that local land management groups and land holders have achieved in fuel hazard abatement is helping management of this area, but above average bushfire potential is still expected for the Gulf Upper Coast region. Neighbouring areas have average bushfire potential.

Central Regions

There has been significant rain across the central reaches of the Northern Territory from the west to middle areas. Rainfall was well above average or at extremely high levels. Average bushfire potential remains elsewhere across the central Northern Territory, south and east towards the South Australian and Queensland borders.

WESTERN AUSTRALIA

Overview

Bushfire potential depends on many factors including climate and weather, fuel abundance and availability, recent fire history and available fire-fighting resources. The Kimberley and Pilbara are fire-prone landscapes and it is normal for bushfires to occur each year. Above normal bushfire potential means that there is a high chance of fires occurring that may be complex, protracted or that could require resources beyond the local capacity.

Kimberley

Overall there is basically an above average bushfire potential in the central region. The extensive prescribed burning in the northern region of the Kimberley has assisted in reducing the very heavy grass growth to an average bushfire potential. The areas to the east and west of the central region are also of average bushfire potential. This assessment is cognisant of the increase in prescribed burning that is planned or has been undertaken across the region.

Pilbara/Northern Goldfields

In general, rainfall across the Pilbara has been average or above average. Due to these rainfall patterns there is an above average bushfire potential in the central and eastern part of this region. On the western side of the central zone the outlook potential is for an average season.

HAZARD **NOTE**

NORTH QUEENSLAND

Overview

Queensland's bushfire season is primarily influenced by long-term and seasonal short-term climate conditions and the relationship the climate has on vegetation.

In the 2014 wet season monsoon Tropical Cyclones Dylan and Ita provided much needed rainfall over Queensland, during a neutral ENSO phase over six months. Rainfall has generally been moderate tending average to below average across most of northern and central Queensland with the exception of Cape York Peninsula where above average rainfall occurred.

The wet monsoonal conditions and consistent thunderstorm activity encouraged vegetation growth over grasslands throughout regional areas of northern, central, coastal and western Queensland.

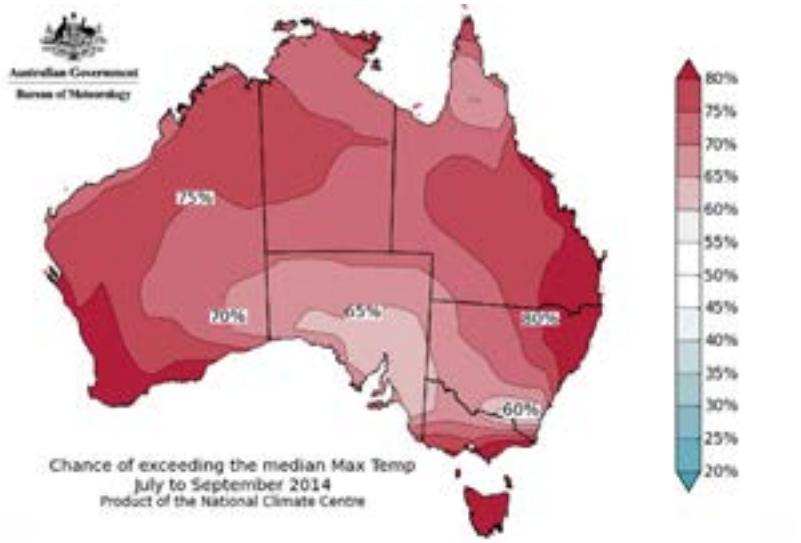
Consistent above average temperatures from April to June 2014 promoted considerable drying of the soil moisture profile, adversely affecting vegetation conditions.

With the onset of the dry season the condition of the vegetation is declining across inland and northern inland areas, significantly increasing bushfire risk especially over landscapes with moderate to abundant grassland fuel loads.

Pasture conditions vary considerably throughout the state with sparse grass conditions in the far western border and nearby inland regions with moderate to abundant grass fuel loads over the northern, central and coastal regions. Winter frosts over inland pastures have added to the denigration of grassland conditions.

Livestock numbers are reduced over large areas due to the increasing drought conditions now covering most of inland Queensland. Landowners are now focused on protecting existing pasture growth, which has increased the risk of fire in some regions.

Forecast climate conditions indicate the potential of receiving less than 50 percent chance of median rainfall over most of



Queensland. The temperature outlook for the same period indicates an increase in day time and night time temperatures.

This in combination with the drying soil profile will contribute to an increased bushfire risk. Bushfires may develop and spread quickly in grassland areas, challenging the response. Already, fire activity is noted to be freely burning during cool overnight temperatures.

In collaboration between state fire and land management agencies, Carpentaria Land Council, landowners and Bushfires NT the following areas have an Above Normal Bushfire Potential for the 2014/2015 bushfire season:

- A buffer area surrounding Coen.
- Inland Northern Tablelands – from Hopevale west of Cooktown south to follow along the western edge of the dividing range south to Innisfail, west to Bulleringa NP north to Laura and east to Hopevale.
- Gulf Plains – north of Normanton to Julia Creek west to about Mary Kathleen, north to Gregory Downs and west to the Northern Territory Border.
- Mitchell Downs and Uplands – West of Pentlands near White Mountain NP, south west to Winton, northwest to Kynuna north to Saxby, east to Dutton Park and south east to White Mountain NP.
- Brigalow Belt North (Bowen Basin) – Bowen River east to Eungella Hinterland south along the ranges to Alsace (north of Dingo), west to Blackwater, north west to Capella, Clermont, north to Pasha and northeast to Bowen River/Bowen Development Road crossing.
- Central West – Barcaldine east to Bogantungan south west to Tambo, North West to Blackall and north to Barcaldine.
- Upper Burnett - Colosseum south to Childers, Miva, west to Tansey, and Monogroilby, northwest to midway between Eidsvold and Cracow, north to Lawgi Dawes, north east to Kroombit Tops NP, east to Wietalaba NP, south east to Colosseum.

A Normal Bushfire Potential is predicted for all other areas north of latitude S25º.

Regions of South East and Western Queensland south of latitude S25º will be assessed during the Southern Australia Bushfire Season workshop August 2014.

Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government in the Cooperative Research Centre (CRC) Program. It was formed in 2013 in partnership with the fire, land and emergency service management agencies in Australia and New Zealand for an eight year program to undertake end-user focused research.

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Future Workforce

HAZARD **NOTE**

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ISSUE 93 APRIL 2021

TOPICS IN THIS EDITION | DECISION MAKING | EMERGENCY MANAGEMENT | MULTI-HAZARD

SUPPORTING EMERGENCY MANAGEMENT TEAM PERFORMANCE DURING EMERGENCIES

Above: THIS RESEARCH DESCRIBES THE KEY TASKS COGNITIVE AID THAT CAN BE USED TO SUPPORT STATE AND REGIONAL-LEVEL EMERGENCY MANAGEMENT TEAMS DURING AN EMERGENCY. PHOTO: SOUTH AUSTRALIA COUNTRY FIRE SERVICE.

ABOUT THIS PROJECT

This research was conducted by CQUniversity and the South Australian Country Fire Service, in partnership with the Bushfire and Natural Hazards CRC and Fire Rescue Victoria, as part of the *Improving decision making in multi-team environments* project. This *Hazard Note* presents the Key Tasks Cognitive Aid – one of six tools developed by this project. The Aid is a checklist designed to support regional and state-level emergency management team operations.

Hazard Note 33 discusses two team management tools developed earlier by A/Prof Chris Bearman and colleagues – the Emergency Management Breakdown Aide Memoire and the Team Process Checklist.

Hazard Note 73 discusses two strategic decision-making tools developed by A/Prof Benjamin Brooks and Dr Steven Curnin – the Psychological Safety Checklist and the Cognitive Bias Aide Memoire.

Hazard Note 92 presents the Emergency Management Non-Technical Skills (EMNoTS) tool, also developed by Dr Peter Hayes and A/Prof Bearman, which further supports emergency management teamwork.

AUTHORS

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SUMMARY

State and regional-level emergency management teams are often required to work under considerable pressure and heavy workloads. On occasion, these pressures can overwhelm individuals or the team and disrupt the ability to function effectively, leading to key tasks and functions being neglected. The Key Tasks Cognitive Aid supports state and regional-level emergency management teams by providing a checklist of key tasks that need to be completed during an emergency.

You can access all tools developed by this project, including the Key Tasks Cognitive Aid, at www.bnhcrc.com.au/driving-change/tools, under the 'Teamwork tools' heading.

BACKGROUND

State and regional-level emergency management teams play a central role in coordinating the response to thousands of incidents each year. The demands on these teams in large-scale emergencies can be considerable. They can be required to coordinate multiple incidents, make sense of information from multiple disparate sources, assist in the provision of public information and warnings, and liaise with numerous stakeholders with different information needs.

These demanding conditions can lead to very high workload, fatigue and stress, which impacts on both individual and team performance (Bearman et al., 2015; Brooks et al., 2018; Owen et al. 2014). It is important to better support people in these roles so that they can maintain effective performance under these conditions. One way to do this is to provide simple checklists and cognitive aids that people can refer to to ensure that critical tasks are not being neglected.

Checklists and cognitive aids are now routinely used in many different safety critical industries to help people reduce errors and omissions, and to improve the speed and fluency of performance. The use of cognitive aids is particularly beneficial for people working under conditions of stress and fatigue, as stress and fatigue have been shown to adversely affect an individual's thinking and perceptual (that is, cognitive) processes, making it more likely that critical tasks will be neglected.

BUSHFIRE AND NATURAL HAZARDS CRC RESEARCH

Since 2015, the research team has been developing tools that support and enhance the performance of individuals and teams in emergency management. The Key Tasks Cognitive Aid featured in this *Hazard Note* is the sixth tool developed by this research team (see the breakout box on page 1 for how to access all six tools).

The Aid was developed using a hierarchical task analysis – an analytical technique that can be used to identify fundamental goals, information processing and cognitive activities that underpin complex activities. This is done by identifying critical activities undertaken by an individual or team and clustering these into discrete tasks and subtasks, and identifying typical sequencing. These tasks can then be assessed for effectiveness or possible improvements.

To develop the Aid, researchers constructed initial task analyses using observations of state and regional coordination centres, and through discussions with agency personnel experienced in working at the state and regional levels. These analyses were converted into a preliminary observation tool, which was developed, refined and evaluated in an iterative cycle during a set of exercises with four regional coordination centres (RCCs) using a human-centred design method.

The exercises required each centre to coordinate the response to a large-scale simulated fire. Two state-level observers evaluated the performance of each regional coordination centre and used the preliminary observation tool to assist in this assessment. The observers considered the extent to which the tasks were undertaken and made comments alongside the items if they observed something noteworthy. At the end of each exercise, the observers met to discuss the tool, how well it captured the key activities, and how it could be improved. The review of the tool at the end of each exercise led to modification of tasks and the amendment of wording to better describe the tasks.

The tool was further developed and evaluated through a set of interviews with six subject matter experts from two additional emergency management agencies. Each of the experts was an experienced state or regional-level controller. The interviewees reviewed the state and regional task analyses and suggested further refinements.

RESEARCH FINDINGS

A set of tasks and subtasks was identified for the state and regional level. Two task analyses were developed, one for the state and one for the regional level. Each task analysis identified five phases of activity, which are now reflected in the Key Tasks Cognitive Aid: *Readiness*, *Escalation*, *Coordination*, *De-escalation* and *Termination*. Each of the phases lists between three and 25 tasks or subtasks that must be carried out to ensure effective coordination of emergencies at state and regional levels. These sets of tasks form the basis of the Aid, which can be accessed in both digital and PDF format at www.bnhcrc.com.au/driving-change/tools under the 'Teamwork tools' heading.

Readiness is when a state or regional team is in place due to the elevated threat of incidents. During this phase, the state or regional coordination centre team ensure that they are aware of, and are monitoring, weather conditions and resources, and have appropriate plans in place to scale-up if required. During the *Escalation* phase, there is a shift in emphasis to responding to evolving incidents, ensuring that regional and state teams anticipate likely developments and review resourcing. The third phase, *Coordination*, is the most active period and has the greatest number of tasks. The focus of this phase is on the requirements to coordinate multiple operations, liaise with other agencies, and monitor and assist with public information provision. The *De-escalation* phase covers the period in which there is decreasing intensity of incident management operations. This phase requires careful sequencing in the wind-down of activities and resourcing. The final phase is *Termination* and has the fewest number of tasks. This phase focuses on wrapping up the centre's activation.

The Aid reflects the tasks and subtasks relevant to the participating agencies. The actual tasks and subtasks required in state and regional coordination centres may differ depending on jurisdictional arrangements, agency protocols and hazard type.

Although the Aid indicates a logical order for undertaking these tasks and subtasks, the dynamic nature of incidents means that it is likely managers will work through each phase of the Aid several times in a cyclical manner. The sequencing of tasks and activities is indicative only, so the order in which tasks are handled may vary depending on the circumstances. Users may find it useful to identify the status of each task by using a traffic light coding system of green (G) for good or in-hand, amber (A) for marginal or incomplete, and red (R) not yet addressed.

HOW SHOULD THIS RESEARCH BE USED?

All of the tools developed by this project are helpful in improving the performance of individuals and teams. This is particularly the case for complex activities, such as those completed by state and regional-level emergency managers.

There are some important differences between emergency management and other sectors that routinely use checklists, such as aviation and medicine. Emergency management teams coordinate operations in environments that are dynamic and tend to have less structure. The demands on emergency management teams may rapidly change as the number, scale and complexity of incidents fluctuate. These

MARCH 2021

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CFS

Key Tasks Cognitive Aid

PURPOSE

This tool is designed as a prompt to help regional and state-level incident and emergency management teams. It ensures they are undertaking tasks important to effective performance, especially when under stress, fatigue or pressure. It is a cognitive aid, providing a checklist of key tasks that need to be completed during an emergency.

USING THE AID

The checklist is reasonably high level and is divided into five phases of incident management that are common to regional control centres (RCC) and state control centres (SCC).

The actual tasks required in each phase, and the order that they are undertaken, will differ between centres, depending on jurisdictional arrangements, agency protocols and hazard type. It is likely that managers will work through each phase several times in a cyclical manner.

1

READINESS PHASE

Preparing for the likely escalation of incidents

- ☐ Understand what resources[1] are available for incident(s) vs. those likely to be required
- ☐ Reviewed the current and forecast weather conditions
- ☐ Reviewed relevant intelligence (e.g. planned community or other events)
- ☐ Reviewed the incidents currently underway and their respective status
- ☐ Identified the potential risks to the community
- ☐ Reviewed any precautions or restrictions in place (e.g. fire bans, road closures)
- ☐ Checked for existing information relevant to likely incidents (e.g. preaction review)
- ☐ Ensured the control centre:
  - ☐ is suitably resourced (e.g. activation level, staffing and facilities)
  - ☐ is organised (e.g. personnel know their roles and are working in them)
  - ☐ is suitably configured (e.g. no significant constraints to information flow or collaboration)
- ☐ Ensured adequate liaison and coordination is occurring with the internal (e.g. other regions or state) and external parties (e.g. other agencies)
- ☐ Issued Chief Officer's or Commissioner's intent

1 Note: resources might include SCC/RCCs/ICCs, general and specialist response resources (e.g. swiftwater rescue, HAZMAT, heavy rescue, urban search and rescue), aviation (available and on standby), other agencies such as police, fire, SES, local government, health, environmental protection, agriculture, Bureau of Meteorology, Australian Defence Force and utilities (gas, electricity, water, sewage), communications, fire towers, control centre food supplies and backup power.

2

▲ **Above:** A SAMPLE OF THE KEY TASKS COGNITIVE AID. YOU CAN ACCESS THE FULL AID ON THE CRC'S ONLINE TOOLS PAGE, UNDER THE 'TEAMWORK TOOLS' HEADING.

teams may be required to concurrently manage multiple incidents at different phases of development. These incidents may be the same hazard type, but could also be different (for example, floods and bushfires). The Key Tasks Cognitive Aid can be used to keep track of tasks for multiple incidents. Users are likely to revisit some task items multiple times within a phase (for example, updating the state-level coordination centre, Chief Officer or Commissioner with a situation report).

It is recommended that state and regional emergency management teams use a separate Aid checklist for each incident to enable tracking of phases and tasks. Use of the Aid is a simple way that these teams working in fast, complex and demanding workload conditions can improve their ability to remember and sequence important and interdependent tasks.

The Aid can be used by state and regional coordination centres in at least three ways:

As a memory aid

It has been designed to help managers ensure they are undertaking tasks important in coordinating the control centre and the incidents they have oversight of. State and regional teams may be working under conditions of stress and fatigue, so a tool that helps to reduce mental workload and improves cognitive ability is valuable. The Aid provides a useful prompt for new personnel or those returning after a period away. Use of this Aid can help practitioners focus on completing tasks rather than having to use their cognitive resources remembering what tasks to do next or what might have been missed. The experienced managers who piloted the checklist reported that it provided useful cues to help them stay on track with tasks and activities.

As a training and development resource

It can be used in several ways to support the training and development of practitioners. The checklist conceptualises the likely

sequence and interdependence of key tasks and activities. This can be used as a training resource to help new personnel build a clear understanding of the phases of an incident and the likely hierarchy of tasks required to coordinate the control centre. These features of the Aid can be used to develop appropriate face-to-face and online training materials.

An additional way the Aid can be used by emergency managers, instructors and coaches is as a diagnostic tool to help structure their feedback for training and development purposes. The checklist provides a common vocabulary that can be used to discuss an individual's or team's performance and provide more structured feedback. The checklist can be used with personnel during exercises, warm starts and on the job, and so can assist new personnel to transition into their roles more quickly.

For continuous improvement

It can be used as part of continuous improvement programs to assess how well a coordination centre is operating. The checklist can also play a useful role in guiding after-action review discussions of a coordination centre's arrangements and activities at the end of a shift or period of operation.

This Aid has already been adopted by the South Australian Country Fire Service and incorporated into its standard operating procedures for conducting and managing real time evaluations (SOP12.4). The CFS also use the checklist to identify the functions of a state or regional coordination centre as specified in a range of procedures that include SOP 1.05 and 1.06. There has been strong interest in this tool from various other agencies including Emergency Management Victoria, Fire Rescue Victoria, and Fire and Rescue NSW.

FUTURE DIRECTIONS

For agencies planning to use the Aid, it will be important to ensure it reflects their local arrangements and aligns to the types of hazards their organisation manages. This may require some customisation. Widespread adoption of this checklist by Australian and New Zealand agencies would help enable:

- the development of a common language for state and regional-level emergency management
- additional assistance to personnel deployed to state or regional-level teams in another agency or jurisdiction
- further guidance for evaluating the performance of state and regional-level emergency management
- greater visibility of key emergency management tasks and activities undertaken in the sector
- the opportunity to improve consistency in how emergency management is undertaken in the sector.

END-USER STATEMENT

"The progression of an incident can be quite rapid, requiring escalation involving regional and state level coordination. Given the nature of these levels of command, progression through preparedness, alert to managing the incident can place pressure and workload on personnel. The use of checklists that guide regional and state emergency teams can contribute to effective management and ensuring all tasks are appropriately considered. The [Aid] also articulates the difference in tasks between regional and state teams which means more effective coordination and support occurs. When aspects of this research and guide are integrated into organisational procedures, it ensures an end to end process is established and understood by emergency team members."

Mark Thomason AFSM, Manager Risk and Lessons Management, South Australia Country Fire Service

FURTHER READING

Bearman C, Grunwald JA, Brooks B & Owen C (2015) Breakdowns in coordinated decision making at and above the incident management team level: an analysis of three large scale Australian wildfires, *Applied Ergonomics*, 47, pp.16–25.

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The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

HAZARD **NOTE**

bushfire&natural HAZARDSCRC

ISSUE 92 APRIL 2021

TOPICS IN THIS EDITION | DECISION MAKING | EMERGENCY MANAGEMENT | SCENARIO ANALYSIS

IMPROVING EMERGENCY MANAGEMENT TEAMWORK USING NON-TECHNICAL SKILLS

▲ **Above:** THIS RESEARCH DESCRIBES THE EMERGENCY MANAGEMENT NON-TECHNICAL SKILLS TOOL THAT CAN BE USED TO ENHANCE THE NON-TECHNICAL CAPABILITIES OF EMERGENCY MANAGEMENT INDIVIDUALS AND TEAMS. PHOTO: SOUTH AUSTRALIA COUNTRY FIRE SERVICE.

ABOUT THIS PROJECT

This research was conducted by CQUniversity as part of the Bushfire and Natural Hazards CRC's *Improving decision making in multi-team environments* project. Researchers identified the non-technical skills required by incident and emergency management team personnel. This *Hazard Note* outlines the non-technical skills framework, which is operationalised as the Emergency Management Non-Technical Skills (EMNoTS) tool, one of six tools developed by this project.

Hazard Note 33 discusses two team management tools developed earlier by A/Prof Chris Bearman and colleagues – the Emergency Management Breakdown Aide Memoire and the Team Process Checklist.

Hazard Note 73 discusses two strategic decision-making tools developed by A/Prof Benjamin Brooks and Dr Steven Curnin – the Psychological Safety Checklist and the Cognitive Bias Aide Memoire.

Hazard Note 93 presents the recently developed Key Tasks Cognitive Aid, designed to support emergency management team operations during crisis.

AUTHORS

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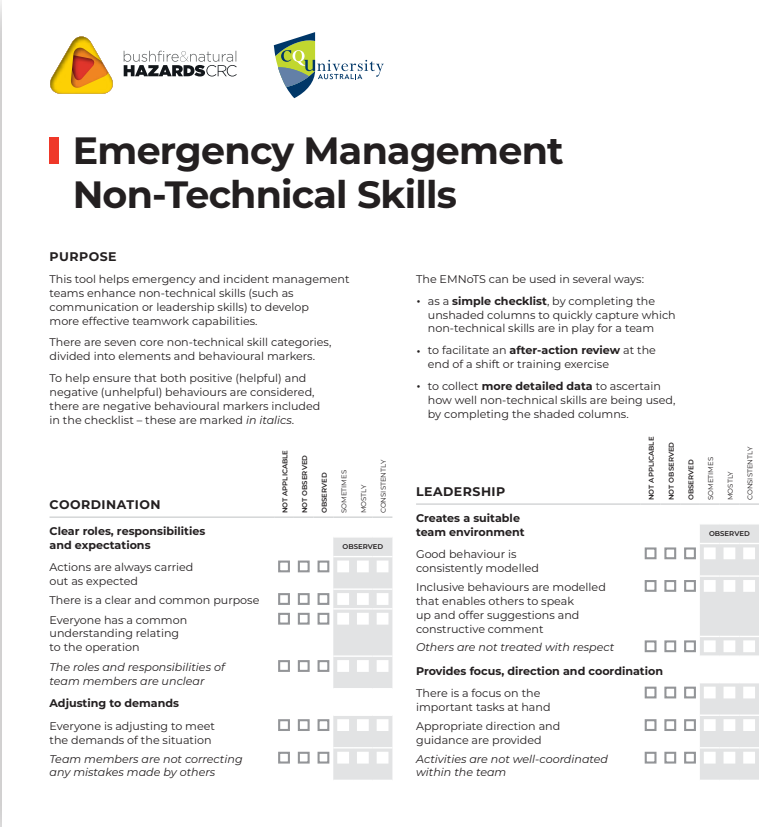
SUMMARY

Incident management and emergency management teams (IMT/EMTs) are regularly required to operate under difficult and demanding circumstances, coordinating the response to large scale emergencies such as storms, floods, bushfires, earthquakes, oil spills, pandemics and industrial incidents. Non-technical skills play a central role in the performance of these teams. Based on a literature review, researchers developed a non-technical skills framework for emergency management. The core non-technical skills included in this framework are: communication, coordination, cooperation, decision-making, situation awareness, leadership, and managing stress/fatigue. This non-technical skills framework is operationalised as the Emergency Management Non-Technical Skills (EMNoTS) tool. This tool can be used to help emergency management individuals and teams enhance these non-technical skills to develop more effective teamwork capabilities.

You can access all tools developed by this project, including the Emergency Management Non-Technical Skills tool, at www.bnhcrc.com.au/driving-change/tools, under the 'Teamwork tools' heading.



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CQUniversity AUSTRALIA

Emergency Management Non-Technical Skills

PURPOSE

This tool helps emergency and incident management teams enhance non-technical skills (such as communication or leadership skills) to develop more effective teamwork capabilities.

There are seven core non-technical skill categories, divided into elements and behavioural markers.

To help ensure that both positive (helpful) and negative (unhelpful) behaviours are considered, there are negative behavioural markers included in the checklist – these are marked *in italics*.

The EMNoTS can be used in several ways:

- as a **simple checklist**, by completing the unshaded columns to quickly capture which non-technical skills are in play for a team
- to facilitate an **after-action review** at the end of a shift or training exercise
- to collect **more detailed data** to ascertain how well non-technical skills are being used, by completing the shaded columns.

COORDINATION	NOT APPLICABLE	NOT OBSERVED	OBSERVED	SOMETIMES	MOSTLY	CONSISTENTLY
Clear roles, responsibilities and expectations			OBSERVED			
Actions are always carried out as expected	☐	☐	☐			
There is a clear and common purpose	☐	☐	☐			
Everyone has a common understanding relating to the operation	☐	☐	☐			
The roles and responsibilities of team members are unclear	☐	☐	☐			
Adjusting to demands						
Everyone is adjusting to meet the demands of the situation	☐	☐	☐			
Team members are not correcting any mistakes made by others	☐	☐	☐			

LEADERSHIP	NOT APPLICABLE	NOT OBSERVED	OBSERVED	SOMETIMES	MOSTLY	CONSISTENTLY
Creates a suitable team environment			OBSERVED			
Good behaviour is consistently modelled	☐	☐	☐			
Inclusive behaviours are modelled that enables others to speak up and offer suggestions and constructive comment	☐	☐	☐			
Others are not treated with respect	☐	☐	☐			
Provides focus, direction and coordination						
There is a focus on the important tasks at hand	☐	☐	☐			
Appropriate direction and guidance are provided	☐	☐	☐			
Activities are not well-coordinated within the team	☐	☐	☐			

▲ **Above:** A SAMPLE OF THE EMERGENCY MANAGEMENT NON-TECHNICAL SKILLS (EMNoTS), SHOWING CORE SKILLS, ELEMENTS OF EACH SKILL AND BEHAVIOURAL MARKERS. YOU CAN ACCESS THE FULL EMNoTS ON THE CRC'S ONLINE TOOLS PAGE, UNDER THE 'TEAMWORK TOOLS' HEADING.

BACKGROUND

The effectiveness of an IMT/EMT is dependent on the ability of team members to successfully interact, maintain appropriate awareness of what is going on and make sound decisions. These types of capabilities, called non-technical skills, are especially important in IMT/EMTs, as these teams are often operating in dynamic, high-consequence and uncertain contexts.

Non-technical skills are defined as the "cognitive, social and personal resource skills that complement technical skills, and contribute to safe and efficient task performance" (Flin et al., 2008, p.1). For example, a firefighter is required to use technical skills to operate the pump on the fire truck and put water on a burning object. The coordination of the crew by the crew leader, how the crew communicates, their decision making and situation awareness are all non-technical skills.

Previous research examining the performance of IMT/EMTs highlights various problems with non-technical skills (Bearman et al., 2015; Brooks et al., 2018). At the individual level, commonly identified issues include inadequate situation awareness, poor decision-making skills and the adverse effects of stress and fatigue. At the team level, common issues are breakdowns in communication, disconnects in the understanding between team members, and uncoordinated decision making/decision errors. Despite evidence that well-developed non-technical skills are central to effective management of large-scale incidents, there has not been much research that focuses on how to improve these skills in IMT/EMTs. This research addresses the basic questions: 'What are the non-technical skills that are required for emergency management and how can we improve their use?'

BUSHFIRE AND NATURAL HAZARDS CRC RESEARCH

Since 2015, the research team has been developing tools that support and enhance performance of individuals and teams in emergency management. The Emergency Management Non-Technical Skills tool featured in this *Hazard Note* is the fifth tool developed by this research team (see the breakout box on page 1 for how to access all six tools).

To identify the non-technical skills required for emergency management, researchers analysed the peer-reviewed published literature in emergency management and other safety-critical sectors. This comprised:

1. research in domains where there is a strong history of research and practice of non-technical skills (such as aviation, maritime, military and healthcare)
2. non-technical skills frameworks developed for fire and emergency response teams (including offshore oil and gas emergency response, nuclear energy emergency response, fire and rescue, and paramedicine)
3. the non-technical skills capabilities and competencies required for emergency incident management, such as the United Kingdom fire and rescue service incident commanders' non-technical skills (Butler et al., 2020), Australian incident management team competency and capability frameworks (Hayes & Omodei, 2011; Owen et al., 2016), and the Team Process Checklist (as featured in *Hazard Note 33*).

As part of the review process, researchers identified aspects of IMT/EMTs that are different to other domains where research on non-technical skills has been conducted, and the issues this raises for the development and application of non-technical skills in emergency management.

Working with existing frameworks

The identification of non-technical skills for a domain typically follows a two-step process: first, identifying the skills and related behaviours for safe and efficient performance, and second, refining and sorting these skills and behaviours into a framework that comprises a list or hierarchical taxonomy (Flin et al., 2008).

Rather than starting from scratch and identifying a set of skills and behaviours to develop a non-technical skills framework, researchers collated and carefully sorted the behavioural indicators from four frameworks identified in the literature review as being most relevant to incident management teams: the Emergency Management Professionalisation Scheme incident management capabilities

(Owen et al., 2016), the Team Process Checklist (see *Hazard Note 33*), incident management team key competencies (Hayes & Omodei, 2011), and a set of incident command skills (Crichton et al., 2005).

Identifying behavioural markers

Each of the four frameworks has a different structure and were developed in a different way, however each framework has in common the provision of a set of behavioural markers. Behavioural markers are statements that identify an aspect of a non-technical skill in a practical and observable way. Researchers used the sets of behavioural markers in each framework as building blocks to identify the core non-technical skills and their sub-components in the new non-technical skills framework. In essence, this list of behavioural markers forms the first part of the Flin et al. (2008) method for identifying non-technical skills.

The second task was to refine and organise this list into a taxonomy. An initial list of 123 behavioural markers for non-technical skills was compiled from the four frameworks. These markers were carefully reviewed and items that were considered unclear or ambiguous were excluded. The remaining 87 items were used to extract an initial set of core non-technical skills and sub-components, called elements. Seven core non-technical skills and 16 elements were identified. This set of non-technical skills, elements and behavioural markers forms the non-technical skills framework for emergency management.

Developing the Emergency Management Non-Technical Skills tool

The non-technical skills framework was developed into the Emergency Management Non-Technical Skills (EMNoTS) tool – that can be used in IMT/EMTs. EMNoTS was developed, evaluated and further refined with end-users using a human-centred design method.

Researchers worked with an iterative cycle of two IMT exercises conducted by the Country Fire Service. In this exercise, people being trained for IMT roles managed a simulated incident with actors playing the role of fireground personnel and other stakeholders (for example, media and police). A prototype EMNoTS was used by the trainer/assessors to supplement their assessment of the candidates. After each exercise, the trainer/assessors provided feedback on the prototype EMNoTS, which was then further revised.

Finally, EMNoTS was evaluated in a separate study with a group of nine experienced incident managers (average experience = 18.4 years). The incident managers watched a video of a response team performing a task and rated their performance using EMNoTS. In this study, EMNoTS was rated (out of 5) as 4.4 for usefulness, 4.3 for clarity and 4.2 for comprehensiveness across the seven different core non-technical skills.

RESEARCH FINDINGS

The EMNoTS tool comprises seven core non-technical skills:

- **Communication** – who says what to whom and the mechanism they use to communicate
- **Coordination** – the synchronisation of individual behaviours and the activities of team members
- **Cooperation** – the willingness of people to work in a team and to support one another
- **Leadership** – the way in which the person in charge of the team provides focus and guidance for the team's activities and models inclusive behaviours
- **Situation awareness** – the team's understanding of the current and possible future situations
- **Decision making** – the making of clear, timely and appropriate decisions
- **Coping with stress/fatigue** – effective management of stress and fatigue within the team

Each of these core non-technical skills can be further divided into sub-components (or elements) and behavioural markers. Communication, for example, has two elements: effective communication and proactive communication. Observable behaviours (behaviour markers) that can be used to determine whether effective communication is occurring are the degree to which: information is passed on in a timely manner, information is passed on accurately, the team members ensure that information has been received and understood by others, and whether inappropriate communication procedures are being used.

To help ensure that the users consider both positive (helpful) and negative (unhelpful) behaviours, each element was described with at least one negative behavioural marker, such as 'Inappropriate communication procedures are being used' within the communication

FURTHER READING

Bearman C, Grunwald JA, Brooks B & Owen C (2015) Breakdowns in coordinated decision making at and above the incident management team level: an analysis of three large scale Australian wildfires, *Applied Ergonomics*, 47, pp.16-25.

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sub-component. These negative behaviours are marked in italics on the EMNoTS.

The EMNoTS, which you can on the CRC's Online Tools page, includes core non-technical skills, elements of those core non-technical skills and sets of behavioural markers for each.

HOW SHOULD THIS RESEARCH BE USED?

The EMNoTS provides guidance on the types of non-technical skills that are important in an IMT/EMT. This tool can be used by emergency management organisations in several ways:

- as a simple checklist
- to facilitate an after-action review
- to collect more detailed data to ascertain how well non-technical skills are being used.

The use of a common non-technical skills framework and tool such as EMNoTS provides the opportunity for emergency management organisations to:

- create clear expectations regarding the required non-technical skills
- provide clear guidance for non-technical skills training content
- develop a common vocabulary for discussing and providing constructive feedback on non-technical skills
- provide assistance on how to address common non-technical skills problems
- provide an objective framework to collect data and monitor trends in non-technical skills at the team and organisational level, to support continuous improvement.

Non-technical skills training

Successful training programs usually embed the development of non-technical skills through three distinct phases: 1) awareness, 2) practice and feedback, and 3) continual reinforcement loop. The *awareness* phase builds understanding of the key concepts and helps participants to develop a common language for non-technical skills.

END-USER STATEMENT

"While incident management and emergency management teams are regularly required to operate under difficult and demanding circumstances, we often find ourselves working with persons well known to us as well as from outside of our normal teams. While incident and emergency management personnel are supported by training and operational procedures, the non-technical skills form an equally important aspect of team management and performance. While it is important for Controllers and emergency management leaders to be aware of this, it beholds all IMT and EMT members to be aware of the non-technical skills and develop strategies to monitor and adjust behaviours and communications to ensure teams operate effectively. The development of the EMNoTS provides opportunities for all emergency managers to use and incorporate these important skills into our training and work."

Mark Thomason AFSM, Manager Risk and Lessons Management, South Australia Country Fire Service

The *practice and feedback* phase uses practical exercises and usually some form of simulation to enable participants to practice and refine their non-technical skills in various situations. The *continual reinforcement loop* phase uses ongoing refresher training in combination with organisational practices, such as workplace auditing, standard operating procedures, and learning and development systems.

In addition, recent work by Thomas (2018) outlines some important principles for the training of non-technical skills, including the need for organisations to carefully coordinate and integrate their efforts with other training programs to upskill their personnel in non-technical skills. Thomas highlights that attitudinal change is an important outcome of non-technical skills training, and that training can take place in various settings, not just during formal training. Thomas emphasises that briefing and debriefing are essential elements for non-technical skills training sessions.

Discussion with several emergency management agencies has indicated the need to ensure that non-technical skills training is part of early training programs and ensure that there are further development opportunities as personnel progress through key transition points to take on more senior roles.

FUTURE DIRECTIONS

The non-technical skills framework provides a valuable start point for developing the types of non-technical skills required by IMT/EMTs. Some suggestions on how to integrate non-technical skills into training programs are suggested in the EMNoTS. To support this process, further work is required to develop support and training materials that agencies can tailor for their own use. These materials will be available in mid-2021.

It is also important that core non-technical skills are well represented in public safety training units and the Emergency Management Professionalisation Scheme. Beyond that, one of the key ways to implement non-technical skills is to embed it in day-to-day activities and management practice so that it simply becomes part of how the organisation conducts its business. Practitioners training emergency management personnel have observed that, to successfully embed non-technical skills, those skills need to become part of all organisational activities, not just used in the emergency management operations. In this way, emergency management agencies can improve their non-technical skills and make their use a core part of everyday operations and activities.

The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

HAZARD **NOTE**

bushfire&natural HAZARDS CRC

ISSUE 84 NOVEMBER 2020

TOPICS IN THIS EDITION | DECISION MAKING | EMERGENCY MANAGEMENT | CAPABILITY

CLOSING THE GAP BETWEEN RESEARCH AND PRACTICE

ABOUT THIS PROJECT

This research was conducted as part of the Bushfire and Natural Hazards CRC's *Improving decision making in complex, multi-team environments* project and is a partnership between the CRC, the University of Tasmania and the Australasian Fire and Emergency Services Authorities Council (AFAC). For this component of the project, researchers built and tested a tool to support emergency services agencies in the self-assessment of their research utilisation capability.

AUTHORS

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SUMMARY

One of the challenges facing the emergency management sector is the gap between research and practice. Despite the considerable investment in publicly funded and commissioned research, the application of research findings to operational practice often lags. Research utilisation capability is about using research in practice to support agency decision making, drive innovation, highlight gaps and opportunities, and deliver desired results.

This project has identified activities involved in the research utilisation process that support agencies to gain maximum benefit from their investment in research. Based on this the authors have developed the Research Utilisation Maturity Matrix – a tool and guidelines to assist agencies in utilising research to support evidence-informed practice.

CONTEXT

The Research Utilisation Maturity Matrix (see Figure 2, page 4) is a self-assessment tool that describes the typical features of an evidence-informed agency at different stages or levels of maturity. The Matrix can be used to:

- indicate how well-established the necessary infrastructures are that support research utilisation within a unit or agency.
- inform which activities and behaviours can be developed to increase levels of research utilisation maturity, in order to assist agencies in getting the best value from their investment in research.

There are also guidelines that advise agency practitioners on how to use the matrix to review and develop research utilisation maturity within their team or agency.

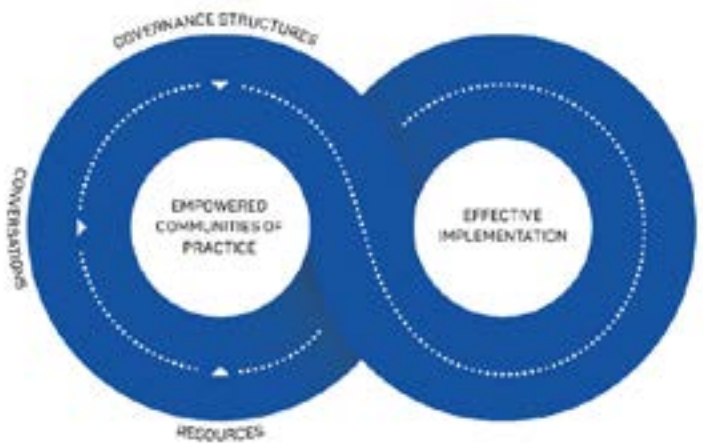

Figure 1: A MODEL TO CONCEPTUALISE HOW THE ELEMENTS OF RESEARCH IMPLEMENTATION (GOVERNANCE STRUCTURES, EMPOWERED COMMUNITIES OF PRACTICE, CONVERSATIONS, AND RESOURCES) WORK TOGETHER TO SUPPORT EFFECTIVE IMPLEMENTATION OF RESEARCH FINDINGS. THE ARROWS INDICATE DIRECTIONS OF SUPPORT, SHOWING THAT RESOURCES, CONVERSATIONS AND GOVERNMENT STRUCTURES SUPPORT EMPOWERED COMMUNITIES OF PRACTICE, WHICH THEN SUPPORT EFFECTIVE IMPLEMENTATION OF RESEARCH OUTCOMES. THESE RELATIONSHIPS ARE DYNAMIC AND ONGOING – ADAPTING AND TRANSFORMING IN WAYS TO FIT EACH ORGANISATIONAL CONTEXT.

BACKGROUND

In emergency management organisations, there is an increasing drive to use research to inform policy and practice, however decision makers face barriers to utilising and integrating research. Although using research to inform practice may sound straightforward, negotiating this in the real world is often difficult because findings are not easily or directly usable by practitioners (for example, when published in journal papers). Yet, the need to demonstrate evidence-informed practice has never been greater, and there has been increasing scrutiny on emergency management organisations to justify their actions. One way to do this is for end-user organisations to actively engage in partnerships with

researchers and their institutions, in the utilisation of research outcomes.

As part of this project, emergency services practitioners were surveyed regularly between 2010 and 2018 to assess how they were utilising research to gain maximum benefit from their investment (see Owen, Bethune & Krusel 2018). The early surveys revealed opportunities for the CRC to improve communication, engagement and collaboration, and the subsequent research utilisation strategy focused on these areas.

In parallel, there was evidence that end-user agency research literacy was also a barrier to research utilisation. Drawing on discussions of the findings from the surveys, a Research Utilisation Maturity Matrix (see Figure 2, page 4) was developed with the AFAC Knowledge Innovation and Research Utilisation Network. Building on this, the 2018 research utilisation survey provided an opportunity to empirically test some of the indicators included in the Matrix, and to test their relationships with indicators of effective research implementation. For further discussion of this research see Owen (2018), Owen et al. (2018), and Owen, Krusel and Bethune (2020).

RESEARCH ACTIVITY

The 2018 survey was completed by 190 respondents from 29 fire and emergency services agencies, land management and policy organisations across Australia and New Zealand. The survey tested two models of research utilisation: the science-push-pull model and a more relational model of knowledge building called the socially interactive organisation model (for further information see Owen, Krusel & Bethune 2020).

The latter was found to be a better fit for indicators of effective research implementation, which include conversations, empowered communities of practice, governance and resources. Figure 1 (page 1) shows a conceptual model of how these elements may work together to support the effective implementation of research.

In addition, discussions with KIRUN members informed the development of a set of indicators of effective research implementation (see Table 1, right).

In terms of considering what successful implementation would look like, the authors speculated that the level of 'maturity' to use research would impact the use of research products. For example, when maturity to use research is low, use of research products would be limited (e.g. outputs 'sit on the shelf'). If findings are implemented, they might be done so in a fragmented way – that is, tied to one-off projects and not linked to core business. However, when organisational maturity to use research is high, research outputs would be discussed and adapted, used in multiple applications, and connected to organisational or operational policy and practice. These indicators were included in the 2018 survey and can be found in Table 1.

RESEARCH FINDINGS

Table 1 shows the indicators of effective implementation that were found to be positively associated with higher levels of implementation, incorporating the indicators from the socially interactive organisational model.

Conversations and empowered communities-of-practice were found to be significant predictors of effective implementation. While there was a positive correlation between effective implementation and resources and governance, these were not significant predictors of implementation, leading the researchers to conclude that resources and governance processes are necessary but not sufficient to support research utilisation alone.

The research found that, when practitioners are engaged in conversations about things that matter to them, and when there are collective groups high in efficacy and commitment, then resources are used more skilfully and organisational structures that further enable effective research implementation are more likely to exist.

Using the Research Utilisation Maturity Matrix

The Research Utilisation Maturity Matrix (see Figure 2, page 4), which can also be found on the AFAC website, is presented as a matrix (or table), with rows representing the different enablers that influence the way an agency utilises research to support evidence-informed practice. There are eight enablers included in the Matrix and these are described in more detail in Table 2.

The four columns of the Matrix represent the levels of maturity for each enabler, from basic (the least mature) to leading (the most mature).

Basic: There are pockets of research utilisation in the agency, however these are not systematically organised. Attempts to keep up to date with research depends on individual effort.

Developing: Some systems and processes are documented, which enables research to be disseminated. There is limited evidence of analysis or impact assessment.

Established: There are systematic processes in place for reviewing research (e.g. dissemination and review, either through job responsibilities or an internal research committee).

Leading: There is evidence of using research proactively.

Table 1: Indicators positively associated with research implementation

Element	Indicator
Conversations	• There are frequent discussions of the implications of research knowledge. • Conversations about how evidence-based policy and practice informs decision making. • There is active and widespread engagement in utilisation and learning activities.
Empowered communities-of-practice	• People are empowered to transform research products to suit multiple applications. • The agency culture values research and its use. • Testing research findings includes processes that trial new practices and allows for 'safe fails'. • There is active participation in testing and prototyping research products to make them suitable for the context. • There is a focus on research being about solving problems and 'problem seeking', to proactively explore and develop solutions.
Governance	• Responsibility for using research is formally embedded in job roles. • There are structures (e.g. research committees) that review and monitor research utilisation. • Reporting processes are well established.
Resources	• Resources are available to implement and drive changes based on research findings, and to make changes part of core business. • Resources are in place for individuals to participate in professional development events.

Operational and strategic decisions are informed by assessing research and using formal research utilisation processes. These processes and systems are widely understood. Within each box of the Matrix, there are a number of statements describing examples of organisational characteristics at each of the four levels of maturity. Practitioners are encouraged to use this matrix to self-assess their agency by reading the statements and choosing which statement (and level of maturity) best describes the characteristics of their agency for each enabler.

The Matrix comes with accompanying guidelines, advising that the statements should not be used as a precise checklist but are examples of the type of features and behaviours expected at that level. It may be that some of the level statements are relevant but not all, in which case the practitioner would need to decide which box is the closest fit for their agency.

HOW IS THE RESEARCH BEING USED?

Since 2018, members of AFAC's Knowledge Innovation Research Utilisation Network have been consulted to identify and trial the Matrix. Case studies of implementation success were also used to evaluate the matrix and the role that maturity plays in understanding the different stages in research utilisation.

In addition, guidelines on the AFAC website provide advice about how to use the Matrix, including how to get started, some ways that conversations may be facilitated and how the insights may be used to move forward.

The Matrix and guidelines help practitioners assess their unit or organisation's capability in research utilisation. A number of emergency service agencies are currently using the Matrix before they embark on commissioning research, to evaluate their organisational infrastructures to ensure they have the right processes in place to benefit from the research results.

Table 2: Enablers in the Research Utilisation Maturity Matrix

Enabler	Description
People	The degree to which people in the unit or agency are expected to have, or are supported in obtaining, the skills necessary to find, appraise and use research. The degree to which utilisation is authorised as part of core activity, embedded within job roles.
Culture	The underlying beliefs, values and behaviours of the unit/agency that inhibit or support research utilisation. This includes how receptive (or resistant) the culture is to adopting and promoting research utilisation in its everyday practice and decision making, and the extent to which research utilisation is viewed by personnel as central to the development and improvement of future policy and practice.
Communities-of-practice (communication and engagement)	The degree to which engaging in using research is an individual or collective activity. Is it driven by passionate individuals alone or are there engaged communities-of-practice where people discuss, share insights? Are these found within the unit or agency and/or between agencies; potentially introducing utilisation insights from other sectors?
Resources and professional development	The degree of investment in resources to develop and improve the capability of all personnel to understand and enable research utilisation. This includes the extent of sufficient learning opportunities provided for personnel to develop their skills, knowledge and experience of research and utilisation.
Policies, procedures and doctrine	The presence or absence of appropriate policies, procedures and doctrine so that research is used to inform policies and practices. The processes by which policies may link using research to the agency's core business.
Structures	The presence or absence of appropriate mechanisms to capture and facilitate research utilisation, to monitor its implementation and to disseminate and promote it throughout the organisation and the wider sector.
Governance	The processes in place to monitor, implement and report on research utilisation including quality assurance for continuous improvement.
Products	The degree to which emerging research products are adopted (i.e. are these taken up across the agency or do they simply 'sit on the shelf'?).

FUTURE DIRECTIONS

The true value of the Research Utilisation Maturity Matrix is in the conversations that it fosters. It is designed to aid reflection, inform development and promote change. It can be used by individuals, in teams, or across a whole agency at a strategic level. The Matrix can be used to support structured and ongoing conversations about the level of utilisation maturity in the organisation.

In addition to this, it is useful at different stages in the development of research-informed practice, including:

- benchmarking current research utilisation capability
- identifying differences in perceptions, and building consensus across different roles, functions and teams about research utilisation
- helping units and agencies identify their own areas of strength and areas for improvement, and tracking these over time
- demonstrating characteristics of an organisation and/or team with a more developed approach to research utilisation
- encouraging peer support – matching those with something to share to those with something to learn.

The Matrix is not intended to be used for performance management or external assessment purposes.

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Enablers	Basic	Developing	Established	Leading
People	Utilisation is not part of core job role. Individuals bring prior skills and find their own professional development.	Utilisation acknowledged but limited systemic understanding or support for using research for practice.	Inquiry related practices embedded in all or many job roles. A learning culture supports testing new ideas and their implications.	Open knowledge sharing and evidence used to improve, adopt, anticipate and question existing understanding and practice.
Communities-of-practice (communication and engagement)	Occurs through individuals who use their own resources and networks.	Some engagement but is not linked to organisational processes.	Active engagement in adapting products to suit context. Active exploration of issues.	Proactive testing and integration of research insights into multiple aspects of activity.
Resources	Support is limited to individuals and their influence within the organisation.	A research policy or unit exists but is not connected to core business.	Capability support provided. Technical systems in place to monitor, review and evaluate.	Support systems are resourced as part of core business. Wide sharing of learning for capability.
Policies procedures and doctrine	No systematic quality assurance, monitoring and reporting on research utilisation.	Policies, procedures and doctrine exists but with limited connection to core business. Some processes exist but are largely spasmodic and unconnected.	Policies, procedures and doctrine is codified, clearly visible and accessible.	Policies, procedures and doctrine is embedded in core business.
Structures	No structures in place supporting research utilisation.	Reactive structures are put in place when a problem emerges.	Research utilisation is strategic, planned and systematic.	Structures support risk taking and innovation.
Governance	No systematic quality assurance, monitoring and reporting on research utilisation.	Governance is project-based only.	Research utilisation is monitored and reporting is reasonably established within governance structures.	Research utilisation is monitored and reported. Governance allows for 'safe fails' and transformational change.
Products	Research products sit on the shelf. Some individuals 'know' and use the products but information disappears when people leave.	Products are one-off and tied to a specific project. Experience of use is often short-lived and organisational memory of utilisation is partial. Utilisation is not sustained (i.e. does not get built into business-as-usual).	Products are user-friendly, fit-for-purpose, easily accessible, widely known and actively incorporated into business-as-usual. Products are widely disseminated, resourced, may have a cost-benefit assessment and are likely used in multiple applications.	There is active testing and prototyping of products emerging from research outputs. Widespread knowledge and use of products. Products may be tested and transformed and there is application beyond the organisation.

▲ **Figure 2:** THE RESEARCH UTILISATION MATURITY MATRIX

END-USER STATEMENT

"The members of the Knowledge Innovation and Research Utilisation Network involved in piloting the Research Utilisation Maturity Matrix have found the tool to be beneficial to help identify the factors that may contribute to the limited utilisation of research and implementation of learnings."
Heather Stuart, Operational Improvements and Lessons Manager, NSW State Emergency Service

The Research Utilisation Maturity Matrix and guidelines can be accessed via the AFAC website.

The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

HAZARD **NOTE**

bushfire&natural HAZARDSCRC

ISSUE 78 SEPTEMBER 2020

TOPICS IN THIS EDITION | CAPABILITY | MULTI-HAZARD | RESPONSE

ON THE FRONTLINE: THE ROLES OF PHARMACISTS IN DISASTERS

ABOUT THIS PROJECT

This research was completed in 2019 at the Queensland University of Technology as part of a Bushfire and Natural Hazards CRC associate student PhD project, *The roles of pharmacists in disaster health management in natural and anthropogenic disasters*.

AUTHORS

Dr Kaitlyn E Watson, Queensland University of Technology and University of Alberta.
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SUMMARY

Pharmacists are among the unsung heroes in health-related impacts of disasters. As the most accessible primary healthcare professionals, they have always assisted in emergencies, but are not adequately recognised for their contributions. The global COVID-19 pandemic identified the essential role pharmacists have in managing the health needs of the community.

This research identifies that pharmacists' roles extend beyond just logistics, also incorporating 43 roles throughout the disaster cycle – prevention, preparedness, response, and recovery – across four practice areas: public health, patient care, governance and logistics. This knowledge is applicable to natural hazards, but can also be applied to any disaster or emergency where healthcare is required, such as the COVID-19 pandemic.

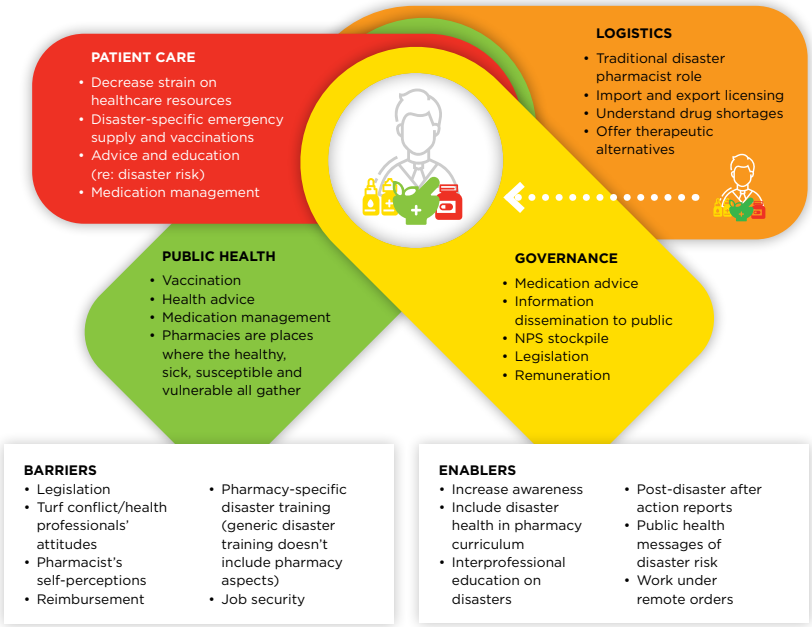

Figure 1: CONCEPTUAL FRAMEWORK MODEL OF PHARMACISTS' CURRENT LOGISTICS PRACTICE AREA AND HOW THEY SHOULD BE ALLOWED TO TRANSCEND THE BOUNDARIES INTO MULTIPLE PRACTICE AREAS. BARRIERS AND ENABLERS TO PHARMACISTS' ROLES IN DISASTERS ARE INCLUDED.

CONTEXT

Disasters are highly stressful environments and often result in the affected community being unable to access basic healthcare services in a timely manner. Healthcare during disasters is often associated with emergency services and hospitals. However, research has identified many disaster-affected individuals avoid these overburdened services and will present to pharmacies for their healthcare needs. Thus, pharmacists provide essential health services to the public and are highly accessible due to their numbers and locality within the community.

BACKGROUND

Pharmacists are uniquely placed to provide frontline healthcare to a large portion of the population in everyday practice, including during a disaster. It is suggested that disasters bring out the best in pharmacists and the best in pharmacy practice. The COVID-19 pandemic and the 2019/20 Australian bushfires have illustrated the essential roles that pharmacists play in providing healthcare to disaster-affected communities, especially in terms of medication continuity.

However, owing to the fragmented nature of disaster management and the organisations closely involved therein, pharmacists are currently limited to their roles within the logistics practice area. The pharmacy profession successfully transcends these individual practice boundaries in daily practice, working collaboratively to provide best-practice patient care. Yet, when a disaster arises, this level of multidisciplinary partnership is generally lost, and pharmacists are allocated to disaster teams as logisticians. Pharmacists need to be accepted and acknowledged for their ability to bring a unique skillset and knowledge to disaster management and be allowed to transcend the boundaries of the restrictive individual practice areas.

BUSHFIRE AND NATURAL HAZARDS CRC RESEARCH

This PhD study identified the roles that pharmacists play in the disaster management prevention, preparedness, response and recovery cycle, and what their roles and responsibilities could be using an all-hazard approach (including both natural and anthropogenic hazards).

This multi-phased, mixed-methods study included both quantitative and qualitative methods, incorporating a disaster pharmacy legislation review and international surveys, interviews, and a Delphi study. International disaster health experts and key opinion leaders from a range of backgrounds (e.g. non-government organisations, government, pharmacy, military, public health, emergency services and disaster management) participated in this study to provide multiple perspectives on pharmacists' roles in disasters.

RESEARCH FINDINGS

This research found that pharmacists can undertake 43 different roles, during and following disasters, and that these roles span four practice areas – public health, patient care, governance, and logistics (see Figure 1, page one). These roles are not in substitution to those of other healthcare professionals, but an additional resource to assist communities during disasters.

PUBLIC HEALTH Pharmacists are involved in several public health roles in their everyday practice. During disasters, which can quickly become public health emergencies, many patients will seek pharmacists for public health advice before making an appointment with another health professional or going to hospital emergency departments. This has been demonstrated in the recent COVID-19 pandemic, with pharmacists providing symptom screening, asymptomatic testing, and being identified as a significant vaccinator for distribution of a vaccine once it becomes available.

PATIENT CARE Evidence-based research has identified the value of pharmacists in optimising patient outcomes and safety. The thunderstorm asthma event in Melbourne in 2016 highlighted that without the pharmacists' response, the mortality and morbidity would have been significantly worse.

GOVERNANCE By giving pharmacists more authority during disasters to adequately look after the needs of chronic disease patients, doctors and nurses can focus their attention and resources on more critically ill patients. Pharmacists need to be more active in government roles and be given more opportunities to contribute to health policy decisions related to disaster management.

LOGISTICS Pharmacists already play an important logistics role during disasters, including import and export licensing, understanding drug shortages, and offering therapeutic alternatives. However, while this role is valuable and essential, it is not the only role that pharmacists can play, and they should be allowed to transcend the boundaries of logistics into multiple practice areas (see Figure 1, page one).

END-USER STATEMENT

"[Pharmacists] need to be involved in the preparedness – if they don't plan for it … then in fact their response is not going to be appropriate. They need to be involved and participating in the whole cycle."
Government Emergency Management Advisor, Participant I13

HOW IS THE RESEARCH BEING USED?

This research has led to increased awareness of pharmacists' roles in disaster management, both within the pharmacy profession as well as international disaster health organisations. Further research is being undertaken internationally to provide additional evidence of pharmacists' preparedness, willingness in disasters, and to identify barriers and enablers to pharmacists' roles in disasters.

The author, Dr Kaitlyn Watson, has been involved in leading disaster tabletop exercise workshops internationally for pharmacists and healthcare students, to increase their understanding and preparedness for health-related impacts of disasters. Dr Watson is currently furthering her research, looking specifically at the impact of COVID-19 on pharmacists' roles and services.

FUTURE DIRECTIONS

Pharmacists have been found to have roles spanning across multiple practice areas. Their roles evolve as a disaster unfolds and depend on the needs of the community and the extent of the collapse of normal healthcare services. A 2019 study conducted by the author found a correlation between the number of disasters experienced by a specific country's jurisdiction and the presence of disaster-specific pharmacy legislation (e.g. emergency supplies, vaccinations, and pharmacy relocation/mobile pharmacies). Further research is required that examines the cost-effectiveness of pharmacist interventions and their willingness to work during disasters.

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HAZARD **NOTE**

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ISSUE 76 JULY 2020

TOPICS IN THIS EDITION | RECRUITMENT | VOLUNTEERING | NON-TRADITIONAL RECRUITMENT

AUTONOMY, BELONGINGNESS AND COMPETENCE: THE ABCs OF EMERGENCY VOLUNTEER RETENTION

ABOUT THIS PROJECT

This research began in 2017 and was conducted as part of the *Enabling sustainable emergency volunteering* project. This component of the project investigated issues of recruitment, retention, diversity and wellbeing among State Emergency Service volunteers, and is part of a larger study on volunteering conducted by the Bushfire and Natural Hazards CRC.

AUTHORS

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▲ Above: THIS RESEARCH ASSESSED THE SATISFACTION OF VOLUNTEERS' PSYCHOLOGICAL NEEDS AND HOW THIS IMPACTS ON RETENTION OUTCOMES IN EMERGENCY SERVICES. PHOTO: DEPARTMENT OF FIRE AND EMERGENCY SERVICES WA.

SUMMARY

Across Australia, emergency services organisations are seeking ways to improve volunteer satisfaction, wellbeing and retention. This research is providing insights and data nationally to help to develop new recruitment and retention strategies for State Emergency Services volunteers. With the research team being based in Western Australia and with the support of the Department of Fire and Emergency Services WA, the study involved a survey of 398 SES volunteers about their volunteer background, leadership, wellbeing and motivation.

Findings show that satisfaction of basic psychological needs (autonomy, belongingness and competence) has a positive effect on volunteer role satisfaction and wellbeing, and reduces volunteers' intentions to leave the service. Volunteers reported feeling high levels of competence and belongingness, but lower levels of autonomy in their roles. Autonomy and belongingness were found to be the more significant drivers of retention, rather than competence. There were also significant differences found between genders and volunteering role types. Women reported feeling less competent compared to men, and non-managers felt less competent and less connected with others compared to managers.

This study proposes several recommendations to increase needs satisfaction for specific volunteer groups. Key recommendations include skill-building activities, adequate support systems and work design changes, ensuring volunteers' freedom and control over their tasks and responsibilities.

CONTEXT

Australian emergency services agencies have expressed a need to improve volunteer retention, which remains a significant challenge. While previous research has investigated various predictors of turnover, it did not consider the individual psychological needs of volunteers. This research investigated the needs satisfaction of volunteers and how it affects their role satisfaction, wellbeing and intentions to remain with the service.

BACKGROUND

Previous research found that interpersonal and group cohesion factors have a significant impact on volunteer turnover (Baxter-Tomkins & Wallace, 2009), thus highlighting the importance of creating an inclusive and cohesive environment to promote volunteer retention. While for-profit organisations rely on financial incentives to retain employees, not-for-profit and volunteering organisations must rely on alternative methods of encouraging people to continue volunteering.

Self-Determination Theory (SDT) argues that the satisfaction of basic psychological needs – *autonomy, belongingness and competence* – are essential to psychological growth and wellbeing (Deci & Ryan, 2000).

The need for *autonomy* refers to an individual's desire to have the freedom to carry out an activity in their chosen way; the need for *belongingness* refers to an individual's need to relate and connect

with people around them; and the need for *competence* refers to the extent to which an individual feels capable of performing effectively in their role.

Previous research has shown the strong influence of autonomy and competence on volunteers' intentions to leave (Haivas, Hofmans, & Pepermans, 2013; Gagné, 2003). When these needs are satisfied, job satisfaction increases and the chance of an individual leaving an organisation decreases (Van den Broeck *et al.*, 2016; Gagné, 2003). The current study investigated the effects of needs satisfaction on retention outcomes within an emergency volunteering context.

BUSHFIRE AND NATURAL HAZARDS CRC RESEARCH

This project investigated the recruitment, retention, diversity and wellbeing practices impacting on State Emergency Service (SES) volunteers in Western Australia. A Cultural Assessment Tool (CAT) survey was conducted to assess volunteers' overall experience.

The CAT survey was conducted with a sample of 398 WA SES volunteers, from 53 SES units, between September 2018 and February 2019. The sample group comprised 37% women and 62% men (with 1% preferring not to say), with an average age of 46.1 years (standard deviation of 15.5 years), with a fifth of respondents being unit managers. This survey included questions about volunteer background, leadership, wellbeing and motivation. Overall, the survey sample was representative of the SES volunteer population in WA at the time.

In the survey, respondents were asked whether they have ever felt like leaving the service and why. These qualitative responses were coded thematically. Almost 64% of volunteers indicated that there was at least one point in time where they considered leaving. When reflecting on this, 70% indicated that, at the time, they felt there were issues with their unit environment or culture, while 20% had felt that their group was not cohesive and 8% felt as though they had little autonomy in their role. Importantly, however, these individuals ultimately chose to remain with their service.

To investigate this further, researchers analysed survey responses to assess whether or not volunteers' basic psychological needs – autonomy, belongingness, and competence – were being satisfied in their roles, and whether this differed between genders or ages. Finally, researchers investigated needs satisfaction and its effect on four retention outcomes: role satisfaction, intentions to remain, learning and vitality.

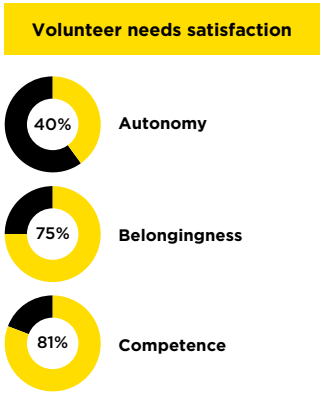

Figure 1: PERCENTAGE OF PARTICIPANTS WHO AGREED OR STRONGLY AGREED WITH FEELING AUTONOMOUS, WELL-CONNECTED AND COMPETENT.

RESEARCH FINDINGS

After examining the needs satisfaction of SES volunteers, researchers found that most surveyed volunteers felt competent and well-connected with other volunteers. This is a positive result, as feeling socially connected with others has been shown to influence role satisfaction, thriving and turnover intentions within this emergency volunteering context. However, volunteers did not feel they had much autonomy in their roles. Specifically, volunteers often felt like they had to follow other people's commands and that, if they could, they would do things differently.

Group differences in needs satisfaction

When examining group differences, women rated similarly to men on feeling autonomous and connected with other SES volunteers (see Figure 2, page 3). However, despite women feeling that they were good at the things they did in their role, they largely felt unsure about their ability to accomplish and master the most difficult tasks in the SES, leading to lower levels of feeling competent overall.

When comparing unit managers with non-managers (see Figure 2, page 3), managers reportedly felt more competent and connected with other volunteers compared to non-managers. However, managers and non-managers felt similarly low levels of autonomy. Where they differ in belongingness ratings, managers felt like they mixed well with other people and had close friends in the SES, while non-managers did not feel this as strongly. Comparing competence ratings, non-managers felt somewhat less confident in their ability to accomplish difficult tasks than managers. Differences in feelings of competence could be attributed to level of experience, thus, the lower levels of confidence could be a key issue to target with non-managers in training activities.

No significant differences were found when examining the relationship between needs satisfaction and unit location or age, however certain trends were observed when examining specific survey items. For example, volunteers older than 45 years of age typically felt more connected with other volunteers than their younger counterparts. Similarly, volunteers between the ages of 56 and 65 felt the most competent. However, this is somewhat expected considering that older volunteers often had longer tenures in the SES, resulting in higher levels of feeling competent.

This study also examined the relationship between volunteers' needs satisfaction and four retention outcomes – role satisfaction, intentions to remain, learning, and vitality (see Figure 3, page 3). Learning and vitality were included as two measures of thriving: a psychological state where an individual believes they are continuously learning and developing in their role, and that their role is

END-USER STATEMENT

"Social and economic conditions are causing major changes in how people volunteer and what they are expecting out of their volunteering experience. This is particularly important knowledge, as understanding the challenges and opportunities that exist for volunteers will be pivotal to maintaining a sustainable volunteer base to provide essential emergency services to the community. This research has provided valuable findings, as well as practical and usable recommendations that have supported the work being undertaken by the Department of Fire and Emergency Services. The outcomes of this project have given us an evidence base to guide and support decisions regarding the recruitment and retention of volunteers. By highlighting the need for greater autonomy in volunteer roles, we have greater direction on improving the focus of motivation and retention strategies in our future work. We look forward to the continuing release of the work produced by the project team, and have appreciated and actively implemented the work that has come to date."

– Jennifer Pidgeon, Strategic Volunteer and Youth Programs Manager, Department of Fire and Emergency Services, Western Australia

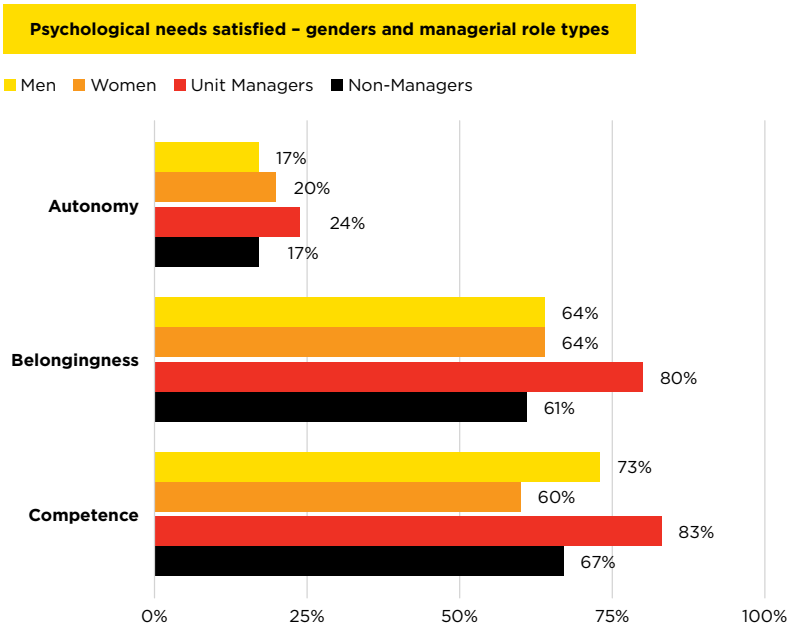

Figure 2: PERCENTAGES OF MEN, WOMEN, UNIT MANAGERS AND NON-MANAGERS WHO AGREED OR STRONGLY AGREED THAT EACH PSYCHOLOGICAL NEED WAS SATISFIED IN THEIR VOLUNTEERING ROLE.

Influence of needs satisfaction on retention outcomes

		Retention outcomes			
				Thriving	
		Role satisfaction	Intentions to remain	Learning	Vitality
Psychological needs	Autonomy				
	Belongingness				
	Competence	x	x	x	

Influenced Strongly influenced

Figure 3: THE RELATIONSHIPS BETWEEN NEEDS SATISFACTION AND FOUR RETENTION OUTCOMES, INDICATING WHICH OF THE RETENTION OUTCOMES WERE SIGNIFICANTLY INFLUENCED BY THE SATISFACTION OF EACH PSYCHOLOGICAL NEED.

a vital source of energy for them (Spreitzer *et al.*, 2005).

Overall, autonomy and belongingness were found to be significantly linked with all four retention outcomes. Autonomy had the strongest association with role satisfaction, intentions to remain, and learning. This highlights how crucial autonomy is to volunteer retention and suggests that volunteers are more likely to be satisfied with their roles, more likely to stay with the service, and more likely to feel like they are continuously learning and developing, if they are helped to feel more autonomous.

Results also suggested that belongingness has significant influence on all volunteer retention outcomes, most significantly on volunteers' vitality. Volunteers may be relying on the benefits of social connectedness and camaraderie in order to feel fulfilled, energetic and psychologically satisfied within their roles.

Contrary to previous research (Haivas, Hofmans & Pepermans, 2013), competence was only significantly associated with vitality, not with volunteer turnover intentions. This result suggests that the feeling of capability significantly impacts how energetic and alive volunteers feel in their roles. However, feeling competent may not necessarily be sufficient for influencing volunteer turnover intentions, of which autonomy and belongingness have the stronger influence.

These results support the qualitative data collected about why people have considered leaving the SES. Few people cited feelings of incompetence as a reason they felt like leaving. However, similar to the survey results, feeling autonomous and connected with other volunteers is highly valued by volunteers and should be improved in SES units to promote volunteer retention. Furthermore, even though women and non-managers reported feeling less competent, this may not necessarily result in these volunteers leaving, however it may present an ongoing challenge that keeps these volunteers coming back.

HOW COULD THIS RESEARCH BE USED?

This study investigated the level of needs satisfaction among SES volunteers and the influence of these needs on retention outcomes (role satisfaction, intentions to remain, learning and vitality). Overall, the volunteers in the sample reported feeling high levels of belongingness and competence, but low levels of autonomy. Based on these results, there are several practical recommendations that can be implemented by volunteer managers, so that they can better tailor their management and training practices to satisfy the needs of specific groups.

Volunteers reported feeling low levels of autonomy, which was shown to be a significant influencer of all four retention outcomes. Therefore, volunteer managers should consider how autonomy could be promoted in their highly regulated environments if they want to improve volunteer retention:

- While it would be hard to allow autonomy in operational duties due to standard procedures, **autonomy should be encouraged in non-operational tasks**. For example, volunteers in one SES unit have re-organised the way the unit is run. Instead of a typical executive committee consisting of several members largely responsible for all organisational tasks, every member of the unit was given responsibility for a small part of the unit's operations. This has had a positive impact on volunteer retention and recruitment. In another unit, volunteers are more involved with the delivery of training, whereby an individual is responsible for planning and facilitating a training session for a particular

topic. Both examples illustrate how increasing volunteer autonomy can be accomplished by allowing volunteers to participate in the everyday activities of their units. By allowing volunteers to assign themselves new tasks, volunteers are also given a sense of ownership over their duties and responsibilities. Sharing the workload of administrative and training duties also allowed volunteers to obtain new skills and development opportunities. This will likely lead to an increase in confidence in their abilities, which is particularly important to non-managers and women, who feel less competent than their experienced or male counterparts.

- Where autonomy isn't possible (for example, in operational procedures), **the crucial need to follow procedures should be made clear to volunteers** for them to fully accept and endorse these procedures. Any **feelings of frustration regarding the lack of autonomy in operational duties should be acknowledged and discussed** between volunteers and their managers.

Belongingness was a key concern for non-managerial volunteers. Satisfying the need for belongingness is an important step that should be addressed in the volunteer onboarding phase:

- **New recruits should be paired together** in a buddy system, allowing newcomers to have shared experiences together.
- **Pairing newcomers with mentors** will also help foster bonding and team cohesion, as it encourages older and newer volunteers to mix.
- An inclusive unit environment can also help improve social connectedness. **Allowing volunteers to speak up and contribute in decision-making processes** within the unit will help them feel like their input is valued.
- **Social functions involving volunteers and their families** might encourage a sense of camaraderie and community within the unit.

Feeling competent was a key issue for women and non-managerial volunteers. While this may be due to lack of exposure or experience, various methods could be considered to improve their overall confidence:

- **Experienced volunteers could mentor less-experienced volunteers**, which provides newcomers with a role model that they can aspire to and a support person they can rely on for task and social support.
- Allowing women and non-managerial volunteers the **opportunity to master difficult tasks in training sessions**, with sufficient feedback and guidance, will also allow their confidence to be built and their misconceptions be challenged and corrected.

Through the provision of adequate training, social support, and development opportunities, it is likely that volunteers' psychological needs will be satisfied, which may result in them being more likely to stay within the service and organisation over time.

FUTURE DIRECTIONS

Opportunities to extend this study would include regularly repeating the study to track any changes over time. To address this, findings from the CAT 2018/19 survey were used to inform the design of the follow-up CAT 2019/20 survey, intended to highlight areas of the volunteering experience that have improved, or have stayed relatively the same, in addition to uncovering which areas are in need of further improvement. For future research, it is advised that specific interventions, as outlined in the section above, be carried out in units to target needs that require improvement. By measuring the needs of the volunteers before and after interventions, the effectiveness of the intervention can be assessed. This will help determine whether the intervention improved the needs satisfaction of volunteers and, as a consequence, their overall volunteering experience, which will benefit the volunteers in addition to improving the service they provide to the organisation and public overall.

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HAZARD **NOTE**

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ISSUE 73 MAY 2020

TOPICS IN THIS EDITION | DECISION MAKING | EMERGENCY MANAGEMENT | SCENARIO ANALYSIS

CREATING PSYCHOLOGICALLY SAFE TEAMS AND MANAGING COGNITIVE BIAS IN STRATEGIC DECISION MAKING

ABOUT THIS PROJECT

This research began in 2017 and forms part of the *Improving decision making in complex multi-team environments* project, conducted by the Bushfire and Natural Hazards CRC. This component of the project investigated strategic decision making in emergency management.

AUTHORS

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Above: THIS RESEARCH EXPLORED THE COMPLEXITIES OF STRATEGIC DECISION MAKING DURING THE DEPLOYMENT OF THE AUSTRALIAN URBAN SEARCH AND RESCUE TEAM TO FUKUSHIMA, JAPAN, IN 2011. PHOTO: FIRE AND RESCUE NSW

SUMMARY

Decision making is a skill that is required for every type of incident and every level of emergency management. In this environment, decision makers are confronted with incidents that are often dynamic, complex and uncertain. This presents challenging physiological contexts that can contribute to poor decisions, resulting in potentially catastrophic outcomes for affected communities. This project comprises three studies that examined different elements of strategic decision making: (1) analysis of decisions made during a series of exercises, (2) analysis of decisions made during an international deployment for a disaster and (3) a training course on strategic decision making. The findings identified a consistent set of decision themes that can change the quality of strategic decision making in emergency management. Appropriately managed, these themes can support effective, efficient and safe decision making. The results of this project provide evidence for a suite of cognitive decision tools and training aides that have been developed and tested for industry use.

CONTEXT

Strategic decision making in high-consequence environments is challenging and stressful due to the dynamism, complexity, uncertainty and time constraints that occur in this environment. In addition, if poor decisions are made at a strategic level, it can also have a cascading effect on the tactical and operational levels of emergency management.

BACKGROUND

In a previous evaluation of decision-making structures and processes with end-users, several aspects of good decision making were evaluated around the response to Level 3 incidents. The highest level of incident under the Australasian Inter-service Incident Management System structure, Level 3 incidents are characterised by degrees of complexity that may require a more substantial organisational structure to manage the emergency, including a delegation of functions. The results identified the following possible opportunities for improvement in strategic decision making skills: (1) an awareness of and an ability to work across the spectrum from intuitive to classically rational decision approaches as the context requires; (2) the ability to monitor themselves and their teams for evidence of bias or decision errors; (3) recognition of the dynamic nature of the process and the need to not just decide, but also to make sense of the situation; (4) an ability to balance the need to record decisions for future reference with the effect that recording has in creating bias in decision making; and (5) the ability to create a psychologically safe decision making environment that builds and maintains trust between teams. This evaluation provided the foundation for this research.

BUSHFIRE AND NATURAL HAZARDS CRC RESEARCH

The team conducted three interrelated studies with the aim of discovering whether the decision maker can be effectively supported. Researchers developed and tested cognitive tools that help to integrate knowledge about human performance with an organisational culture that fosters a supportive environment for strategic decision making. The first study developed a survey to assess decision making in a series of emergency management exercises. The second study used a Critical Decision Method to deepen the understanding of the challenges associated with strategic decision making during a specific international disaster. The third study expanded on the findings of the two previous studies, to develop and refine a training course in decision making that is complemented with supporting tools.

RESEARCH FINDINGS

Following a process called user-centred design, the research team visited emergency services agencies and collected documentary and interview data to understand the nature of decision making. This not only identified opportunities for improvement, but also built awareness of the context for the tools that were later developed. The findings from this first study indicated opportunities for improvement, including creating psychologically safe places for members of a team to speak up, improving record-keeping of decisions, and an awareness of how new intelligence might change decisions.

For the second study, researchers conducted a series of semi-structured interviews with the leadership team of Australian Urban Search and Rescue (USAR), who were deployed to Japan after the 2011 earthquake and tsunami. This deepened the research team's understanding of several insights for good strategic decision making, including the requirement for team leaders to build psychologically safe environments, and an awareness of leaders' own thinking (meta-cognition), particularly when they are moving between different decision styles (for example, from intuitive to more rational analyses).

Finally, the third study confirmed that decision makers should evaluate important strategic decisions for the influence of possible bias or error. Based on these findings, a set of cognitive tools were developed, tested and refined during a series of training sessions, conducted with organisations from the public, not-for-profit and private sectors. Further information about these tools is available below.

HOW COULD THIS RESEARCH BE USED?

By revealing the challenges and mechanisms of managing good strategic decision making in emergency management, this research provides a clearer path for end-users to enhance their strategic decision-making capabilities. Understanding the knowledge and skills required to enhance strategic decision making will contribute to addressing agency expectations. For example, poor decisions at the strategic level can often have a cascading effect on decision making at the tactical and operational levels, which may ultimately result in decisions that can impact a community, such as the decision to evacuate or not. This project has produced two cognitive decision tools and training aides that address these challenges and that can be embedded into policy and operational doctrine. The Psychological Safety Checklist and the Cognitive Bias Aide Memoire are both available here.

This research is currently being used in local government in Western Australia, where the Shire of Mundaring are incorporating one of the tools – the Psychological Safety Checklist – into their Shire Leadership Team Charter.

FUTURE DIRECTIONS

Future research must continue to investigate approaches that seek to address the challenge of making strategic decisions in emergency management. This includes longitudinal studies that would permit evaluation of ongoing outcomes. There is also a need to develop effective ways of managing cognitive predictions, such as anticipatory and divergent thinking, and to explore how these concepts are used to enhance creativity in decision making for low-probability but high-consequence events.

END-USER STATEMENT

"The importance of strategic decision making is crucial in any type of disaster. We need to provide our emerging leaders with tools to assist them to build their capability to make sound strategic decisions focusing on critical factors pertaining to the incident and impacted communities. The outputs from this project will greatly assist the industry in preparing our future leadership for disasters and the decisions they will be expected to make."

– Rob McNeil AFSM, Assistant Commissioner Regional Operations, Fire & Rescue NSW

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The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

HAZARD **NOTE**

bushfire&natural HAZARDSCRC

ISSUE 65 OCTOBER 2019

TOPICS IN THIS EDITION | CAPABILITY | COMMUNITIES | VOLUNTEERING

MOTIVATIONS, EXPERIENCES AND EMOTIONS: BEING AN SES VOLUNTEER

ABOUT THIS PROJECT

This research began in 2017 and was conducted as part of the *Enabling sustainable emergency volunteering* project. This component of the project aims to investigate issues of recruitment, retention, diversity and wellbeing among State Emergency Service volunteers, and is part of a larger study on volunteering conducted by the Bushfire and Natural Hazards CRC.

AUTHORS

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SUMMARY

Across Australia, turnover of State Emergency Service volunteers is high, particularly within their first year of volunteering. This turnover is higher than other volunteer emergency services. Little is known about why individuals volunteer with emergency services and what encourages and supports long-term engagement. This research is providing insights and data nationally to help to develop new recruitment and retention strategies for SES volunteers. With the research team being based in Western Australia and with the support of the Department of Fire and Emergency Services WA (DFES), the study involved in-depth interviews with 70 SES volunteers across Western Australia to explore how individuals make sense of their volunteering experience.

The interviews revealed that volunteers deeply value their connection to their unit, derive meaning from both positive and negative emotional experiences, and sometimes have vague expectations about emergency services volunteering. Managing the expectations of volunteers is not a simple task; some volunteers have too few expectations, and others too many. Both of these scenarios can lead to volunteers having a negative experience and influence their turnover intentions. Based on the findings of the research, strategies to improve volunteer recruitment and retention rates are recommended to include a focus on managing the expectations of volunteers. These include better targeted recruitment messages that emphasise teamwork and personal development opportunities, on-boarding (that is, induction, socialisation, and engagement) processes that convey clear expectations to new recruits, and retention policies that validate volunteers' contributions and achievements.

▲ Above: THIS RESEARCH IS PROVIDING INSIGHTS AND DATA TO STATE EMERGENCY SERVICE'S AROUND AUSTRALIA TO HELP TO DEVELOP NEW RECRUITMENT AND RETENTION STRATEGIES. PHOTO: DEPARTMENT OF FIRE AND EMERGENCY SERVICES WA

CONTEXT

Nationally, SES are seeking to improve their retention of volunteers. Organisational practices have been changing to address this, but there has been a lack of research that investigates individual expectations, experiences and meaning among volunteers.

BACKGROUND

The annual turnover of SES volunteers nationally is high, particularly within the first year of a volunteer's journey. Like all emergency service volunteers, SES volunteers require extensive training, and early turnover incurs significant financial costs and time commitment for training and integration of new volunteers into the organisation. In addition, attracting new volunteers is becoming a considerable challenge, especially in smaller, regional communities.

Previous research on volunteer management advocated for an organisation-based response to recruitment and retention issues, particularly applying targeted human resource (HR) management practices. DFES has successfully developed and implemented several HR policies and practical resources to aid the recruitment, integration and training of volunteers.

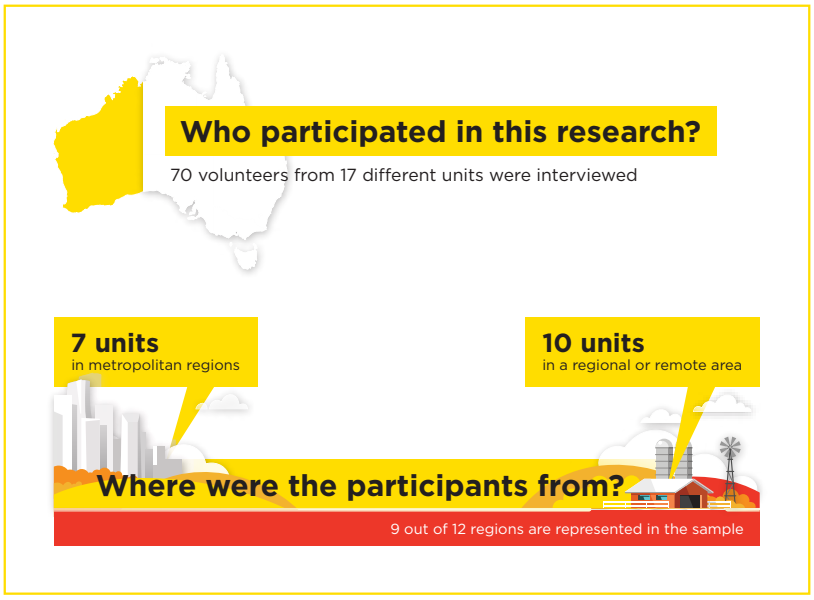

Figure 1: WHO PARTICIPATED IN THE RESEARCH AND THEIR LOCATION.

Little is known about precisely why individuals volunteer with emergency services and what maintains their long-term engagement. This research explored DFES survey data among first year volunteers and identified three types of volunteers, based on their initial motivation to join the service and role expectations. The research found that having too few or too many expectations has a negative impact on volunteer experiences and turnover intentions (Kragt *et al.*, 2018).

Survey data alone is limited in its ability to explore volunteer experiences and perspectives. Building on previous volunteering research from the team, this study conducted extensive qualitative interviews to get a deeper understanding of individual perspectives. These interviews focused on three key aspects: sense of meaning and identity, emotional experiences and expectations.

Identity refers to an individual's self-definition based on a relatively stable set of meanings associated with a particular social role (Stryker & Burke, 2000). Previous research has suggested that the role of emotions in volunteering is poorly understood (Hartel & O'Connor, 2015), and as a result, emotions related to volunteer experiences should be investigated. Finally, a psychological contract is a set of expectations that volunteers have when entering a volunteering organisation. This psychological contract is based on what was promised, or perceived to be promised, by a manager, group, team or organisation (Stirling, Kilpatrick & Orpin, 2011).

BUSHFIRE AND NATURAL HAZARDS CRC RESEARCH

The research team conducted semi-structured interviews with SES volunteers in metropolitan, regional and remote locations across WA. The study sought to understand how meaning, identity and emotions shape volunteer experiences in the SES. Originally, the study aimed to interview a handful of volunteers and volunteer managers. However, the research team recognised that it was crucial to investigate the volunteers' perspective of recruitment, retention and wellbeing, and the scope was deepened and broadened. All interviews were voice recorded and later transcribed. Thematic analysis was used as a data analysis approach.

Overall, 70 volunteers from 17 different units were interviewed. Ten units were located in regional or remote area WA (59%), with nine out of 12 regions represented in the sample. Twenty five interviewees were female (36%), which aligns with the proportion of female volunteers in WA SES overall (37%). Interviewees held a broad range of volunteer roles, including unit managers, training managers, communication managers, team managers and logistics managers.

Half of the interviews were conducted one-on-one, others were conducted in a group setting with two to eight volunteers in a group (average of four interviewees per group). In some cases, a mixed approach was used, where the first part of the interview was conducted in a group, and then one of these interviewees was spoken to one-on-one.

WHAT VOLUNTEERS SAID

"I love working as part of a team. So, that, I guess that meant a lot to me. And it was if, if you're out on a job and you don't know what to do, people are often very, very willing to show you and teach you and help you, so I guess it was quite exhilarating really."

"[Being a volunteer means] to [be a] member of the community and just sort of, just do your part generally. You come in, you work with your team. They're got your back, you've got their back. You go out and you sort of, you see some terrible stuff. But you also see some really great stuff."

"And just so many different experiences. Body, you know, many, many different body recoveries. Which are, which are horrible but they always give you that sense of closure ... to rescues."

"Sometimes the processes can be frustrating. I think we get a lot of admin stuff put onto volunteers, and volunteers don't necessarily want to do that and stuff, you know."

The study focused on questions that addressed interviewees' personal experiences with the SES, and included their background, recruitment, induction and training, expectations, emotional experiences, wellbeing, intention to stay and unit characteristics.

RESEARCH FINDINGS

Volunteering meaning and identity

When asked why they volunteer with the SES, the interviewees often referred to 'community' as their primary motivation. The notion of community was conceptualised in two different ways.

First, community was understood as a more general community of people in the town, state, or country. Being able to help and assist other people in the face of an emergency was identified as the primary driver for joining the SES - interviewees found it empowering and rewarding. This motivation became more meaningful to them as they received recognition for their efforts from the members of their communities.

The second concept of 'community'

was evident in how interviewees related to their fellow volunteers in the unit. The interviewees commonly referred to them as their 'family'. The interviewees found it empowering to belong to a group that is united by a common purpose. Interestingly, some interviewees discussed how their initial motivation to join the SES was to help the larger community, but the reason they continue to volunteer is their connection to the fellow volunteers. In other words, what attracted them to join was different from what kept them coming back.

Emotional experiences

When describing the most exciting and positive experiences they have had as an SES volunteer, interviewees frequently referred to particularly hard and gruesome callouts. Typically, exposure to these types of events could be considered traumatic, rather than 'exciting' or 'positive', however in the case of emergency service volunteers, it seems that the positive aspect of such an experience stems from their ability to be in control and help those in need. Positive effect was also derived from being a part of the team working together in the face of challenging circumstances.

Another form of positive SES volunteer experience was overcoming personal barriers, such as a fear of heights. Interviewees found these personal growth experiences memorable and exciting, and allowed them to better overcome their fears and gain confidence in their abilities both inside and outside the service.

When asked about their most disappointing or negative experiences, some volunteers also mentioned callouts, particularly ones that had a negative outcome. However, more frequently, volunteers mentioned being disappointed when, after being deployed, they were unable to do their part. Frequently, this was cited as being due to organisational procedures and rules that were enforced by those managing the incident. Often interviewees reported administrative hassles and organisational procedures as being negative experiences and did not feel that administrative work should be such a big part of their role. Many volunteers reported feeling misunderstood and undervalued by their governing organisation, which was perceived by some as being focused primarily on firefighting. Other negative experiences reported were related to personal interactions between their unit members.

Volunteering expectations

In line with the concept of the psychological contract, there were several types of initial expectations reported by interviewees. One was the expectation of a highly adventurous and exciting role that involved high risk rescues and frequent callouts.

Other interviewees reported that they expected to contribute to the community, however, these interviewees did not seem to have more specific expectations about what 'helping the community' would actually involve. Because these initial expectations were fairly vague, the interviewees reported some changes in their expectations, which also led to a different meaning derived from the volunteering role. Finally, some reported having no particular expectations at all when joining.

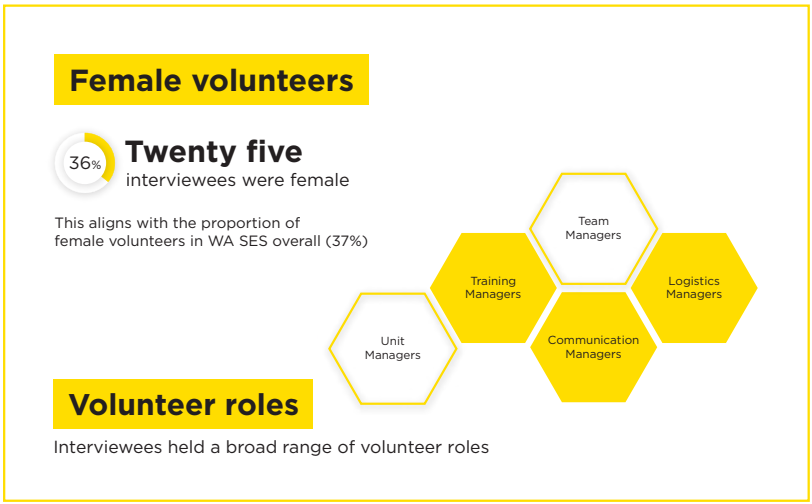

Figure 2: VOLUNTEER ROLES AND THE PERCENTAGE OF FEMALE PARTICIPANTS.

HOW IS THE RESEARCH BEING USED?

This research is already informing DFES volunteer recruitment. It has assisted in the design and content of their volunteer recruitment website www.dfes.vol.org.au, as well as informed the development of the Volunteer Recruitment Roadmap and the associated support materials. It has guided the messaging and approach to DFES' 2019 volunteer recruitment campaign, and contributed to the development of training and workshops for District Officers and other staff on volunteer management.

Nationally, the research findings can inform organisational practices in volunteer recruitment, retention and wellbeing. As is being implemented in WA and other states, targeted recruitment messages that emphasise the role of the SES as community supporters are important. Recruitment messages should also showcase the friendship and support that SES volunteers experience within their local unit, which provides volunteers with a sense of community and belonging. For example, joining the SES might help newer members of a community to build social connections with existing members. Similarly, recruitment campaigns could also showcase the teamwork of SES volunteers as they tackle challenges. Finally, emphasising the opportunities to overcome personal barriers and learn new skills is a key selling point for a prospective SES volunteer. Embedding these

END-USER STATEMENT

"The research conducted by the team has already provided invaluable support to DFES in developing a suite of resources to support volunteers across all our services in their recruitment and retention efforts. The research is providing new insights into the motivation of volunteers and has also raised volunteer interest in targeted recruitment strategies. The project is already providing good guidance relating to the development of recruitment, and we believe it is relevant across the emergency services nationally. We are looking forward to the ongoing release of information and resources from the project."

– Jennifer Pidgeon, Manager Strategic Volunteer and Youth Programs
Department of Fire and Emergency Services, Western Australia

key messages in recruitment materials may attract new volunteers who value community assistance and teamwork, which could potentially improve retention.

Similarly, this improved understanding of volunteer expectations could inform the content of the recruitment messages to attract more volunteers. This aligns with the findings of previous research that clear role expectations are very important for volunteer retention (Kragt *et al.*, 2018). The findings from the interviews highlight that many volunteers have fairly vague expectations or no expectations at all for their volunteer experience. Targeted recruitment and carefully designed on-boarding processes may help to shape the expectations of the incoming volunteers. It is important that the signals create realistic rather than exaggerated expectations, otherwise new volunteers may feel they are not getting what they signed up for.

This research suggests that retention could be improved by undertaking activities within the units that promote integration of volunteers into the unit and build and foster unit cohesiveness. It found that many volunteers derive meaning from their roles as members of their unit, especially later in their tenure. Improving the interactions between unit members could be achieved by incorporating team building activities, providing training on conflict resolution, and encouraging unit managers to involve members in decision making. Improving the recognition of volunteer contributions and skill development is another retention strategy that should be considered. Indeed, the research showed that engaged volunteers particularly enjoyed the personal growth they experienced through training and overcoming challenges, achievements that units could celebrate and recognise as a team.

FUTURE DIRECTIONS

The findings of the interviews have informed the design of a large-scale quantitative survey that all SES volunteers in WA were invited to participate in, in October/November 2018. A second survey will be launched at about the same time in 2019. Together, the quantitative and qualitative research findings will enable a better understanding of volunteer experiences and can be used to help improve SES volunteer recruitment and retention nationally. The findings of the interviews and implications for recruitment, on-boarding and retention will be communicated to a broader group of stakeholders in the emergency services sector via publications, presentations and online workshops.

▲ Above: THIS RESEARCH IS EXPLORING HOW VOLUNTEERS MAKE SENSE OF THEIR VOLUNTEERING EXPERIENCE. PHOTO: NSW STATE EMERGENCY SERVICE

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The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

HAZARD **NOTE**

bushfire&natural HAZARDSCRC

ISSUE 64 SEPTEMBER 2019

TOPICS IN THIS EDITION | NON-TRADITIONAL RECRUITMENT | RESILIENCE | VOLUNTEERING

UNDERSTANDING MODELS FOR SPONTANEOUS VOLUNTEERING

ABOUT THIS PROJECT

This *Hazard Note* draws on research across two related projects. The first, *Out of uniform* – building community resilience through non-traditional volunteering (2014-2017) investigated current and emerging issues around people's participation in non-traditional, or unaffiliated, emergency volunteering. The second, *Enabling sustainable emergency volunteering*, began in 2017 and is engaging with stakeholders to consider the future of emergency volunteering.

AUTHORS

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▲ Above: (LEFT) THE SAMARITAN'S PURSE SITE LEADERSHIP TEAM IN GAWLER, SOUTH AUSTRALIA, FOR THEIR RESPONSE TO THE PINERY BUSHFIRE IN 2015. PHOTO: SAMARITAN'S PURSE. (RIGHT) SPONTANEOUS VOLUNTEERS WITH LISMORE HELPING HANDS ASSISTED IN THE CLEAN UP AFTER THE 2017 FLOODS IN NORTHERN NSW. PHOTO: LISMORE HELPING HANDS.

SUMMARY

The dominant image of spontaneous volunteering in Australian emergency management – of many disorganised outsiders converging on an affected community – is overly narrow and unhelpful for emergency planning. This research provides evidence and a tool to better understand these volunteers and how they come together. It uses case studies of Samaritan's Purse after the 2015 Pinery bushfire in South Australia and Lismore Helping Hands after the 2017 NSW floods to demonstrate the narrowness of the dominant image. The research developed a typology of spontaneous societal responses to disasters that planners can use to help them understand the links to the affected communities and motivations for action, and thus prepare for, diverse forms of spontaneous volunteering that may be more realistic for their hazard conditions, communities and jurisdictions. This typology is included in Australia's first national handbook on planning for spontaneous volunteers, *Communities Responding to Disasters: Planning for Spontaneous Volunteers*, published in 2018 by the Australian Institute for Disaster Resilience (AIDR).

CONTEXT

While spontaneous volunteering is romanticised and celebrated in the media, it has been distrusted and feared within emergency management circles. The dominant image of spontaneous volunteering in these circles is one of overwhelming numbers of well-intentioned but disorganised, uninformed and untrained people converging on an emergency site from outside, creating problems for the disaster-affected communities and the organisations and trained responders seeking to help them. While spontaneous volunteering can look like this, it often doesn't. This overly narrow and misleading image can therefore potentially undermine emergency planning.

BACKGROUND

The International Organisation of Standardisation's 2017 definition of a 'spontaneous volunteer' is "an individual who is not affiliated with an existing incident response organisation or voluntary organisation but who, without extensive preplanning, offers support to the response to, and recovery from, an incident". However, this relatively new term applies to an established, well-documented prosocial behaviour: people stepping up to help others in crisis.

More recently, the scale and visibility of spontaneous volunteering have grown, driven in part by the rise of social media and other new communications technologies. These digital technologies have increased both people's virtual exposure to disasters and their capacity to independently coordinate assistance outside of formal organisations when a disaster strikes (McLennan *et al.* 2016a).

This trend has fuelled distrust and wariness of spontaneous volunteering within the emergency management sector.

The dominant image of this phenomenon within the sector has been fed by the more challenging, large-scale examples that followed major events, such as the September 11 terrorist attacks in the United States (2001), which originated the term 'spontaneous volunteer'. Other large-scale examples followed the Black Saturday bushfires in Victoria (2009), the Brisbane 'Mud Army' in Queensland (2010-2011) and the Christchurch earthquakes in New Zealand (2011-2012).

Emergency managers often focus on the risks and challenges of spontaneous volunteering, particularly at these larger scales. However, risks and challenges can be significantly reduced through effective planning, collaboration and communication, and the benefits for the community, organisations and the volunteers can be high (McLennan *et al.* 2017).

In recent years, the understanding of spontaneous volunteering has grown. Emergency managers in local governments, not-for-profits and emergency service agencies now have a better understanding this phenomenon, its potential benefits, and the need to plan for contributions from spontaneous volunteers. Where resources and support exist, these managers are developing plans and processes for engaging with this emergent, human resource. Key examples include: volunteering peak bodies registering and building local capacity to manage spontaneous volunteers, led by Volunteering Queensland (see McLennan *et al.* 2016b); local government planning such as in Gannawarra and Yarra Ranges Councils in Victoria, and Logan City Council in Queensland; and approaches under the New South Wales State Emergency Service's Volunteering Reimagined strategy (launched in 2017).

BUSHFIRE AND NATURAL HAZARDS CRC RESEARCH

Through the *Out of Uniform* and *Enabling sustainable emergency volunteering* projects, researchers interviewed people who have coordinated or worked with spontaneous volunteers. The *Out of Uniform* project included two research reviews about spontaneous volunteering: the first on informal, 'unaffiliated' emergency volunteering; the second examined the changing landscape of volunteering and its implications. The *Out of Uniform* project also held two workshops with stakeholders from Victoria, New South Wales and South Australia to develop a risk-benefit framework for 'non-traditional' emergency volunteering. Traditional organisations can use this framework to inform strategic decisions about non-traditional emergency volunteering, including spontaneous volunteering.

RESEARCH FINDINGS

This research supports the view that, especially in less severe events, most emergency response and recovery organisations are unlikely to face a scenario of mass, disorganised, spontaneous volunteering involving people from outside the disaster-affected community. In less severe events and outside large, metropolitan areas, spontaneous volunteering can take very different forms. Even in large-scale cases, spontaneous volunteering is more varied in its characteristics, degree of coordination, and impacts than the dominant image portrays.

Counter-examples of spontaneous volunteering

The following are two examples among many that counter the dominant image of spontaneous volunteering, drawn from interviews with coordinators of spontaneous volunteers, quoted anonymously.

Example one: Samaritan's Purse after the 2015 Pinery bushfire, South Australia

Samaritan's Purse is an international, non-profit, Christian organisation that provides emergency relief and development assistance. Through its Australian Domestic Disaster Relief Program set up following the Black Saturday fires in Victoria in 2009, it coordinates and deploys spontaneous volunteers to provide practical support and recovery assistance to disaster-affected communities:

> *"Quite often somebody will roll up; an individual, a group of people, mates, will roll up and say, 'We're here and we'd like to help' and some organisations cannot take, and will not take, untrained volunteers. They'll say, 'Go and see that Samaritan's Purse crowd.' So, we can … we have to be wise how we use people, but people are willing, and you've got to really capture that willing heart."* [Spontaneous volunteer coordinator]

At the request of the South Australian State Recovery Office, Samaritan's Purse worked with the local disaster recovery coordinator in the wake of the 2015 Pinery bushfire. Samaritan's Purse clearly positions itself as a 'second responder':

> *"As we know, the SES and the fireys do a wonderful job here. After they're gone we can then come in when the coast is clear and help people and stay longer."* [Spontaneous volunteer coordinator]

This volunteering was well organised. After assessing the situation, the Samaritan's Purse coordinator deployed their trained volunteer site management team, with its own mobile operations centre. The site team was supported by an offsite management team, also staffed by volunteers. After the team arrived at Gawler, near the fire site, the local Salt Church (now Encounter Church) agreed to host them.

The site management team mobilised around 70 spontaneous volunteers across four weeks to assist local families, businesses and service organisations with work such as building clean up. Most of the deployed volunteers had not mobilised with Samaritan's Purse previously. They included members of the Salt Church in Gawler, nearby small communities, and volunteers from Adelaide contacted via a national email list. Volunteers were diverse in their skills, ages and backgrounds.

> *"We will train those team leaders. Maybe they're people we haven't met before but cream floats to the top. We'll soon find out who's got the ability to lead a team … One of the most valuable people we would ever use is a farmer. They're hard workers and they can do pretty well anything."* [Spontaneous volunteer coordinator]

For information about the 2015 Pinery bushfire, see https://knowledge.aidr.org.au/resources/bushfire-pinery-fire-november-2015/

Example two: Lismore Helping Hands, NSW 2017

In March 2017, Lismore in northern New South Wales was extensively flooded after ex-Tropical Cyclone *Debbie's* deluge overtopped the flood levee. Responders included emergency service agencies, not-for-profits and the Lismore City Council, as well as many informal groups from within the local and wider communities. Lismore Helping Hands was one, and it used Facebook and then recovers.org software to mobilise around 1000 spontaneous volunteers to assist with tasks such as cleaning and debris removal over the three to four week aftermath period. Its base of operations, the Helping Hands Hub, was close to the flooded area and became a grassroots relief centre involving many formal organisations and informal groups.

The Lismore Helping Hands experience challenged key aspects of the dominant image of spontaneous volunteering. Local community members led the spontaneous volunteers, who were also mostly locals with strong ties to the people and businesses directly affected. An organiser explained:

> *"It's not just that it's a whole bunch of strangers from all over the country. It's the community coming out and the community wanting to participate in ... helping their fellow community members." [Spontaneous volunteer coordinator]*

Neither was the spontaneous volunteering disorganised, risky and problematic for the affected community and traditional first responders:

> *"It's been recognised that the way that we did things in that three to four weeks after the event was efficient and effective and a good use of the energy of the spontaneous volunteers. Whereas, I think in the past, spontaneous volunteers have presented problems."* [Spontaneous volunteer coordinator]

Lismore Helping Hands applied basic volunteer management principles and processes, relating to Occupational Health and Safety and team supervision, for example. They worked with, and were supported by, Lismore City Council and referred situations that were beyond their capacity to traditional response and recovery organisations. Their Helping Hands Hub operated as a complementary service to the government-run relief centre.

For its achievements, Lismore Helping Hands won the 2017 NSW Get Ready Community Award. One of the organisers reflected on the importance of community helping community through spontaneous volunteering:

> *"If we shut that down, then I think that has really grave implications for the longer-term recovery of the community, and for that community's willingness to do the same thing in another event."* [Spontaneous volunteer coordinator]

For information about the 2017 northern NSW floods, see https://riskfrontiers.com/the-2017-lismore-flood-insights-from-the-field/

HOW THIS RESEARCH IS BEING USED

Figure 1, below, shows a typology of possible societal responses to disaster. It was developed by Dr Blythe McLennan (author of this *Hazard Note*) for the Australian Institute for Disaster Resilience (AIDR) as a utilisation activity for the *Out of Uniform* project. It is included in the *Communities Responding to Disasters: Planning for Spontaneous Volunteers Handbook*, released by AIDR in early 2018 as the first national handbook for this area.

The typology is a simple, useful tool for checking assumptions about spontaneous volunteering and considering its different forms.

This typology builds upon a well-established typology of organised response to disaster (Dynes 1970), combined with insights from Ronnie Faggoter, Director of the South Australian State Recovery Office at the time of the Pinery fire. The typology has two dimensions:

- The degree to which the volunteers are tied to the local community (represented by the concentric shaded circles); and
- The radial sections showing the ways that volunteers can be organised

Figure 1: A TYPOLOGY OF SOCIETAL RESPONSES TO DISASTER (SOURCE: AIDR 2018, FIGURE 1, P.6, REPRODUCED WITH PERMISSION).

END-USER STATEMENT

"The Australian Disaster Resilience Handbook Collection provides authoritative and trusted guidance on national principles and practices in building disaster resilience in Australia. The *Communities Responding to Disasters: Planning for Spontaneous Volunteers Handbook* provides guidance on planning for and supporting spontaneous volunteers by providing general guidance on ways to incorporate the principles into plans and activities. The handbook has drawn upon current and ongoing activities regarding spontaneous volunteers, building on latest research and the expertise, capability and knowledge of organisations and individuals across Australia and internationally.

"Development of the handbook was supported by Dr Blythe McLennan, through development of a discussion paper for consultation with stakeholders, support in conceptual development, research knowledge and connecting with relevant stakeholder networks, research assisting in environmental scan and literary review and a review of existing spontaneous volunteer management approaches, guides and manuals."

– Amanda Lamont, Director Engagement and Projects, Australian Institute for Disaster Resilience

The differing degrees to which responses have ties or connections with a disaster-affected community is important to element in understanding the volunteers. At its core, the bullseye depicts responses mobilised from within a disaster-affected community. The next layer out captures responses that have strong ties to the community, and the outermost layer depicts responses that have weak or no ties.

The radial sections show the different ways that people and groups may be organised to respond:

- **Individual and informal helping**
- **Emergent groups** – new groups and networks that did not exist before
- **Extending groups and organisations** – no prior involvement in disaster management, who mobilise their volunteers after an emergency (for example, sporting clubs, businesses)
- **Expanding organisations** – have wider missions such as social welfare, but also hold recognised emergency management roles in relief and recovery (for example, Salvation Army)
- **Established organisations** – primary mission and structures are focused directly on emergency management (for example, Surf Life Saving Australia).

In combination with the three levels of association with the community, the five radial sections combine to create 15 categories for spontaneous volunteers.

These categories highlight the value of understanding the degrees of connection that the spontaneous volunteers have to the disaster-affected community and how they are, or are intended to be, organised.

USING THE TYPOLOGY

Each of these five ways of organising responses to disaster, and each of the differing degrees to which these responses have ties to the affected community, come with their own benefits, strengths, risks and weaknesses. Thus, they warrant different considerations in planning.

The dominant image of swarms of disorganised spontaneous volunteers who converge on a disaster site from outside a community sits most comfortably within the two segments of the typology depicting people responding with weak/no ties to the disaster-affected community, either individually/informally or possibly organised through an emergent group. By contrast, in example one (Samaritan's Purse), spontaneous volunteers with strong ties to the affected community mobilised through an expanding organisation with no previous ties to the community (Samaritan's Purse) that was supported by an extending organisation with strong community ties (Salt Church). In example two (Lismore Helping Hands), spontaneous volunteers mobilised within the affected community and with strong ties to it, and they were organised through an emergent group.

The typology's inclusion in the AIDR Handbook can help emergency planners from a range of organisations to distinguish, and thus prepare for, different forms of spontaneous volunteering that may otherwise be conflated together within an overly narrow, dominant image of what this diverse phenomenon looks like, its risks, coordination needs, and impacts.

FUTURE DIRECTIONS

The Emergency Volunteering Shared Learning Network was established in 2018 in association with the *Enabling sustainable emergency volunteering* study as an avenue for managers, volunteers and researchers – irrespective of their organisational affiliations – to share their knowledge and experience with emergency volunteering. Spontaneous volunteering is a key area of focus for the network. For more information and to register to join the network please visit https://emergencyvolunteering.wordpress.com/about or email the author.

FURTHER READING

Australian Institute for Disaster Resilience (2018), *Communities Responding to Disasters: Planning for Spontaneous Volunteers Handbook*, Australian Institute of Disaster Resilience, Melbourne.

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The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

HAZARD **NOTE**

bushfire&natural HAZARDSCRC

ISSUE 60 APRIL 2019

TOPICS IN THIS EDITION | DIVERSITY AND INCLUSION | CAPABILITY | EMERGENCY MANAGEMENT

MAKING DIVERSITY AND INCLUSION THE NEW NORMAL IN EMERGENCY SERVICES

ABOUT THIS PROJECT

This research was conducted during phase one of the Bushfire and Natural Hazards CRC project *Diversity and inclusion: building strength and capability*, which began in 2017. This phase provides a '360 degree view' of diversity and inclusion practice and understanding within emergency management organisations. The research spans organisational, economic and community contexts, and provides a basis for developing a draft diversity and inclusion framework. This *Hazard Note* covers the organisational stream of this research phase.

AUTHORS

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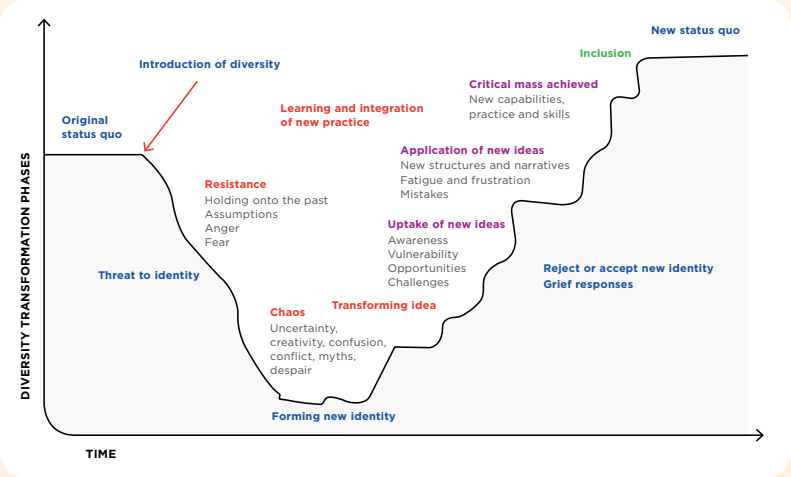

Figure 1: PHASES OF THE DIVERSITY AND INCLUSION TRANSFORMATION PROCESS.

SUMMARY

It is widely acknowledged that the emergency services have still not unlocked the full benefits that come from developing diverse and inclusive paid and volunteer workforces, or the potential opportunities from interactions with their increasingly diverse communities. The practice of diversity and inclusion within emergency service agencies is patchy, and the benefits diversity and inclusion provide are not yet well enough understood. A diverse and inclusive workforce that better reflects the community from which it is drawn can increase trust and help to build more resilient organisations and communities. It can also strengthen the capabilities and skills within emergency management agencies and their communities, so they can more effectively respond to social, environmental and economic drivers of change. A diverse and inclusive workforce is also a critical aspect of managing the escalating risks from these drivers, especially those from natural hazards. This makes diversity and inclusion an organisational imperative for the effective development of the emergency management sector. The research findings, based on case studies of the Queensland Fire and Emergency Services, Fire and Rescue New South Wales and the South Australian State Emergency Service highlighted key characteristics that enable diverse and inclusive organisations, such as being strategic, collaborative, outward thinking, future focused, and empowerment of individuals.

CONTEXT

Implementation of diversity and inclusion is a dynamic and at times, uncomfortable process for many organisations – this includes emergency management agencies. Mostly, implementation has been reactive and inconsistent and has not been fully integrated into organisations. For this to be achieved it needs to be embedded as part of the overarching transformation organisations are going through as they develop their future organisational strategies.

Most investigations to date have focused primarily on the problem of diversity rather than whether implementation is achieving the desired outcome. There has been limited analysis of questions such as: what is 'effective implementation' of diversity and inclusion? What makes it effective? How is this best measured? And what strategies would support its widespread adoption in a way that can ensure it will be sustained?

BACKGROUND

As a systemic issue, diversity and inclusion needs to be managed sustainably for

DECISION TYPE	SIMPLE	COMPLICATED	COMPLEX
Features	Linear, actionable, resolvable with one solution. Often static risks with known treatments and outcomes.	Systemic, may require more than one solution. Uses both known and unknown treatments. Dynamic but can usually be stabilised.	Requires many systemic, broad, inter-related actions and solutions. Dynamic. Treatment often evolves. Often high impact, low probability.
Example	A faulty piece of machinery.	Containment of a natural hazard.	Climate change, resilience, recovery.
Activator	Individuals or people responsible; may be asset owner and/or organisations.	Collaboration by parties linked to and affected by event, assuming delegated areas of responsibility.	'Whole of society' collaboration, sharing ownership through inclusive partnerships.
Thinking frameworks	Logical, analytical, prescriptive and practical.	Short to medium term, analytical, responsive. Mostly prescriptive with intuitive elements that respond to changes.	Long-term, strategic, conceptual, lateral, analytical, creative, reflexive, continuous, flexible.
Leadership actions	Direct and review.	Consult, assess, respond and direct.	Consult, facilitate, reflect, empower, guide and collaborate.
Skills	Technical.	Technical, tactical, soft skills.	Strategic, technical, soft skills.

▲ Table 1: DECISION MAKING TYPES (ADAPTED FROM YOUNG EL AL., 2017 AND JONES ET AL., 2014).

the longer term. This requires complex decision making (see Table 1, above) which incorporates diverse and systemic ways of thinking This presents a major challenge to emergency service agencies, which predominantly use either simple or complicated types of decision making in command-and-control structures. Agencies are less familiar with the complex type needed for systemic and strategic decisions; for example, planning for disasters never before experienced.

The institutional, organisational and social systems that have developed from a history dominated by tactical decision making are often hierarchical, rigid and siloed. This research found that the resulting organisational characteristics of emergency service agencies are often very different to those needed for implementing effective diversity and inclusion (Table 2, right). These characteristics shape how decisions are made and how values and narratives are interpreted, communicated and enacted in organisational contexts. It is important that diversity and inclusion is seen to complement, rather than replace, existing characteristics. Planned transitions are needed to ensure that new characteristics can be developed and integrated so they enhance service delivery and community safety.

FEATURES OF EMERGENCY SERVICE AGENCIES	FEATURES OF EFFECTIVE DIVERSITY AND INCLUSION
Hierarchal	Valuing everyone, equality
Tactical	Strategic
Focused primarily on technical skills	Focused primarily on soft skills
Authoritative leadership directed at organisational areas	Enabling leadership at all organisational levels
Shorter-term decisions	Longer-term visions
Reactive	Reflexive
Resistant to change	Continuous change
Traditional	Forward focus
Working *for* organisation and communities	Working *with* organisation and communities
Inward thinking with organisational focus	Outward thinking across all society
Directive communication	Interactive communication
'Fixes things' within a timeframe	Does not 'fix things' – requires ongoing, longer term management
Knowing what to do and not making mistakes	Expecting the unexpected and learning from errors
Positional power	Empowerment of individuals

▲ Table 2: FEATURES OF EMERGENCY SERVICE AGENCIES COMPARED TO EFFECTIVE DIVERSITY AND INCLUSION.

BUSHFIRE AND NATURAL HAZARDS CRC RESEARCH

Phase one of this project, conducted between July 2017 and July 2018, entailed a systemic analysis using case studies to examine the current context of diversity and inclusion within three agencies and three communities. The researchers applied values, narratives and decision making lenses across organisational, community and economic themes. The economic theme focused on the changing capabilities of the organisations. The organisational theme looked at the key influences on the organisation's decision making and practice. The community theme explored community values and community attitudes and understanding of emergency service agencies. Both the community and organisational themes examined barriers, opportunities and strengths in relation to diversity and inclusion.

The participating case study organisations were the Queensland Fire and Emergency Services (QFES), Fire and

Rescue New South Wales (FRNSW), and the South Australian State Emergency Service (SASES). The community case studies selected were Bordertown in South Australia, Bendigo in Victoria and south western Sydney in New South Wales, representing rural, regional and urban communities.

The researchers used a collaborative, mixed-methods approach for the organisational assessment which included a literature review, targeted interviews in emergency service agency case studies, a survey, reviews of publicly available documents and a visual audit of websites. Interviews were also undertaken outside of the case studies to provide additional insights and to ensure that the data was representative of the industry as a whole. Aspects of diversity examined were: culture and ethnicity, gender, demographic status (age and education), and disability (physical). Data collected was then provided to the case study organisations for review. This was then synthesised and the draft reports were reviewed by the working group and selected stakeholders to ensure that key observations were also relevant to the sector as a whole.

As the literature yielded no clear definition of effective diversity and inclusion, the research team developed the following definition to guide the project: *Effective diversity is the result of interactions between organisations and individuals that leverage, value and build upon characteristics and attributes within and beyond their organisations to increase diversity and inclusion, resulting in benefits that support joint personal and organisational objectives and goals, over a sustained period of time (Young et al. 2018, p19).*

RESEARCH FINDINGS

Diversity and inclusion activities were being undertaken in all organisations, but were not well integrated into organisational systems and processes, nor connected to daily tasks. There are many ways to undertake diversity and inclusion and its effectiveness depends upon the agency's organisational context, their ability to act and how well they can leverage resources and relationships. The largest barrier to diversity and inclusion was cultural, and the largest need was in the area of management.

The research also reinforced the finding that effective inclusion is the critical component that enables effective diversity and that integrating this into an organisational fabric is a long-term proposition.

Key findings about organisations were:

- There is a need to identify, build, value and reward specific diversity and inclusion capabilities, skills and attributes.
- Increasing the visible presence of diversity in the workforce is important. However, a positive workplace experience for individuals with diverse backgrounds is critical if this diversity is to be maintained.
- Response-based and hierarchical structures, processes and decision making with 'fix it' and 'fit in' cultures were predominant in all organisations. These are often at odds with the more strategic and people-based skills and structures required for diversity and inclusion.
- Diverse organisational cultures exist in each organisation and there are cultural gaps between these, particularly between upper management and brigades and units. This often results in 'us and them' attitudes.
- Skills to support development of increased awareness of how to respond constructively to uncomfortable situations and challenging conversations is critical. Greater awareness of appropriate language use and behaviours and how these are perceived and received by others is also needed.
- Diversity and inclusion is mostly understood as being about 'men and women'. There is limited understanding of how different types of diversity intersect and how to manage their specific needs, for example, for an LGBTIQ member of a culturally and linguistically diverse community in a rural area.
- There is a key need for facilitative approaches that guide rather than direct and for proactive management of difficult and destructive behaviours. Establishment of clear boundaries and accountability is also important.

There was limited understanding of the benefits and opportunities that diversity and inclusion offer. Community benefits are currently not measured. Emergency service agencies also had limited knowledge of the attributes and capabilities held by diverse communities and individuals. Identification and leveraging of these is needed to develop more effective partnerships and communication between agencies and their communities.

Due to the hybrid nature of emergency management agencies and their relationship with the community, measurement and management models tailored to this specific context need to be developed.

END-USER STATEMENT

"I have found the project to be both challenging and enlightening. While it has confirmed some of the good things about the current diversity at SASES, it has also highlighted many areas where we have room for significant improvement. The challenge for all of us is to drive greater diversity in a resource-constrained environment. I am confident that the research to date and the ongoing work of the team will help inform our strategies and support our success."

– Dermot Barry, Deputy Chief Officer, South Australia State Emergency Service

"This research is a ground-breaking opportunity for Australian emergency services. The project brings together practitioners and academics with deep expertise to construct an informed narrative of what inclusion really looks like and means to our organisations.

"The project is already exploring highly nuanced territories that defy previous assumptions and unpack the real mechanics behind staff engagement. It is also discovering the broader benefits of increased diversity within our services. I am proud to be involved with this project. FRNSW is already beginning to benefit from the project's potent data, which will help to better target our inclusion, equity and diversity energies towards meeting future challenges."

– Sonja Braidner, Lead Diversity and Inclusion, Fire and Rescue New South Wales

Implementation

The context assessment revealed that many organisations had not adequately socialised or primed their workforce and past activities were often seen as reactive and resulting in poor outcomes. Myths, assumptions and stereotypical perceptions of diversity and inclusion had also contributed to negative outcomes. Visions and accompanying narratives of what diversity would look like

in future organisations were also lacking. However, at the time of this assessment, QFES were addressing these issues through visioning workshops. Many interviewees felt that diversity and inclusion activities had generated confusion, fear and resistance, particularly at brigade and unit level.

The hero narrative featured strongly in organisational and personal identities in many organisations; these were reflected in public narratives perpetuated by the media and in communities. The visual audit of agency websites found the dominant image displayed was of men of Anglo-Saxon appearance undertaking response activities. As identity has a key role in the transformation process, these images and narratives were found to be both positive and negative and required proactive management during implementation activities.

Examples of effective practice were found in all three case study organisations. These included; the Indigenous Fire and Rescue Employment Strategy (FRNSW), QFES Transforms through Leadership (QFES) and a lateral entry program to increase representation in management (SASES).

Authentic actions and representation of diverse individuals (particularly at leadership level), together with long-term programs and trust were seen as key needs for effective diversity and inclusion by both organisations and the community.

HOW IS THE RESEARCH BEING USED?

Anecdotal evidence suggests the research is already contributing to diversity conversations across upper levels within the sector. Early findings were presented at the Bushfire and Natural Hazards CRC Research Advisory Forum in April 2018, the AFAC18 conference and the AFAC Diversity and Inclusion Group (both September 2018). Many stakeholders have told the research team they find the conversations and reflection which is part of this process valuable and useful. It has also catalysed the establishment of the Emergency Management and Defence Inclusion Practitioners' Association by one of the members of the working group. The project has also undertaken collaborative research with Women And Firefighting Australasia (WAFA) and QFES and the output from this is being used as a basis for further collaborative research activities.

The research methodology for assessment and the strategic change process for diversity and inclusion have received positive feedback from stakeholders as being useful tools for organisational management. Sharing of research outputs has also resulted in the project being approached by other government agencies to conduct research. The research to date has also been presented to a number of key stakeholder organisations during 2018 and 2019.

This research is contributing to improving diversity and inclusion practice within the sector, alongside the many programs within organisations and sector wide programs such as AFAC's involvement in Male Champions of Change.

FUTURE DIRECTIONS

The team is continuing to build upon the evidence based Draft Diversity and Inclusion Framework. They have devised a programmatic continuous improvement process and an organic growth model to support implementation of the strategic change process - published in *The Long Road: Effective Diversity and Inclusion in Emergency Management* report in July 2018. They are also undertaking further interviews to understand how diversity and inclusion is connected to tasks in brigades and units. The economic stream will undertake case studies of selected programs and the community stream will map community capabilities and attributes.

The researchers are also synthesising the outputs from the Into the Future Workshop undertaken in December 2018 and undertaking further investigation into risks associated with this. Early findings indicated that diversity and inclusion related shocks may pose a major risk to organisations and their communities and should be listed on risk registers.

The project will continue working with diversity and inclusion practitioners in their stakeholder agencies to sustain the mutually beneficial learning process.

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The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

HAZARD **NOTE**

bushfire&natural HAZARDSCRC

ISSUE 56 NOVEMBER 2018

TOPICS IN THIS EDITION | MENTAL HEALTH | RESILIENCE | RISK MANAGEMENT

MENTAL HEALTH NEEDS OF FIRST RESPONDERS

Beyond Blue

ABOUT THIS PROJECT

This pioneering Australian research is part of the *National mental health and wellbeing study of police and emergency services*, initiated by mental health organisation Beyond Blue, with support from the Bushfire and Natural Hazards CRC.

It has three key phases:

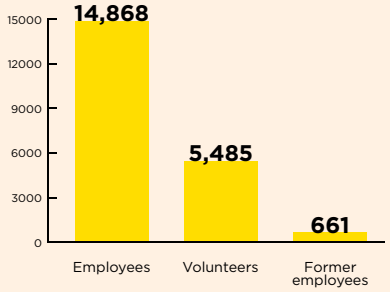
- Phase one – a qualitative project gathering the personal mental health experiences of current and former employees of police and emergency services, their partners and families.
- Phase two – the first national survey of the mental health and wellbeing of police and emergency services personnel, titled *Answering the call*.
- Phase three – a collaborative project that helps police and emergency service communities to optimise their mental health by translating into action the evidence from the police and emergency service program.

This *Hazard Note* focuses on phase two, *Answering the call*, for which Beyond Blue commissioned the University of Western Australia, which partnered with Roy Morgan Research to conduct the survey.

Who participated in this research?

21,014

total survey participants from 33 agencies



38% Employees worked outside major capital cities

77% Volunteers worked outside major capital cities

Figure 1: WHO PARTICIPATED IN THIS RESEARCH?

SUMMARY

Answering the call established a national, representative picture of the prevalence of mental health conditions, suicidal ideation (suicidal thoughts) and attempts, stigma, use of support services, risk and protective factors and individual knowledge and behaviour factors across Australian police and emergency service personnel. More than 21,000 current and former employees, and volunteers, were surveyed. The research found that police and emergency service personnel are deeply impacted by both their work and their work environments. Key results are:

- One in three employees experience high or very high psychological distress, compared to just over one in eight of all Australian adults.
- Almost one in 2.5 employees and one in three volunteers had been diagnosed with a mental health condition at some point, compared to one in five of all Australian adults.
- Employees and volunteers are more than twice as likely to report having had suicidal thoughts than adults in the general population and are more than three times more likely to have a suicide plan, despite comparable rates of suicide attempts.

CONTEXT

Despite extensive, anecdotal evidence that police and emergency services personnel are at greater risk of experiencing a mental health condition, until now, no comprehensive, national data existed. This data void has created challenges in understanding the true extent of mental health issues in the sector and in advocating for genuine reform and change. This landmark research, for the first time, provides a detailed and accurate picture of these issues.

The results of this research have established national baseline measures of wellbeing, mental health conditions and suicide risk among police and emergency services personnel. They also provide evidence about the issues affecting their health and the best ways to provide support.

BACKGROUND

At the time of the survey, there were 117,500 employees and 237,800 volunteers in the participating agencies. Police agencies employed two thirds of the sector's paid workforce, while more than 85% of volunteers

were affiliated with fire and emergency service agencies.

The workforce is geographically dispersed with 38% of employees and 77% of volunteers working outside major capital cities. Most employees worked in operational roles, 20% of employees worked in non-operational roles, and 15% worked in roles that have both non-operational and operational aspects.

Most respondents see their work as a career, with a high proportion of employees having worked for their agency for more than 10 years. Many volunteers also make long-term commitments to their agencies. Most employees work full time, and most do shift work or are on call. Within the ambulance sector, 68% of employees were doing rotating shift work or a combination of shift work and being on call at other times. One third of fire and emergency service employees and 40% of police employees were doing rotating shift work. Around a quarter of full-time employees usually work more than 45 hours per week.

RESEARCH

Answering the call was conducted from October 2017 to March 2018. The scope of the survey included current employees (operational and non-operational), current volunteers, and former/retired employees working in ambulance, fire, police, and state emergency service agencies in each Australian state and territory. Of the 36 agencies in the sector, 33 participated in *Answering the call*.

With the assistance of each agency, a random sample based on defined workforce demographics (stratified random sample) of their current employees and volunteers was selected (or full censuses in smaller agencies) and contacted via email to participate in the online survey.

In total, 14,868 employees and 5,485 volunteers participated in the survey. In addition, a sample of 661 former employees was recruited through associations of former employees and related groups. The total number of survey respondents was 21,014.

RESEARCH FINDINGS

Many of the most significant key messages and findings from nine survey themes are summarised here.

PREVALENCE OF MENTAL HEALTH AND WELLBEING

Key messages

Despite the higher rates of psychological distress, probable PTSD (post-traumatic stress disorder) and suicidal thoughts and planning compared to the general population, many employees have good levels of positive mental health and wellbeing, resilience and low levels of distress.

Key findings

- Ten per cent of employees had probable PTSD. Rates of PTSD ranged from 6% in the state emergency services sector, to 8% in ambulance, 9% in fire and rescue, and 11% in police. In comparison, the prevalence of PTSD has been estimated at 4% in adults in Australia and 8% in the Australian Defence Force.
- Twenty one per cent of employees had high psychological distress and 8% had very high psychological distress – much higher than the 9% and 4% respectively among all adults in Australia, and the 9% and 4% respectively of personnel in the Australian Defence Force.
- Thirty nine per cent of employees and 33% of volunteers reported having been diagnosed with a mental health condition in their life by a mental health professional, compared to 20% of all adults in Australia.

Volunteers showed lower levels of psychological distress and probable PTSD and higher levels of positive wellbeing than employees.

- Four per cent of ambulance volunteers, 5% of fire volunteers and 6% of state emergency service volunteers had probable PTSD.

SUICIDAL THOUGHTS AND BEHAVIOURS

Key messages

Suicidal thoughts and planning were twice as common in the police and emergency services sector as in the Australian population, while rates of suicide attempts were comparable.

Employees with higher levels of social support and resilience reported lower levels of suicidal thoughts and behaviours, even if they had experienced traumatic events that deeply affected them in their work or were likely to have PTSD.

Key findings

- The rate of self-reported suicide attempts was comparable between police and emergency services employees and volunteers, and adults in the general population.

INDIVIDUAL RISK AND PROTECTIVE FACTORS

Key messages

Employees and volunteers in the early stages of their career (less than two years) had high levels of mental wellbeing and very low levels of psychological distress, probable PTSD and suicidal thoughts.

Higher rates of psychological distress and probable PTSD were associated with greater length of service, low levels of social support and more exposure to traumatic events that deeply affected individuals.

Employees and volunteers who reported strong social support mechanisms, maintaining healthy levels of physical activity, and obtaining regular good sleep, had higher levels of mental wellbeing.

Key findings

- Psychological distress was almost twice as high among those who had spent 10 or more years in the service when compared to those who had spent less than two years in the service (32% and 17% respectively).
- More than 80% of employees and 90% of volunteers reported both providing high levels of social support to others, as well as receiving similar support.
- Nearly one in five employees and one in 10 volunteers get poor quality sleep.

SUBSTANCE USE

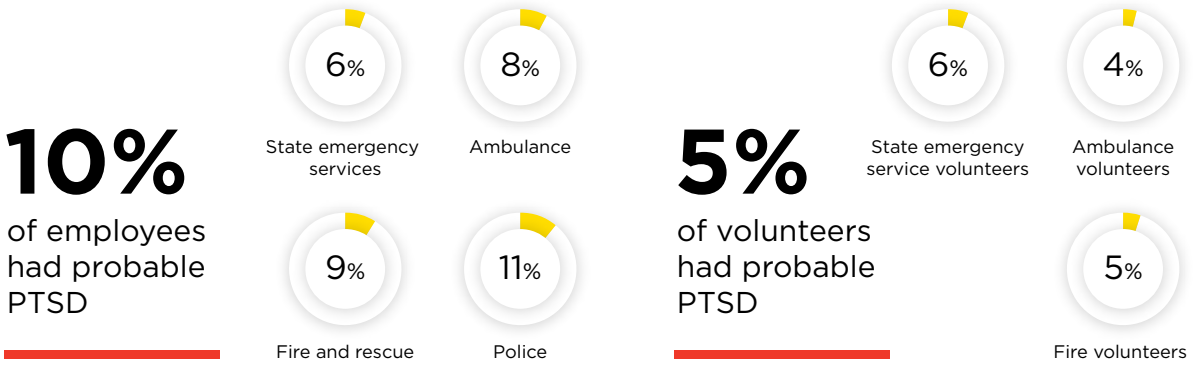
Key messages

Many police and emergency services employees reported high rates of alcohol consumption, which may indicate its use for coping with stress or other symptoms of poor mental health. Personnel with probable PTSD or high levels of psychological distress had the highest rates of harmful levels of drinking.

Key findings

- Almost 50% of employees' alcohol consumption exceeded National Health and Medical Research Council guidelines. Sixteen per cent of employees drank five or more drinks in a single session at least weekly, and 17% drank 10 or more drinks in a single session in the past month.
- Rates of illicit drug use were comparatively low. About 5% of employees reported having used illicit drugs within the past year, although 13% of employees with probable PTSD reported having done so. This

Prevalence of mental health and wellbeing



▲ Figure 2: PREVALENCE OF MENTAL HEALTH AND WELLBEING.

compares with 16% of Australians aged 14 or older who reported using illicit drugs within a 12 month period as part of the 2016 National Drug Strategy Household Survey.

RISK AND PROTECTIVE FACTORS ASSOCIATED WITH THE WORKING ENVIRONMENT

Key messages

The workplace environment, particularly team culture and workplace stress factors, such as inadequate resources and unpaid overtime, had significant impacts on the mental health of employees.

Workplaces that provided sufficient opportunity to recover after stressful events, and had lower levels of gossip, stigma and bullying and higher levels of support and inclusiveness, had lower levels of psychological distress and PTSD and higher levels of resilience.

Key findings

- Three per cent of employees and 1% of volunteers reported experiencing frequent, high-stress bullying, and 8% of employees and 2% of volunteers reported infrequent, high-stress bullying. About half of those exposed to high-stress bullying had high or very high levels of psychological distress.
- In agencies with higher average levels of resilience, more employees were able to take time off after experiencing a traumatic event at work (76%), more frequently had debriefings (74%) and reported that work did not drain so much energy as to affect their private life (83%).
- About half of employees had been involved in an incident that was the subject of a formal investigation or inquiry, and about one in five had been involved in an incident that received adverse attention in the media. These events were often associated with higher levels of psychological distress.

STIGMA

Key messages

Employees and volunteers tended to believe that others in the workplace held negative beliefs towards those with a mental health condition or a low commitment to support those with mental health conditions.

Key findings

- Employees held notable levels of stigma surrounding their own mental health (self-stigma), such as the amount of shame they had about their mental health condition (33%), the amount of burden it causes those around them (32%) and avoiding telling people about their mental health condition (61%).
- Most employees and volunteers reported they would support any colleague who experienced a mental health condition. For example, a very low number of employees and volunteers believed that mental health conditions are the fault of the individual suffering from them (1%) and mental health conditions were a burden on others (2%).
- Employees needing support were more likely to seek it through their agency if they felt that there were lower levels of stigma within their workplace.

SEEKING SUPPORT

Key messages

More people in the police and emergency services sector seek support when they need it for a mental health condition than in the Australian population overall.

Barriers to seeking support commonly cited, for employees and volunteers alike, included wanting to deal with it themselves, concerns about being treated differently or being perceived as weak. Employees were also worried about harming their career prospects or being removed from operational work.

Key findings

- About half of employees (47%) who received support or treatment felt they received sufficient support for their needs. While this may seem low, it is comparable with the general population (45%).
- More than 25% of employees with high or very high distress and about 18% of employees with probable PTSD acknowledged that they had an emotional or mental health issue but did not feel that they needed any support. In addition, more than 20% of employees with probable PTSD perceived a need for support but either did not seek it or did not receive any support.

WORKERS' COMPENSATION

Key messages

Most respondents making workers' compensation claims found the process to be unsupportive, stressful and that it had a negative impact on their recovery.

Key findings

- About 14% of employees had made a workers' compensation claim as a result of trauma, stress or a mental health condition sustained during workplace duties.
- Among employees with probable PTSD who made a claim, 75% felt it had a negative impact on their recovery with only 8% reporting a positive impact on their recovery. More than half (52%) felt that they were not supported at all during the claims experience, and 63% reported that they found the claims experience to be very or extremely stressful.

FORMER EMPLOYEES

Key messages

Former employees who participated in the survey had high rates of probable PTSD, psychological distress and suicidal thoughts.

Former employees had lower resilience and were much less likely to receive high levels of social support compared with current employees – particularly those former employees currently having probable PTSD or high rates of psychological distress.

Key findings

- Twenty eight per cent of former employees had seriously thought about taking their own life. Of those, 66% felt this way while still working in the police and emergency services sector and 62% felt this way after leaving the sector.
- Former employees reported lower levels of social support compared with current employees, particularly those former employees identified as having probable PTSD or high rates of psychological distress. Just over half of former employees (56%) have high levels of both providing social support to others and receiving social support from others.

Figure 3: RISK AND PROTECTIVE FACTORS ASSOCIATED WITH THE WORKING ENVIRONMENT.

HOW THE RESEARCH IS BEING USED

The research results are the basis for recommendations by Beyond Blue to emergency service agencies and governments. The research is also being translated into action as part of phase three of the project.

A major recommendation is that agencies review their existing health and wellbeing strategies to ensure that they have a comprehensive workplace mental health and wellbeing strategy that is a fully integrated element of their core business. Further recommendations suggest guiding principles for agencies, for example, that this strategy should promote the benefits of social support to ensure personnel are protected from suicidal thoughts and behaviours.

FUTURE DIRECTIONS

These results form a baseline that can be used for future research, both nationally and by each individual agency. This research provides an opportunity for police and emergency service agencies to develop, refine and implement strategies and programs that can minimise the long term mental health impacts for future employees and volunteers, who are the future workforce for providing essential emergency services to our communities.

FURTHER READING

Answering the call – national survey (2018), Beyond Blue's National Mental Health and Wellbeing Study of Police and Emergency Services – full report. www.beyondblue.org.au/pesresearch

The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

HAZARD **NOTE**

bushfire&natural HAZARDSCRC

ISSUE 34 JUNE 2017

TOPICS IN THIS EDITION | DECISION MAKING | EDUCATION | MULTI-HAZARD | RISK MANAGEMENT

HELPING AGENCIES LEARN FROM EXPERIENCE

ABOUT THIS PROJECT

This research was part of the *Improved decision-making in complex multi-team environments* project.

AUTHORS

Dr Christine Owen, Dr Benjamin Brooks, University of Tasmania; Dr Chris Bearman, CQUniversity.
Contact christine.owen@utas.edu.au

SUMMARY

The ultimate aim of this research is to help emergency management staff and volunteers to function more effectively in increasingly complex environments. Its overall approach is to help agencies to 'learn how to learn', so they understand how to embed effective learning practices and systems into their organisation's culture. The experiential learning model, which is grounded in real-world experiences rather than classroom training, is a key focus of this *Hazard Note*.

Broad challenges have been identified that agencies need to manage in order to enhance and sustain learning. These include shifting value from action post an event, to reflection, focusing on the bigger picture and allowing enough time to effectively embed the new practices after an emergency.

No organisation can forgo learning. All experiences provide opportunities for learning to occur. A key insight for agencies interested in facilitating improvements in learning is to locate potential weak links in the learning cycle and to develop a better understanding of how to learn.

▲ **Above:** THIS STUDY IS INVESTIGATING HOW ORGANISATIONS CAN IMPROVE THEIR CAPACITY TO LEARN THROUGH EXPERIENCE. PHOTO: NEW ZEALAND FIRE SERVICE

CONTEXT

In emergency management internationally, the drive to learn is growing. This increasing interest is evidenced by a search for the terms 'learning lessons' and 'emergency management' in a publications database. Of the 266 publications identified by this search, more than half had been published in the past five years.

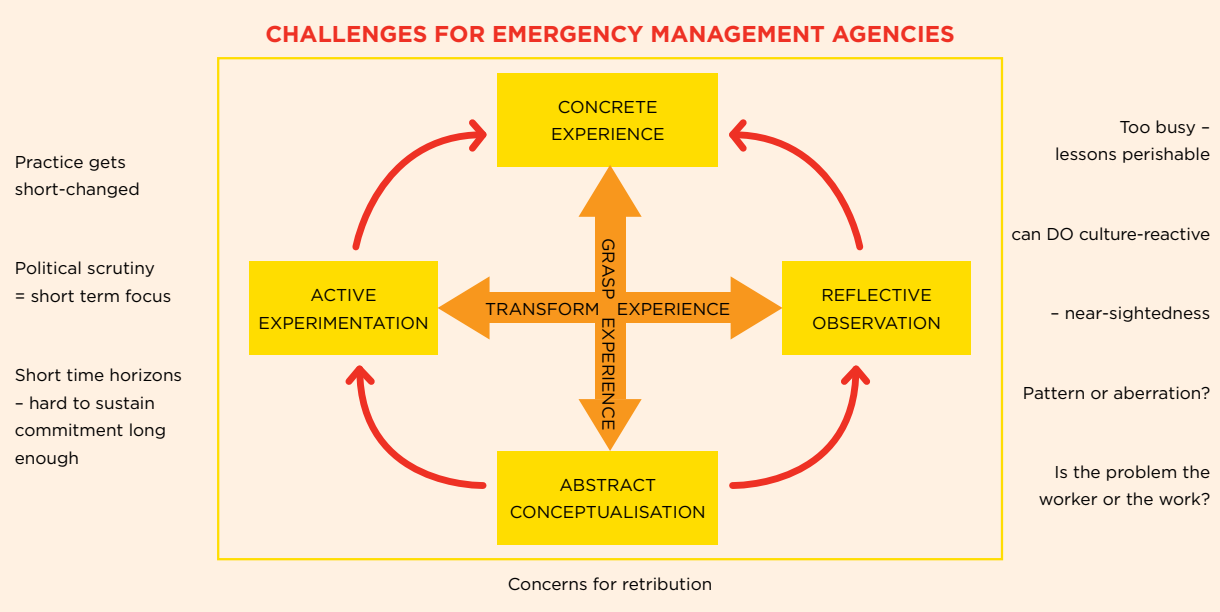
BACKGROUND

Learning in emergency management organisations occurs in a range of contexts. These include after-action reviews, externally led inquiries, and practice-led research projects.

But how do emergency management practitioners learn in these various settings? This research is investigating how organisations can improve their capacity to learn through experience. It focuses on how they review and evaluate their past performances, and how they monitor any changes that are based on their insights. This research is meeting a critical need: translating research outcomes into practice is complex and typically beyond the control of both researchers and emergency managers.

In previous research, the project group (see Owen *et al.*, 2015), had found that many agencies were actively working to identify learning opportunities. The agencies also evaluated research insights and their implications for reinforcing or changing current practices. However, while agencies were developing 'lessons learned' frameworks, these frameworks were not always effective in translating research outcomes into practice. This is because, too often, the structures for managing lessons were disconnected from the structures for reviewing and evaluating research. That is, there was no channel between research outcomes and lessons management.

These observations align with this study's literature review, which showed that many of the 'lessons learned' publications fall into a theme that this project's researchers have dubbed 'the creation myth' (see for examples of this Farazmand, 2007; Kenney *et al.*, 2015). In this scenario, researchers review a crisis event, publish their insights, and assume that the act of publication itself signifies that 'lessons' have now been learned.



▲ **Figure 1:** THE EXPERIENTIAL LEARNING CYCLE AND SOME CHALLENGES FOR AGENCIES TO LEARNING.

Other literature themes included how emergency services organisations are establishing processes for managing and learning from lessons (see Jackson 2016), why learning is so hard and, some argue, almost impossible (see Birkland 2009; Donohue & Tuohy 2006).

BUSHFIRE AND NATURAL HAZARDS CRC RESEARCH

The research for this component of the project started in 2015 with a literature review and interviews with 18 end-user agency personnel from South Australia, New South Wales, Victoria and Tasmania to ascertain their strategies for learning from incidents. This *Hazard Note* reports on the next stage of the research, which further investigates the experiential learning model. This model highlights the ways in which experiences – including from after-action reviews, research projects or other types of inquiries – may support learning.

The experiential learning model, developed by David Kolb (2014) and adapted by Christine Owen (2017), was selected because of several key factors. It grounds learning in actual experiences rather than classrooms or training environments. It is well established in both education and organisational learning. It draws upon the ways people in organisations may experience problems and then learn from them. Kolb's model is based on explicit processes that are necessary for effective learning. Its useful framework explains the phases of learning that personnel may seek in a range of work activities.

▲ **Above:** EXPERIENCES SUCH AS OPERATIONS, AFTER-ACTION REVIEWS, RESEARCH PROJECTS OR OTHER TYPES OF INQUIRIES CAN ALL SUPPORT LEARNING. PHOTO: SOUTH AUSTRALIA SES

The model suggests that learning results from a resolution of a contradiction or conflict between opposing ways of dealing with the world. That is, between reflection and action on one hand and between doing and thinking on the other. Beneath these processes is the notion of both apprehending (initial sense-making based on experience) and comprehending (understanding and improved action – see Figure 1). An impetus for learning can start anywhere, for example, through reflecting on an experience, considering a problem or trial-and-error experimentation. The key is that all four elements indicated in the learning cycle in Figure 1 are important if learning is to lead to a change or a reinforcement of existing ways of acting – because the practitioner now better understands why these actions work.

▲ **Above:** THIS RESEARCH WILL HELP EMERGENCY MANAGEMENT STAFF AND VOLUNTEERS FUNCTION MORE EFFECTIVELY IN INCREASINGLY COMPLEX ENVIRONMENTS.

RESEARCH FINDINGS

Based on the study's interviews with practitioners involved in lessons learned, after-action reviews or research-usage activities, the researchers have identified broad challenges that agencies need to manage in order to enhance and sustain learning (indicated in Figure 1).

Valuing action over reflection

Staff often lack adequate time to reflect on and gain meaning from their experiences. Their potential insights may then be lost rather than embedded in their organisation's practices. Reflection can also be inhibited by a tendency to focus on the immediate and the tangible, which is reinforced by the 'can-do culture inherent in many organisations that encourages action, sometimes at the expense of reflection.

Blind to the big picture

When emergency agencies do reflect on their experiences, their vision may be too near-sighted, focusing on the individual as the aberration, rather than identifying broader, systemic problems. Where the focus is on individuals, the individual may fear possible retribution, and be less likely to voice concerns that could contribute to improved practices.

Short term-ism

When organisations identify the need for changes and trial the changes, they may not allow enough time to effectively embed the new practices. This is exacerbated by the demands placed on staff, noted earlier. And when external pressures, including political scrutiny, are the impetus for new practices, the changes may be short term, rather than sustained.

END-USER STATEMENT

This research provides evidence that will help lessons practitioners across the emergency services ensure that lessons from events and experiences are learned. The model developed helps to articulate some of the barriers to organisational learning that most emergency service agencies are struggling with. Agencies will be able to utilise this research to inform the development of strategies to address some of these barriers, which will help them move from merely identifying lessons to achieving changes in behaviour. Then we will truly be able to say that lessons are being learned.

– Heather Stuart, Manager, Knowledge and Lessons Management, NSW State Emergency Service

HOW IS THIS RESEARCH BEING USED?

Facilitators who manage lessons could use this research to extract meaning from after-action reviews. The study's outcomes could also support staff who draw upon research implications to analyse their own organisations by

▲ **Above:** ALL EXPERIENCES PROVIDE OPPORTUNITIES FOR LEARNING TO OCCUR. PHOTO: SOUTH AUSTRALIA SES

asking: how is the experiential learning cycle being managed? How are the processes of reflection, sense-making, and experimentation being fostered, to support new ways of working?

The literature review and research interviews identified many strategies for improving organisational learning. These included: embedding roles and responsibilities for learning, review and follow-up; monitoring and measuring change; and linking learning and practice.

They also suggest that crises could offer opportunities that support learning by exploiting political attention, and drawing knowledge from low-complexity, low-risk events.

Another key strategy is to invest in quality, rather than quantity. This translates into fewer exercises but better training that is well targeted at clear objectives.

FUTURE DIRECTIONS

The next phase of the project is to trial and test a research-utilisation maturity matrix, in collaboration with lessons learned practitioners and end-user agencies. AFAC's Knowledge Innovation and Research Utilisation Network is currently trialling the matrix.

The matrix will assist agencies to more systematically assess and evaluate their own internal processes to support learning and change. This engagement will be written up in a way that other agencies may be able to use and to learn from.

No organisation can forgo learning. All experiences provide opportunities for learning to occur. A key insight for agencies interested in facilitating improvements in learning is to locate potential weak links in the learning cycle and to develop a better understanding of how to learn.

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HAZARD **NOTE**

bushfire&natural HAZARDSCRC

ISSUE 33 JUNE 2017

TOPICS IN THIS EDITION | DECISION-MAKING | EMERGENCY MANAGEMENT | MULTI-HAZARD |

TOOLS TO ENHANCE EMERGENCY MANAGEMENT TEAM PERFORMANCE

▲ **Above:** THIS RESEARCH HAS BEEN USED BY THE COUNTRY FIRE SERVICE TO ENSURE THEIR TEAMS ARE WORKING SAFELY AND EFFICIENTLY. PHOTO: MARK THOMASON, CFS

ABOUT THIS PROJECT

This research was conducted as part of the *Improving decision-making in complex multi-team environments* project. It has developed tools to help identify and resolve issues in teamwork.

AUTHORS

Dr Chris Bearman, Dr Sophia Rainbird, CQUniversity; Dr Christine Owen, Dr Benjamin Brooks, University of Tasmania. Contact c.bearman@cqu.edu.au

SUMMARY

Effective teamwork is vital when managing emergencies, which can exert extreme pressures on response and management teams, their leaders and co-responders. These pressures sometimes cause breakdowns in teamwork that can lead to impaired operational response. This research helps to improve teamwork through better real-time identification and resolution of teamwork issues. To do this the project has developed two tools: the Emergency Management Breakdown Aide Memoire (EMBAM) and the Team Process Checklist (TPC). The tools' flexibility and ease of use helps emergency managers to strengthen teamwork before, during and after emergencies. The tools can be used during training, in actual emergencies, and in after-action reviews, with emergency managers finding the tools to be highly valuable.

CONTEXT

The highly demanding nature of managing emergencies can disrupt effective team performance. These disruptions can lead to an impaired operational response, creating risks to public safety, property and other assets. This project is helping to foster cohesive teamwork when it is most needed – when teams are responding under pressure to emergency events.

BACKGROUND

Teamwork is an essential part of emergency management. To a large extent, emergency management can be characterised as teams of people interacting within the hierarchical structure of an agency. Within this structure, information flows within a specific team (for example, a strike team), between that specific team and a broader team (that includes radio operators or brigade officers), other teams (for example, other strike teams) and teams at more senior levels (such as group officers or regional-level personnel).

During emergencies, individuals and teams often work under considerable pressure that can disrupt effective team performance. The implications of these disruptions can be serious. An analysis of three large-scale bushfires in Australia, (Bearman *et al.*, 2015) showed examples where team breakdowns led to confusion, miscommunication and inconsistent fire-management plans.

It is important, however, to acknowledge that people managing emergencies will sometimes make errors and that

▲ **Above:** THE STRAIGHT-FORWARD, PRACTICAL TOOLS DEVELOPED THROUGH THIS RESEARCH WILL BE OF GREAT BENEFIT TO EMERGENCY SERVICE AGENCIES. PHOTO: NEW ZEALAND FIRE SERVICE

disruptions to teamwork will occur. Many organisations now recognise that error is a normal part of human performance and emphasise both error recovery and minimisation. This shifts the focus from blaming people, to designing mechanisms and systems that can identify and resolve disruptions as quickly as possible (Bearman *et al.*, 2017, Grunwald and Bearman, 2017).

BUSHFIRE AND NATURAL HAZARDS CRC RESEARCH

Since 2015 the project team has been developing two tools that help to identify and resolve breakdowns in teamwork. These tools are known as the Emergency Management Breakdown Aide Memoire (or EMBAM) (Grunwald and Bearman, 2017) and the Team Process Checklist (TPC). The TPC is based on research into teamwork breakdowns by Wilson *et al.* (2007) and Bearman *et al.* (2015b). These tools are checklists that help people to think about teams and team processes and are designed to be used in real time during an incident, training sessions or debriefs post-incident.

The two tools take slightly different approaches to monitoring teams. EMBAM is designed to be integrated into the activities of a senior officer and focuses on the outputs of teams and organisational networks. This checklist is reasonably quick and easy to apply and identifies problems at a general level. EMBAM also includes different strategies that can resolve issues in teams (see About the Emergency Management Breakdown Aide Memoire, above).

If EMBAM identifies a problem, or if a more detailed health check of the team is needed, then the TPC is used. The TPC contains questions about the coordination, cooperation and communication processes that should occur in effective teams. The team's performance is considered in relation to each of these questions. Any issues that the tools identify should be discussed with the team (see About the Team Process Checklist, page 3).

ABOUT THE EMERGENCY MANAGEMENT BREAKDOWN AIDE MEMOIRE

The Emergency Management Breakdown Aide Memoire is a checklist that helps people to recognise teamwork breakdowns through team outputs (for example, incident action plans) and formal/informal organisational networks. It also provides some practical resolution strategies shown below:

How you might resolve breakdowns:

1. **Delegate:** find someone who is close to the breakdown or has the most appropriate skills and have them resolve the issue.
2. **Resource:** breakdowns can be caused by missing resources. Find out what is missing, or what will assist the other teams, and get it to them.
3. **Mentor:** a subtle form of resolution, mentoring allows you to tactfully suggest alternatives, opinions and strategies.
4. **Assert:** if you have tried more subtle strategies without success, you can use your authority to resolve the problem.
5. **Replace:** if breakdowns are caused by disruptive personalities in the management team, or even factors like fatigue, you can stand the disruptive people down or give them other duties.

RESEARCH FINDINGS

The researchers developed the tools together with end-users through an iterative cycle of

END-USER STATEMENT

Good teamwork is an increasingly important part of emergency management. When teams are not working effectively a variety of problems can result, including confusion, miscommunication, differing plans and unexpected actions. To manage incidents effectively and to ensure safety, it is vital that teams are performing as well as possible.

The straight-forward, practical tools developed through this research are of great benefit to emergency managers to ensure their teams are functioning to the best of their ability. They cover communication, coordination and cooperation, and include suggestions for how to best resolve problems.

Those who work in incident management teams and strike teams, or at higher levels such as Regional or State Operations Centres, team leaders and people close to, but outside the team (such as neutral observers), will find the tools invaluable during operational response, but also in debriefs and training.

– Mark Thomason, Manager Risk and Lessons Management, South Australia Country Fire Service

Above: DURING EMERGENCIES, INDIVIDUALS AND TEAMS OFTEN WORK UNDER CONSIDERABLE PRESSURE THAT CAN DISRUPT EFFECTIVE TEAM PERFORMANCE. THIS RESEARCH IS HELPING TO ADDRESS THIS. PHOTO: BEN SHEPHERD, NSW RURAL FIRE SERVICE

testing and redevelopment (see Bearman *et al.*, 2017). The initial version of the tools was based on an extensive literature review of methods that could be used by an observer to monitor teams (which was the original intention of the tools). A preliminary evaluation study of the tools suggested that they both showed promise and should be developed further (Bearman *et al.*, 2017).

The tools were then developed and evaluated by a team consisting of four state-level end-users during five regional exercises. These exercises required a fully staffed regional coordination centre to manage one or more significant large-scale bushfires. During the exercise, actors simulated radio traffic on the fireground and adopted the roles of key stakeholders (such as police). Observers used the TPC to help assess the team and to inform the debrief at the end of the exercise. After each exercise, the team met to provide feedback on the checklist, evaluating whether each question needed to be removed or amended. Any changes were made before the next exercise, where the process was repeated.

ABOUT THE TEAM PROCESS CHECKLIST

The Team Process Checklist is designed to provide a health check for teams and, if there is a problem, to help determine what that problem is. This tool is designed to assist people to think through three aspects of teamwork: communication, coordination and cooperation. Examples of the communication items are below:

- Are team members passing on information in a timely manner?
- Are team members passing on information accurately?
- Is communication between team members clear?
- Are team members providing appropriate feedback?
- Are team members providing updates on the situation?
- Are appropriate communication procedures being used?

The tools were also evaluated by six regional and state coordinators during two large-scale storm and flood events. During these emergencies, the research team conducted a telephone interview with each of the coordinators participating in the study. In these interviews, the coordinators considered the performance of teams against each item on the TPC. This allowed the coordinator to identify issues in those teams that needed to be considered in the next hour, the next shift, the next day and the next week. As part of the discussion, the participant evaluated whether each item on the checklist provided useful information.

Finally, two senior officers (a state controller and state information officer) used both tools throughout a fire season. This fire season contained many significant bushfires. At the end of the fire season, the researcher team interviewed the two senior officers about how they used the tools and whether

▲ **Above:** THE TOOLS DEVELOPED THROUGH THIS PROJECT CAN BE USED DURING AN INCIDENT, IN DEBRIEFS OR IN TRAINING. PHOTO: NSW RURAL FIRE SERVICE

the tools were effective. The participants found the tools to be valuable, and had used them as memory aids to ensure nothing had been overlooked, to conduct team health checks and to resolve team problems before they escalated.

HOW IS THIS RESEARCH BEING USED?

The tools are a very flexible way to examine teamwork from many perspectives.

They are being used as a health check to ensure the team is functioning effectively, to identify suspected problems, as a debrief tool and to foster better teamwork. They are utilised in real time during an incident, as a way to reflect on teamwork during periods of relative calm, and as an assessment and/or debrief tool during training. They are being used by team members, team leaders, external people who have operational oversight (for example, regional coordinators) and by independent observers. If your agency can benefit from these tools, contact the author for further information.

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FUTURE DIRECTIONS

The tools have been developed together with end-users and used in a number of different settings. In each setting, the tools have provided useful information to the user. All of the agencies involved in developing the tools have either adopted them, or are considering adoption. More testing to validate the use of the tools in different settings will be done over the next year (2017-2018). However, both EMBAM and TPC have shown considerable promise as a viable way of identifying and managing issues in teams.

The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

Hazard Notes are prepared from available research at the time of publication to encourage discussion and debate. The contents of *Hazard Notes* do not necessarily represent the views, policies, practises or positions of any of the individual agencies or organisations who are stakeholders of the Bushfire and Natural Hazards CRC.

HAZARD **NOTE**

bushfire&natural HAZARDSCRC

ISSUE 28 MAY 2017

TOPICS IN THIS EDITION | COMMUNICATION | LOCAL KNOWLEDGE | RESILIENCE | VOLUNTEERING

DIGITAL VOLUNTEERING IN DISASTER RISK REDUCTION: AN OPPORTUNITY OR A CHALLENGE?

ABOUT THIS PROJECT

This research was conducted as a PhD study: *Volunteered geographic information, community engagement and bushfire preparation*, which was part of the broader CRC project *Out of uniform.*

AUTHOR

Dr Billy Haworth, University of Western Australia. Dr Haworth completed his CRC PhD in 2016 at the University of Sydney. Contact billy.haworth@uwa.edu.au

SUMMARY

In recent years, information from community members contributed online has proved highly useful in emergencies. Information sharing activities by private citizens using social media, smartphones, and web mapping tools have been termed volunteered geographic information (VGI) or digital volunteering. This research examined the potential role of VGI in fostering community engagement in bushfire preparation.

Findings show that VGI is more than just technology – it is about people sharing their knowledge and mapping collaboratively as a social practice. It presents opportunities for citizen empowerment in line with shared responsibility, but also challenges with power moving away from the traditional command and control of emergency services. This research provides a clearer path for emergency service agencies to best-utilise these technologies.

Left: SMARTPHONES ARE JUST ONE TOOL ENABLING CITIZENS TO COLLECT AND SHARE LOCAL DISASTER INFORMATION. PHOTO: BILLY HAWORTH.

CONTEXT

The Internet, social media and smartphones have enabled private citizens to create and share geographic information, dramatically increasing public participation in disaster response. While there are numerous documented benefits and challenges, this research examines the role of these technologies and practices in promoting community engagement in disaster risk reduction.

BACKGROUND

Practices of citizens creating, sharing and mapping their own information have been termed volunteered geographic information (VGI), and in emergency management digital volunteering or digital humanitarianism. VGI enables cost-effective, rapid sharing of diverse information from community members at all stages of disaster management. However, VGI also presents new challenges, including issues of trust and data quality, data management, liability, and the digital divide (or those without access to VGI technologies being excluded). Existing literature emphasised disaster response, but as preparing for disasters significantly reduces the likelihood of negative impacts, there is a need for increased community engagement in disaster risk reduction. VGI is one tool that can help to achieve this.

BUSHFIRE AND NATURAL HAZARDS CRC RESEARCH

This research assessed the usefulness of VGI in fostering community bushfire preparation engagement and increased disaster resilience in Tasmania. It also examined the broader impacts of VGI on traditional top-down disaster management.

The research had three main components. Firstly, surveys were completed with 154 residents of bushfire-risk communities. These examined bushfire preparedness and the uptake, usage, and limitations of VGI technologies like social media.

Following this, interviews with 13 emergency management professionals were conducted to evaluate how community VGI practices are impacting authoritative disaster management.

Lastly, workshops were conducted with 31 residents of bushfire-risk communities to assess participatory mapping activities, examining the user-experience of contributing VGI for bushfire preparation, and the value of sharing local knowledge and mapping together with other community members.

RESEARCH FINDINGS

Three key insights are presented in this *Hazard Note*. More information is available in the 'further reading' panel on page 2.

First, VGI is not just about technology, it is also about people – people sharing knowledge and mapping collaboratively. Conceiving VGI as a social practice, rather than simply data, can lead to opportunities such as increased community connectedness, shared risk understanding and collective engagement in activities such as disaster preparation.

Second, VGI does not include everybody. Many people are excluded from contributing through lack of access to technology, skills, time, or the 'right' cultural/social circles. Worryingly, those marginalised for the reasons above are often the most vulnerable to disasters. On the other hand, VGI may disproportionately promote the views of those who can contribute.

Finally, VGI involves shifts in the control

of information and decentralisation of power away from emergency service agencies. This provides opportunities for citizen empowerment in line with notions of shared responsibility and resilience, but also challenges, where organisational adaption is required to effectively harness VGI.

HOW IS THIS RESEARCH BEING USED?

By revealing the opportunities, challenges, and implications of VGI in emergency management, the research provides a clearer path for emergency service agencies to best utilise these technologies for and *with* communities. While significant challenges remain, understanding of the benefits gained by valuing citizen knowledge, embracing change and harnessing the power of technological and communication innovation will contribute to more effective use of VGI to meet agency and community needs.

Insights gained through this research into VGI have contributed to the broader national understanding of the changing nature of emergency volunteering in Australia and internationally, with close links to other CRC projects. This research will influence local and national policy and sectoral change, with an enhanced understanding of digital volunteering contributing to goals of increasing volunteering sustainability, community engagement and national disaster resilience.

Working collaboratively with Tasmania Fire Service has resulted in research outcomes that can be directly applied in agency thinking on community development and the use of VGI in the future. The TFS Bushfire Ready Neighbourhoods Program has expressed interest in adopting participatory mapping into their community engagement activities. The findings, however, are not limited to Tasmania or bushfire, but are applicable to other natural hazards, social settings and regions across the globe, and questions right across the discipline of geography.

FUTURE DIRECTIONS

Strategies that seek to bridge the digital divide must continue to be investigated, including how to engage a wider variety of people in VGI, particularly those most vulnerable to emergencies.

Longitudinal studies would permit evaluation of ongoing outcomes associated with VGI use for community engagement. Studies of longer duration would also allow for better appraisal of methods for managing VGI data and initiatives. There is a need to develop effective ways of managing, verifying, and filtering community data for integration with other databases.

VGI should be examined in other emergency management contexts, such as disaster recovery, other geographic or political settings, and other hazards and crises.

END-USER STATEMENT

The Bushfire Ready Neighbourhoods program at the Tasmania Fire Service collaborated with this research to explore a different community engagement technique that can be utilised in the programs' 'one size doesn't fit all' approach to working with communities.

Billy has provided an important evidence base for the use of participatory mapping in community engagement, and I'd encourage other agencies to use these findings to inform their approach. **– Peter Middleton, A/Manager, Community Development & Education, Tasmania Fire Service**

PARTICIPATORY MAPPING

Participatory mapping involves providing skills and expertise for citizens to create maps themselves that represent their own spatial knowledge, including through VGI. This might be drawing freehand, using existing printed maps, or digitally via GIS or the Internet. Participatory mapping can facilitate shared decision-making, community advocacy and increased community empowerment.

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The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

HAZARD **NOTE**

bushfire&natural HAZARDSCRC

ISSUE 27 APRIL 2017

TOPICS IN THIS EDITION | VOLUNTEERING | NON-TRADITIONAL RECRUITMENT | RESILIENCE

THE CHANGING LANDSCAPE OF DISASTER VOLUNTEERING IN AUSTRALIA

ABOUT THIS PROJECT

This research was conducted as part of the *Out of uniform: building community resilience through non-traditional emergency volunteering* project. The project aims to better engage the potential of volunteering to build disaster resilience in Australian communities.

AUTHORS

Prof John Handmer, Dr Blythe McLennan, Dr Tarn Kruger, RMIT University; Dr Josh Whittaker, University of Wollongong.

SUMMARY

As our way of life changes, the way we volunteer is changing too, presenting both challenges and opportunities for emergency service organisations. This project has identified four key large-scale forces reshaping the nature of volunteering in the 21st century. These are changing lifestyles and values and the changing nature of work; the impact of new communications technology; greater private sector involvement; and growing government expectations of and intervention in the voluntary sector.

Five key areas of focus have also been identified to best capitalise on emerging opportunities, providing evidence and impetus to shift away from a reliance on traditional, structured volunteering models, to models that are more flexible, adaptive and inclusive of newer and diverse volunteering styles.

Emergency management organisations are aware of this shift in the volunteering landscape and its impacts, and in some instances are already responding. Findings from this project are being used to address these areas, with change makers at organisational, jurisdictional and national levels driving a shift towards more flexible, adaptive and inclusive volunteering models.

▲ **Above:** MUD ARMY AND SES VOLUNTEERS WORKING TOGETHER DURING THE 2011 FLOODS IN QUEENSLAND. PHOTO: QUEENSLAND FIRE AND EMERGENCY SERVICES.

CONTEXT

Drawing upon international and national volunteering research with a focus on disasters and emergencies, this study identifies key shifts in the volunteering landscape as a whole, and considers the possible implications and opportunities for Australian emergency volunteering.

BACKGROUND

It is now well accepted that the scale and frequency of natural disasters across the planet will increase because of climate change. There is a growing expectation that volunteers will play greater and, at the same time, different roles in disaster risk reduction and disaster management in the future.

There is also now more attention being given by the Australian emergency management sector to non-traditional or informal emergency volunteers – people who volunteer without affiliation with the established organisations that have recognised roles in emergency and recovery plans, particularly episodic and spontaneous volunteers (e.g. ANZEMC 2015).

Agency leaders show a variety of attitudes and approaches to non-traditional emergency volunteers – some see them as creating legal and occupational health and safety risks for the agency, and as distracting the organisation from its core business. Others view them as a basis for surge capacity, a valuable resource and almost always the initial responders. Regardless of how they are viewed by emergency management organisations, such agencies are increasingly concerned with bringing non-traditional volunteers into the formal system.

Key issues of concern for agencies and large non-profits are potential legal liability, health and safety issues, and the lack of agency control over non-affiliated volunteers. Nevertheless, whether agencies are supportive or not, non-traditional

emergency volunteers are playing significant roles in response and recovery, and also in preparation and prevention. Some Australian examples of community-based and volunteer-led groups and initiatives include the Brisbane Mud Army, Tassie Fires We Can Help, Community on Ground Assistance (Victoria), Be Ready Warrandyte (Victoria), and BlazeAid.

BUSHFIRE AND NATURAL HAZARDS CRC RESEARCH

The *Out of Uniform* project has investigated current and emerging issues around volunteering and volunteers responding to disaster events, and the different factors that can influence people's participation in non-traditional emergency volunteering (Whittaker, McLennan and Handmer 2015).

The project has also investigated several case studies of non-traditional volunteering, selected to ensure coverage of different stages of disaster risk management, hazard types and types of non-traditional emergency volunteering. They include community led preparedness (Be Ready Warrandyte, see McLennan, Whittaker and Handmer 2015b), community-led recovery (Community on Ground Assistance in Kinglake, see Whittaker, McLennan and Handmer 2017), spontaneous volunteer management (Volunteering Queensland's Emergency Volunteering Community Response to Extreme Weather, see McLennan, Molloy, Whittaker and Handmer 2016 and McLennan, Whittaker and Handmer 2016), the role of volunteers from faith-based groups in recovery (Pinery fire, South Australia), digital volunteering following 2015's Cyclone Pam in Vanuatu, and a review of the national surge capacity for response that occurred for Cyclone Tracy in Darwin (1974).

The research team has brought stakeholders together to help map out risks and benefits of six strategic options for engaging with non-traditional emergency volunteering in response and recovery phases, aiming to support decision-making at a strategic level (McLennan, Kruger and Handmer 2017). This has revealed opportunities for emergency management organisations.

END-USER STATEMENT

This research helps to shift the narrative around emergency volunteering from one of crisis and decline, to one of transformation and opportunity. This is in fact good news as it may be the very shift that we need to drive organisational change. This is where we must focus our energy and efforts; as communities change, so must we. If we don't, we face a very real chance of being left behind, and looking back at what might have been. Twenty years ago, Kodak were market leaders in photography and synonymous with Australian culture; today they barely exist. There must be something we can learn from this about growth and development.

Established emergency management organisations need to adapt and embrace emerging opportunities through more flexible, diverse and inclusive volunteering models and closer partnerships with community groups, businesses, and the not-for-profit sector. This will involve confronting very real challenges and barriers to current organisational structures and cultures, and the desire to often want to do it all ourselves.

Failure to accept and adapt to the changes means running a very real risk of falling behind as new voluntary and community-based organisations pursue their own ways to get involved in disaster management, powered by new technology, start up business models, very clear purpose and smart volunteer value propositions. There is much to learn from this and a joined up approach with these new 'organisations' offers a way to augment our own capacity and possibly achieve better community outcomes.

– Paul Davis, Manager, Volunteer Development and Change, Emergency Management Victoria

RESEARCH FINDINGS

A study of key shifts in the volunteering landscape and the potential implications for, and responses by, Australian emergency management organisations identified four key large-scale forces of change that are reshaping the nature of volunteering in the 21st century. The major forces and trends driving change in volunteering stem from:

- changing lifestyles and values and the changing nature of work (e.g. work and commuting being more time consuming)
- the impact of new communications technology
- greater private sector involvement
- growing government expectations of, and intervention in, the voluntary sector.

A key factor in the shifting nature of volunteering is the impact of broader societal trends creating time poor and a just-in-time approach to life and work. The result of this is that more volunteers want or need a less ongoing commitment. This has led to a widespread rise in people's preferences for shorter-term, more episodic and project-based volunteering that can fit into busy lifestyles (see McLennan, Whittaker and Handmer 2015a; McLennan *et al* 2016).

The revolution in communication technology has significant implications for the way informal, post-disaster volunteering occurs, and indeed all disaster volunteering. Digital or virtual volunteering means volunteers are not tied to specific times and locations and can operate and support the disaster response and recovery from any place. Social media and mobile technology are global and can overcome many information and communication barriers that once inhibited informal, as well as formal, responses to disasters. The enormous capacity of the Internet can enable crowdsourcing, and in particular, volunteered geographic information (Haworth 2016). Directly affected locals can provide valuable situational information about the disaster on social media and this has the potential to reach a wide audience. This rich, localised, real-time information can also have significant benefits for emergency management organisations.

The growth of private sector involvement has seen an increase in employee or corporate volunteering that occurs through diverse avenues. However, there is very little research on this type of volunteering in the context of disasters and emergencies. Private sector involvement to date has been predominantly reactive and event-based. Notwithstanding, there is evidence of more enduring private-NGO and public-private partnerships that can promote more ongoing engagement. Such partnerships may also enable greater value from skills-based volunteering where volunteers with specific skills, training and experience are sought out by organisations and matched to specific tasks or projects.

Growing government expectations of, and intervention in, volunteering and

▲ **Above:** VOLUNTEER-LED COMMUNITY GROUPS, SUCH AS BLAZEAID, WHICH BEGAN AFTER BLACK SATURDAY IN 2009 REPAIRING FENCES DESTROYED BY FIRE, WILL PLAY A SIGNIFICANT ROLE IN EMERGENCIES IN THE FUTURE. PHOTO: BLAZEAID.

MODERN VOLUNTEERING

It is now widely recognised that a significant qualitative shift is occurring in the nature of modern volunteering as a result of a broad transformation in the way people live and work in the 21st century. This transformation is associated with a range of factors that include the influences of cultural globalisation, mass media and access to the Internet, as well as an ageing population, changes in household composition, growing wealth and inequality, changes in the nature of community, growing individualism, shifting values and rising aspirations. A key, widely recognised factor is the rising demands and expectations of modern employment, which spurs people's growing preferences for shorter-term volunteering engagements. It is likely that growing mobility and diversity in forms of employment have also changed people's expectations of more diverse and flexible forms of volunteering.

the voluntary sector is also reshaping the volunteering landscape. Three main factors are influencing this: expectations associated with outsourcing services; bureaucratisation of volunteering and; a shift in public administration philosophy.

In the context of disasters, growing government expectations of volunteers and the voluntary sector is also explicit in the policy shift towards resilience-based strategies that emphasise community resilience, self-reliance, and shared responsibility. There is very little research on the consequences of these changes for emergency volunteering or volunteering more generally. Broadly speaking, the responses of volunteers and voluntary organisations have occurred along two divergent paths: the increased professionalisation of established non-profits and a growth in informal grassroots level groups (McLennan *et al* 2015a).

This provides evidence and impetus for emergency management organisations of the need to shift away from a reliance on traditional, structured volunteering models, where volunteers are formally trained and accredited and stay with an organisation for long-periods, to models that are more flexible, adaptive and inclusive of newer and more diverse volunteering styles. This will require a loosening up of existing management structures and procedures, and the development of a more diverse range of volunteering pathways and roles, including pathways that involve options for shorter-term, project-based or more casual engagements. Importantly, this may provide much needed additional support and relief for the more traditional, committed and highly-trained volunteers that will continue to form the core volunteer base of many emergency management organisations.

There are five key areas for emergency management organisations to focus on to best capitalise on emerging opportunities. They are: developing more flexible volunteer models; targeted spontaneous volunteer coordination and planning; building capacity to engage digital and digitally-enabled volunteers; building partnerships to support employee and skills-based volunteers and; establishing partnerships with existing community groups for disaster risk reduction.

The study highlights promising activity in each of these areas internationally and where available, in Australia:

- Targeted coordination and planning for informal citizen responses to disaster, including spontaneous volunteering (e.g. the Amstelland Safety Region procedures to integrate people's knowledge, skills and capacities with the formal response in the Netherlands; the Emergency Volunteering Community Response to Extreme Weather service by Volunteering Queensland that coordinates and matches spontaneous volunteers with helping organisations).
- Building capacity to engage with digital and digitally-enabled volunteers (e.g. integration experiments conducted in Canada and the United States with digital volunteering groups like Virtual Operations Support Team Canada, and early movements towards establishing a Virtual Operations Support Team network for Australia).
- Establishing partnerships with the private sector to support appropriate employee and skills-based volunteering (e.g. the Ready When the Time Comes corporate volunteer training program of the American Red Cross).
- The co-production of community-based disaster risk reduction with existing, well-established community groups (e.g. Be Ready Warrandyte in Victoria).

HOW IS THIS RESEARCH BEING USED?

There is mounting leadership support across Australian emergency management for the types of changes indicated by this research. This is reflected in recent organisational and sector-wide volunteer strategies. In this context, this research is supporting the change makers that are driving this shift. It provides firm evidence of the need for change and the potential benefits of non-traditional emergency volunteering, identifies key areas of opportunity for emergency management organisations to pursue, and highlights best practice examples from across Australia and overseas.

The research has influenced key national initiatives, with findings used extensively for the development of the National Spontaneous Volunteer Strategy by the Australia and New Zealand Emergency Management Committee (ANZEMC 2015). The strategy provides advice to emergency service agencies on best practice principles, as well as what they need to be aware of, and what they need to consider and plan for when working with spontaneous volunteers. Important issues such as legal obligations and social media are also covered, with the work of the project team integral to the strategy's content.

Building on this, the Australian Institute for Disaster Resilience is drawing directly on the research to develop a new handbook on spontaneous volunteer management. The handbook will provide important guidance for organisations on how to incorporate the principles of the National Spontaneous Volunteer Strategy, and the most recent research on spontaneous volunteering, into their own plans and procedures.

The research is also impacting the development of new strategies in volunteer management at the organisational level, for example informing new directions and developments in the Department of Fire and Emergency Services Western Australia and the New South Wales SES. Recent movement in the NSW SES towards trialling a new flexible volunteering strategy, based on research undertaken in this project, is particularly notable and warrants close attention from researchers and volunteer managers. The new strategy aims to encourage greater community participation in emergency services volunteering, increase the diversity of the NSW SES volunteer workforce and strengthen the resilience of local communities. The strategy outlines a wider range of volunteering roles and pathways for NSW SES that reflect the changing landscape of volunteering, including spontaneous volunteering, corporate partnerships and a new Community Action Team pathway.

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FUTURE DIRECTIONS

There is fast growing awareness of the impacts of the shifting volunteering landscape, and of the need for emergency management organisations and the sector as a whole to respond. A key area of research needed to support the capacity to do this concerns the question of how traditionally command and control based organisations can foster the internal cultural change required to embrace less traditional styles of volunteering. Exploring this change collaboratively with end-users will be a key focus of volunteering research currently in planning by RMIT University and the University of Western Australia for the next stage of the CRC.

The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

HAZARD **NOTE**

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ISSUE 006 JULY 2015

TOPICS IN THIS EDITION | VOLUNTEERING | NON-TRADITIONAL RECRUITMENT | RESILIENCE

ENSURING VOLUNTEERING IS SUSTAINABLE

ABOUT THESE PROJECTS

This is an overview of the *Sustainable volunteering* cluster of Bushfire and Natural Hazards CRC research projects. This cluster has two linked studies:

1. **Out of uniform: building community resilience through non-traditional emergency volunteering –** Professor John Handmer, Dr Josh Whittaker and Dr Blythe McLennan, RMIT University and Dr Michael Eburn, Australian National University.
2. **Improving the retention and engagement of volunteers in emergency service agencies –** Dr Michael Jones, Associate Professor Andrew Sense, Dr Yoke Berry, Bill Calcutt, Nick Popov and Valerie He, University of Wollongong.

For more information, contact john.handmer@rmit.edu.au or mjones@uow.edu.au

CONTEXT

This cluster aims to develop new models, strategies and approaches for volunteering that support emergency management to:

- Improve the long-term sustainability of the volunteer workforce.
- Better engage the potential of volunteering to build disaster resilience in Australian communities.

OUT OF UNIFORM

BACKGROUND

The public is usually first on the scene in an emergency or disaster and remain long after official services have ceased.

Citizen participation is a key principle of disaster risk reduction and resilience building. However, emergency management relies on volunteers affiliated with official agencies and a comparatively smaller workforce of paid staff. Individuals and groups working outside of this system have often been seen as a nuisance or liability, and their efforts are largely undervalued.

There is a significant and largely untapped opportunity for emergency management agencies to contribute to community resilience by supporting non-traditional emergency volunteers. It is likely that 'informal' volunteers will provide much of the surge capacity required to respond to more frequent emergencies and disasters in the future.

RESEARCH ACTIVITY

There are many examples of government and non-government organisations, as well as motivated individuals and groups, finding new ways to harness the capacities of non-traditional emergency volunteers. However, these examples are isolated and have not yet been integrated into new and more inclusive models of volunteering. This project is developing new models to provide a framework for engaging with this potential additional workforce.

With this in mind, this project has three key objectives:

- Identifying how non-traditional emergency volunteering contributes to building community resilience to disasters throughout different phases of emergency management.
- Identifying ways the emergency management sector can promote community resilience through support of non-traditional emergency volunteering.
- Developing and evaluating alternative models for emergency volunteering that are inclusive of non-traditional volunteering and volunteering organisations.

The project is currently focused on conducting case studies of non-traditional volunteering. The first three case studies examine community-led preparedness (Be Ready Warrandyte), community-led recovery (Community on Ground Assistance in Kinglake), and spontaneous volunteer management (Volunteering Queensland's Emergency Volunteering Community Response to Extreme Weather).

RESEARCH OUTCOMES

A literature review has been completed on 'informal' emergency volunteering. Three forms of informal emergency volunteerism were identified.

Emergent volunteerism involves new forms of volunteerism that occur in response to unmet needs. Research has focused largely on 'spontaneous' volunteers, but

▲ **Above:** SPONTANEOUS VOLUNTEER GROUPS, SUCH AS CHRISTCHURCH'S STUDENT VOLUNTEER ARMY, HAVE FORMED WITH A SPECIFIC INTENT. PHOTO: EVE WELCH, UNIVERSITY OF CANTERBURY.

new forms of volunteerism may emerge before an event; for example in prevention and preparedness activities, and may be deliberate and carefully planned. Examples include citizen-led search and rescue parties, and groups that form to help those affected clean up or rebuild (BlazeAid after the 2009 Black Saturday bushfires, the Mud Army after the 2011 Queensland floods).

Extending volunteerism involves groups and organisations that do not have regular emergency functions but extend their activities to volunteer in times of crisis (e.g. a football club or school committee).

Digital volunteerism represents a new mode of volunteerism. In particular, social media and web-based mapping software have allowed citizens to freely produce and disseminate their own emergency-related information. Examples range from basic use of sites like Facebook to share information through to more complex uses involving data mining and crisis mapping.

A second report identifies key shifts in the volunteering landscape as a whole and considers the possible implications for Australian emergency volunteering. It identifies four key large-scale forces of change that are reshaping the nature of volunteering: the transformation of life in the 21st Century, the revolution in communication technology, growth of private sector involvement, and a rise in government expectations. These changes have led to three previously uncommon forms of volunteering: episodic (shorter-term engagements), corporate (and skills-based) and digital.

END USER STATEMENT

The community expects us to do everything we can to help them respond and prepare for emergencies. It does not matter where the volunteers come from and whether they are the traditional type of volunteers or not, the bottom line is that our communities deserve to be supported. We as agencies have to find ways to include communities in that.

An important aspect for end users of these projects is to make sure that the outcomes of the research give agencies a chance to understand the issues, and importantly, what changes need to be made to ensure agencies are inclusive of what happens in the community and the volunteers that want to come from the community, as well as our traditional brigade volunteers.

– Lucas van Rijswijk, Coordinator Volunteer Strategy, Tasmania Fire Service.

IMPROVING THE RETENTION AND ENGAGEMENT OF VOLUNTEERS IN EMERGENCY SERVICE AGENCIES

BACKGROUND

Significant time and money is invested in volunteers by agencies. Retaining volunteers saves substantial time and resources, increasing the capacity of individual brigades and units. Two areas contributing to the problem of retention have been attributed to poor leadership and cultural value alignment.

The project has several aims but the core issues addressed are:

1. Retaining volunteers beyond their initial training period.
2. Increasing the skills acquisition of emergency service brigades and units.

Left: RESEARCH WILL EVALUATE THE VALUES THAT MOTIVATE PEOPLE TO VOLUNTEER. PHOTO: ACT SES.

RESEARCH ACTIVITY

The study is identifying the personal and shared values that motivate people to volunteer in emergency services, and is evaluating the importance of individual, group and organisational values that align to volunteer commitment and retention.

In the first stage (June to December 2015) an organisation-specific case study is seeking to determine the distinctive and dominant personal and shared values of New South Wales State Emergency Service (NSW SES) volunteers. In the second stage (December 2015 to June 2016), NSW SES volunteer units will be engaged to explore local strategies to address values conflicts and misalignments. The volunteers will be asked to complete a survey indicating how much they relate to (are like) a series of descriptions of 40 different types of people.

This will be complemented by at least 20 focus group meetings with SES volunteers across NSW to explore the shared values preferences of different groups.

Another component of the project will evaluate the effectiveness of a Leadership Development Program fine-tuned to the unique psychological needs of volunteers, investigating whether leadership intervention can affect positive changes in both the leaders' leadership style and their direct reports' perceptions of the leader and reported job satisfaction (intention to leave, job satisfaction, basic psychological needs satisfaction). This program was developed for use by emergency service volunteer leaders, and was piloted in the NSW SES and New South Wales Rural Fire Service in 2014.

Over the next 12 months the training will be offered to NSW SES volunteer leaders. Support and participation from other agencies is being sought so that the findings better express the value sentiments across the country.

RESEARCH OUTCOMES

Findings from an already completed pilot Leadership Development Program suggest that volunteers whose needs are satisfied (competence, relatedness and autonomy) and whose leaders take an autonomy supportive (versus controlling) approach may be more satisfied with their volunteering job and are less likely to want to leave.

In regards to volunteer leaders, participants learnt to adopt autonomy supportive approaches over coercive approaches to leading their volunteers. The leadership skills of volunteer leaders appear to have improved after attending the program.

Confirmation of the pilot findings is expected as more participants pass through the program.

The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

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Indigenous Initiatives

HAZARD **NOTE**

bushfire & natural HAZARDS CRC

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TOPICS IN THIS EDITION | INDIGENOUS COMMUNITIES | LOCAL KNOWLEDGE | NORTHERN AUSTRALIA

DEVELOPING A CULTURALLY APPROPRIATE NATURAL HAZARDS TRAINING PROGRAM FOR INDIGENOUS COMMUNITIES

ABOUT THIS PROJECT

The *North Australian bushfire and natural hazard training* project began in 2015, as part of the 'building community resilience in northern Australia' cluster of CRC projects. The research is a collaboration between Charles Darwin University, the Aboriginal Research Practitioners Network, emergency management agencies, and several northern Indigenous communities and their leaders.

AUTHORS

Stephen Sutton, Charles Darwin University. Contact stephen.sutton@cdu.edu.au.

▲ **Above:** RESEARCHERS WORKED WITH INDIGENOUS COMMUNITIES TO DEVELOP TRAINING UNITS THAT PROVIDE PRACTICAL SUPPORT AND REINFORCEMENT OF LAND MANAGEMENT CAPABILITIES IN REMOTE INDIGENOUS COMMUNITIES IN NORTHERN AUSTRALIA. PHOTO: STEPHEN SUTTON.

SUMMARY

Nearly 360,000 people, predominantly Indigenous Australians, live in remote communities in northern Queensland, Northern Territory and northern Western Australia. There is concern among Indigenous land, fire and emergency managers in these communities that existing fire and emergency management training is inadequate and does not provide tailored, collaborative strategies to keep communities safe from frequent fires, cyclones, storms and flooding.

This project developed training units that provide practical support and reinforcement of capabilities emerging and needed in remote Indigenous communities in northern Australia. Comprising ten units designed for delivery at the Vocational Education and Training Certificate II level, the training units interweave a set of philosophical and practical understandings of the management of landscapes for bushfire and natural hazards in a changing climate with new economic stressors and opportunities, as well as the integration of Indigenous knowledge and experience with non-Indigenous approaches.

Researchers used a Participatory Action Research approach to provide a 'next-generation' training program that builds on the current assets in northern Australia, such as ranger programs, and leads to increasing levels of competence, confidence and resilience. The ten training units have not yet been subject to national accreditation but are designed to map onto the Standards for VET Accredited Courses as set out by the Australian Skills Quality Authority. Following accreditation, training providers will need to be sourced to deliver the training. The skills and knowledge generated during the development of the training units are already being used in communities in central and western Arnhem Land in the Northern Territory. The training units can be accessed through the CRC by contacting office@bnhcrc.com.au.

CONTEXT

In northern Australia, Indigenous Australians, as well as pastoral land managers and emergency services, perceive natural hazard management (especially fire management) differently to how it is viewed in southern Australia – it is seen as something that is flexible and responsive to human agency. This in turn derives from a deeper Aboriginal understanding of the universe which is embedded in the Dreaming. In this worldview, everything in the world has morality, or a 'correct and appropriate' role and behaviour, including fire. Failure to manage fire, resulting in large-scale late dry season bushfires, is understood as a clear consequence of immoral fire management. Managing fire according to Aboriginal tradition is seen as a moral act that has beneficial spiritual as well as physical consequences.

Technology and practices to achieve fire management, such as the West Arnhem Land Fire Abatement Project, are being shared and developed across northern Australia.

This project is fundamentally aligned with the aspirations and cultural preconceptions of many remote communities. Work is conducted on Country, with family, utilising traditional knowledge and acknowledging Traditional Owners' rights and responsibilities.

BACKGROUND

Nearly 360,000 of the people living in northern Australia (comprising northern Queensland, the Northern Territory and northern Western Australia) are in communities with varying degrees of remoteness. These communities are predominantly inhabited by Indigenous Australians, with the percentage rising in direct proportion to remoteness.

An average of 430,000km^2 is subject to fire each year, while annual widespread flooding also disrupts communities more than 150km from the nearest hospital. Many communities are within 50km from the coast, making them vulnerable to storm surge, erosion and sea level rise. Cyclones are also common, becoming less frequent but more intense with climate change.

This project was initiated following concerns from Indigenous land, fire and emergency managers in northern Australia about the inadequacy of existing training for remote fire and emergency management. People involved in fire and land management in remote Aboriginal communities, in particular, were concerned that existing training did not provide satisfactory levels of skills or knowledge with which an individual or group could effectively manage bushfire and other natural hazards at the landscape scale required in the north – where fire and emergency management is quantitatively and qualitatively different to that in the south. This project established new and relevant training units in fire and emergency management in those northern regions.

BUSHFIRE AND NATURAL HAZARDS CRC RESEARCH

This research used a Participatory Action Research approach, which encourages participants to frame the enquiry as it changes over the lifetime of the project, as well as the generation of answers and training materials. This approach is based on the previous model of research among north Australian Aboriginal communities that was developed by the Aboriginal Research Practitioners' Network (ARPNet).

Using this approach, researchers were able to prioritise not just the inclusion of Indigenous communities, leaders, ranger groups and researchers (including working closely with ARPNet to conduct and facilitate workshops), but also a focus on the social context of the delivery of disaster management services, exploring how power imbalances constrain development of resilience and trust between agencies and communities.

Examination of existing training

Researchers conducted several desktop reviews, which examined existing bushfire and natural hazard training opportunities, as well as any leadership training opportunities existing at the time for Indigenous community members. The reviews found that, at the time, existing training largely omitted Indigenous perspectives relevant to northern Australia, particularly in terms of strategic overviews and planning. Relating to leadership training, it was found that where remote communities were able to access training for bushfire and natural hazards, it did not often focus on leadership, or the leadership components did not include bushfire and natural hazards management.

Development of training through formal engagements

Nine formal 'engagements' were held over the life of the project, including six workshops and three training pilots. The first two of these were invite-only workshops held at Charles Darwin University, while subsequent engagements were conducted in communities across the Northern Territory, including Blyth River, Malyangarnak, Buluhkarduru and Ramingining. *Hazard Note 50*, available at www.bnhcrc.com.au/hazardnotes/50, details the research process and initial piloting of the training units.

These community-based workshops were open and inclusive of everyone available to attend. At each, different components of the ten training units were presented and refined. A detailed culturally appropriate evaluation was undertaken of each pilot and the feedback incorporated into the next round of pilot training.

AN INCLUSIVE TRAINING APPROACH

This project identified several key elements of inclusive training when working with cross-cultural groups.

Culturally appropriate

It is important to establish the sociocultural context that will support the cognitive, emotional and behavioural learning.

'NEED TO KNOW'

'On Country': For Indigenous people, 'Country' encompasses an interdependent relationship between a person and their ancestral lands and seas. This reciprocal relationship is maintained through cultural knowledge and is based on mutual respect between the land and people. 'On Country' refers to activities conducted on Aboriginal land with the objective of promoting ecological, spiritual and human health.

Bininj and Yolngu: Bininj is the local language term for people in western Arnhem Land in the Northern Territory, while Yolngu is the name of the people who live in north eastern Arnhem Land.

Training delivery should be part of a long-term process of collaborative interaction involving a network of Indigenous and non-Indigenous stakeholders – educators, researchers, representatives including Traditional Owners and 'Jungkayi' (guardians) from the community/Country where training is to take place, and other landholder or manager groups and employers.

Pre-engagement

Working with local Traditional Owners, custodians and knowledge-holders prior to any actual training delivery has been found to be one of the best predictors of success and sustained practice. Researchers encourage Traditional Owners to host the training, invite attendees and to 'own' the process. External trainers and support staff should get to know the people and the Country they are working with and develop a rapport that supports co-creation of knowledge.

Training on Country

It is crucial that training takes place 'on Country' and that activities are tailored to the land where participants will be expected to undertake management roles, which allows for the integration of the local landscape into training activities. Presentations may be embedded in other activities consistent with the Transformative Education approach (for example, a leadership session for women might be conducted while doing traditional crafts or fishing). Practical activities around fire management or other natural hazards can be arranged as timely changes of pace throughout the training program.

Training the whole Clan

While there was the customary 'target group' for the training, success was also correlated with the invitation of the whole land-holding Clan to attend. Formal training sessions included the 'target group' but would also include a changing range of family members. People were free to move and use the space as they thought appropriate. By training the whole Clan, the 'target group' were able to receive increased levels of moral support from their families, because the knowledge they hold and the work they do is shared. This also creates a greater empathy for their situation, which is particularly important when that work requires ongoing engagement with 'Balanda' (non-Indigenous people).

Traditional professors as trainers

Training should include experienced members from the organisation and community, and the process should, in part, be viewed as one aspect of inter-generational transfer: the passing on of traditional knowledge from one generation to the next. As well as the obvious advantage of trainees accessing traditional information they may not have, the space created by this training arrangement further secures the framework for incorporating new (non-Indigenous) knowledge into a cross-cultural framework adding to the skills and knowledge of the trainees.

TRAINING UNITS

In response to the desktop reviews and engagements, the project developed a set of 10 training units that, taken together, drew together the essential elements of Indigenous and non-Indigenous bushfire and natural hazards training in a Vocational Education and Training-style (VET) program. Some of the units are entirely new, while others are adaptations of existing training. The style of training is a blend of traditions, from the non-Indigenous pedagogy of VET and the Bininj and Yolngu knowledge systems, resulting in a program of training that may require additional time and resources.

The materials are designed for delivery at the Certificate II level, allowing for rapid delivery at a single field school over five to ten days. All course guides and instructions allow for the scaling up or down of the units to accommodate needs and timing of participants. For example, ten straight days may not be possible during the dry season when cultural burning is taking place.

HOW IS THIS RESEARCH BEING USED?

The material has already been utilised in communities, and the skills and knowledge acquired are being used in bushfire and natural hazards and land management in central and western Arnhem Land in the Northern Territory. Outputs at each stage of the project have been used by local community members to develop their capabilities in bushfire and natural hazard management and leadership. This includes through participation in

TRAINING UNITS OUTLINE

Below is a summary of the ten training units. You can access the full units and support materials by emailing the CRC at office@bnhcrc.com.au.

- **Non-Indigenous and Indigenous bushfire and natural hazards management principles:** This unit acknowledges the existence of a unique Indigenous-led bushfire and natural hazards management regime in the north, placing that system in the wider context of Australia's and the international community's approach. The aim is to provide participants an opportunity to understand their personal perspective and its context, and to then build on that existing scaffold.
- **Applying Indigenous fire management processes in north Australian contexts (local variant):** This unit identifies the local bushfire and natural hazards management regime, and explores the local traditions and culture associated with land, fire and natural hard management. The delivery should be preceded by gathering of some local information from Traditional Owners and djungkayi (meaning 'caretaker'), and these knowledge holders should be included in course delivery. By definition, this course will vary from place to place.
- **Community engagement and cultural protocols (local variant):** This unit seeks to connect the existing protocols for bushfire and natural hazards management with traditional Indigenous cultural norms. It assumes that there is considerable ground for improvement of interactions between specialist management agencies and traditional Indigenous communities.
- **Fire management and the law:** This unit seeks to give an overview of the nature of Australian law and its authority, and then to explore the relevant and appropriate legislation that applies to the community within which the training is being delivered.
- **Digital mapping tools used in bushfire and natural hazards management:** This unit introduces spatial information technology through a series of discussions and practical exercises using current hand-held devices and computing software. The objective is to provide a base for operations, where an individual can begin to use digital mapping tools in the pursuit of the professional and day-to-day lives.
- **Apply Standard Operating Procedures (SOP):** This unit is a preliminary exploration of the concept of SOPs and why they exist, including a step-by-step examination of SOPs applied by some local bushfire and natural hazard organisations. Links are made to conceptual SOPs that exist within the local cultural setting.
- **Participate in debrief (local variant):** This unit includes a session on the concept of feedback within the Australian bushfire and natural hazards management system and why it is important. Participants are encouraged to find culturally appropriate mechanisms to conduct debriefs in a way that generates improvements in outcomes and safety while avoiding inappropriate cultural interactions.
- **Advanced situational awareness and dynamic risk assessment (local variant):** This unit provides some practical examples of dynamic risk assessment and draws out extant examples within the local context. Participants are encouraged to develop their own culturally appropriate mechanisms to assess and avoid risk in different temporal contexts.
- **Remote tactical leadership:** This unit builds bridges between the non-Indigenous and Indigenous leadership protocols, providing participants with trajectories for developing their own leadership styles within the contexts of their local communities and bushfire and natural hazards realities.
- **Develop operational work plans:** This unit exposes the reality of conducting a program of bushfire and natural hazards preparation and mitigation within the context of local culture, legislation and strategic planning. Participants develop tools for satisfying the needs of funders and Traditional Owners.

END-USER STATEMENTS

"The *North Australian bushfire and natural hazard training* project has been an important contributor to the development of remote community resilience to bushfires and natural hazards. By engaging directly with communities, including Traditional Owners and Custodians and their extended families, the project has driven a cross-cultural understanding of effective leadership and decision-making for responding to a natural hazard.

"It has done this by explicitly valuing local, existing knowledge and capacity and then seeking to enable project participants to add to that existing scaffold new knowledge, approaches and understandings. Over a number of workshops and several years this process has documented what worked and what was appreciated by participants. The results have seen enthusiastic support for the project in the communities where the program took place.

"The full benefit of the program has not yet been achieved however, as the training materials are yet to be captured in a formally accredited process. As lead end-user this final step is to be encouraged and Bushfires NT stands ready to provide advice and guidance in this area if required."
Kenneth Baulch, Director of Policy and Planning, Bushfires NT

"That's the real difference from any other project that I have seen, this one is different, we wanna start targeting each clan group, train them so they can be strong leader for own family and clan, they can make their own emergency plan for their community."
Elder, Malanganark

'research' workshops, as well as being both deliverers and participants in pilot training courses. Evaluation reports show that the project has already had an impact in the other small remote communities, in which pilot training has been delivered, with locals requesting further training from this research.

FUTURE DIRECTIONS

The ten training units have not yet been subject to national accreditation but are designed to map onto the Standards for VET Accredited Courses as set out by the Australian Skills Quality Authority. Following accreditation, training providers will need to be sourced to deliver the training.

There is also significant potential for the project to have an ongoing impact beyond north Australia. The materials generate a revised narrative of fire and emergency management in Australia that incorporates the oldest paradigm in the world – the land management skills and knowledge of Indigenous Australians.

While the project set out to provide a service need for northern Australia, the project report – which was delivered following the southern Australian bushfire crisis in 2019/20 – highlighted the need to change the way fire is managed at a landscape level. The training units may assist in developing new understandings and capabilities in communities in fire-prone Australia generally. In particular, the way in which training was conducted – on Country, with family and at a flexible pace – is strongly recommended as a fundamental element for future training and engagement with Indigenous Australians.

Anecdotal reports of project participants making enquiries about tertiary education opportunities in related fields have included calls from some participants to develop effective community emergency management plans. Preparations have been made to conduct workshops in one community using 3D modelling but are currently on hold due to COVID-19.

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The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

HAZARD **NOTE**

bushfire&natural HAZARDSCRC

ISSUE 94 APRIL 2021

TOPICS IN THIS EDITION | INDIGENOUS COMMUNITIES | NORTHERN AUSTRALIA | RESILIENCE

BUILDING COLLABORATIVE EMERGENCY MANAGEMENT CAPACITY IN NORTHERN AUSTRALIA

ABOUT THIS PROJECT

The *Scenario planning for remote community risk management in northern Australia* project was a continuation of research that began in 2014 at Charles Darwin University, assessing emergency management capacity building needs in northern Australian remote communities. This project was a partnership between the Darwin Centre for Bushfire Research at Charles Darwin University, the North Australia Indigenous Land and Sea Management Alliance, regional fire and emergency agencies, conservation agencies and remote Indigenous communities.

Above: THIS RESEARCH USED CONSULTATION AND RESPECT TO EMPOWER INDIGENOUS COMMUNITIES BY ENHANCING THEIR CAPABILITY TO BETTER UNDERSTAND EMERGENCY MANAGEMENT PROCEDURES AND PROCESSES. PHOTO: CHARLES DARWIN UNIVERSITY.

AUTHORS

Prof Jeremy Russell-Smith, Dr Kamaljit Sangha and Dr Andrew Edwards, Charles Darwin University. Contact: jeremy.russell-smith@cdu.edu.au

SUMMARY

Indigenous communities in northern Australia are constantly affected by natural hazards, with large areas of more than 250,000 km^2 experiencing bushfires in the dry season (August–November), coupled with frequent floods and cyclones in the wet season (December–April). Remote communities do not have the same access to services as other towns and communities and, as such, need to develop effective partnerships with centralised emergency management agencies as well as building their own emergency management capabilities. Through a consultative and culturally respectful process, this project has empowered remote Indigenous communities by enhancing their capability to better understand emergency management processes and procedures. Researchers worked closely with Indigenous communities and Indigenous Ranger Groups in the Northern Territory, the Kimberley region of Western Australia, and northern Queensland to understand key issues they are facing when it comes to emergency management, and to explore options through scenario planning for enhancing their preparedness, disaster response capacity and resilience.

For emergency service agencies, a framework and set of protocols has been developed that will help them more effectively engage with, and provide service delivery to, remote Indigenous communities (Sithole et al. 2017; Sangha et al. 2019b). While the classic model of emergency service volunteering isn't suitable for remote communities, the rapidly expanding Indigenous Ranger Program affords a constructive opportunity for enhanced community engagement and on-the-ground operational delivery. A cost-savings analysis of engaging remote Indigenous communities in the emergency management sector clearly demonstrates the huge benefits that such opportunities afford for the governments.

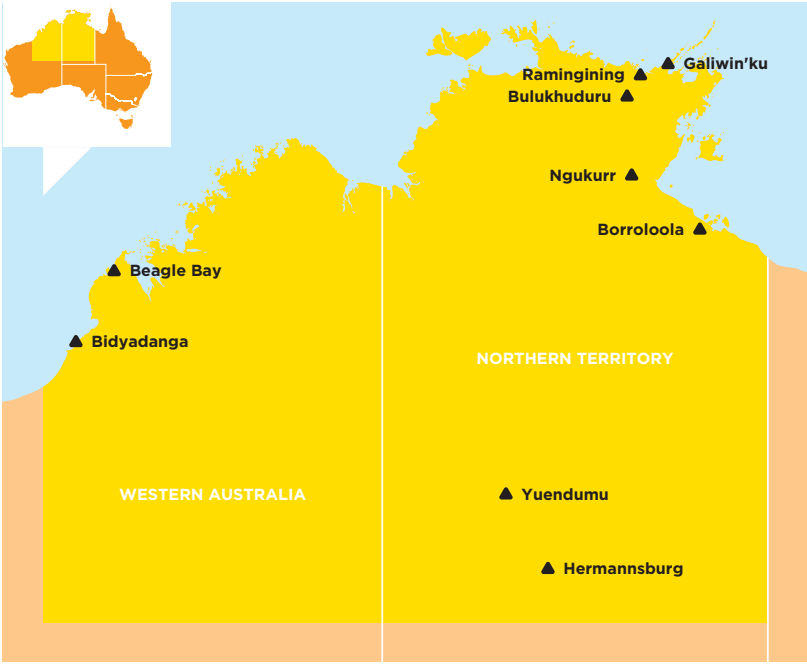
CONTEXT

Northern Australia – spanning northern Western Australia, the Northern Territory and northern Queensland – is an extensive area with a sparse population and minimal infrastructure. There is considerable rain in summer (the 'wet season'), meaning vegetation grows considerably, and very little in winter (the 'dry season') where grassy fuels progressively cure. Temperatures are high all year, and the number of very hot days (>35°C) is projected to significantly increase in coming decades. Large tracts burn annually, and traditionally based early season burning practices are a major part of cultural land management practice, requiring significant resources. Cyclones and flooding recur frequently, especially in higher rainfall coastal and sub-coastal regions.

Fire and emergency services agencies recognise the need to improve the services provided remotely, but also recognise that all jurisdictions (but particularly the Northern Territory) are not adequately resourced to achieve this. The classic model of volunteering does not meet the needs of most Indigenous communities in remote areas given chronic underemployment, poor socio-economic status and related issues.

▲ **Top:** DR ANDREW EDWARDS AND DR GRIGORIJS GOLDBERGS ASSESSING THE EFFECT OF A BUSHFIRE ON TREES NEAR MATARANKA IN THE NORTHERN TERRITORY. PHOTO: NATHAN MADDOCK, BUSHFIRE AND NATURAL HAZARDS CRC.

▲ **Above:** RESEARCHERS WORKING WITH INDIGENOUS RANGER GROUPS. PHOTO: CHARLES DARWIN UNIVERSITY.



▲ **Above:** LOCATION OF PARTICIPATING COMMUNITIES IN THE NORTHERN TERRITORY AND WESTERN AUSTRALIA.

However, the expanding Indigenous Ranger Program is a potential means to engage with local Indigenous peoples and build local emergency management capacity. This research worked closely both with Indigenous Ranger Groups and emergency management agencies to identify issues and opportunities for building more effective emergency management capability.

BUSHFIRE AND NATURAL HAZARDS CRC RESEARCH

This project is part of a suite of projects that commenced in 2014. Conducted by researchers at Charles Darwin University, the collective aim of the projects was to build and empower resilience capability and capacity in north Australian remote Indigenous communities. This phase of the project began in 2017, with the objective of enhancing emergency management capabilities, especially through scenario planning processes – for example, working with communities and Indigenous Ranger Groups to identify current capability and capacity issues, and what was required to address resourcing and structural limitations into the future. Researchers from CDU's Darwin Centre for Bushfire Research worked closely with the North Australia Indigenous Land and Sea Management Alliance (NAILSMA), the Aboriginal Research Practitioners Network (ARPNet), north Australian fire and emergency management agencies, conservation agencies and remote Indigenous communities.

Researchers initially developed a framework – using a suite of case studies based on interviews and workshops with members of Indigenous Ranger Groups – to understand the aspirations, willingness and capacity to engage in emergency management activities. These case studies were developed with remote Indigenous communities, including Hermannsberg and Yuendumu in central Australia; Beagle Bay and Bidyadanga in the Kimberley; Galiwin'ku on Elcho Island off Arnhem Land; Bulukhuduru, Ramingining and Ngukkurr in Arnhem Land; and Borroloola in the Gulf of Carpentaria. Researchers then assessed and reported on the current emergency management situations in these communities, and identified gaps, resource needs and proposed solutions or alternatives to better manage and mitigate natural hazards.

Based on these findings, further research outputs included published analyses addressing: (1) outlining the case for investment in building the emergency management capacity of Indigenous Ranger Groups (Russell-Smith et al. 2020), (2) the true costs of natural hazards in northern Australia (Sangha et al. 2020, 2021), (3) the total costs (direct and indirect) from bushfires in the Northern Territory (Sangha et al. 2019a) and (4) full cost assessment of all major and minor natural hazards in the Northern Territory over the last 10 years (Sangha et al. 2021).

Fire management tools

Associated research activities included ongoing development of land management, monitoring and evaluation tools for practical application by emergency management agency and broader community end-users, including enhancements with fire severity mapping and the use of the Savanna Monitoring and Evaluation Reporting Framework (SMERF – see *Hazard Note 46*, March 2018). Scientific publications describing both these research products are under development.

Fire severity mapping

Fire severity mapping is about how severe the fires are. Fire severity underpins fire management with respect to key ecological fire effects. Unlike fire extent/burnt area mapping, fire severity has proven to be difficult to interpret directly from high resolution aerial photography, or its equivalent, and nearly impossible using moderate resolution satellite imagery. A program has been in development for several years to continually improve the automated algorithms. In particular, this

project has developed a fire severity map product for use in remote communities, not only to inform land management but also to improve savanna burning greenhouse gas emissions calculations. This also directly informs Australia's greenhouse gas emissions inventory.

Savanna Monitoring and Evaluation Reporting Framework

SMERF is an online tool and is the result of research completed with Parks and Wildlife in the Northern Territory, Kakadu National Park (Parks Australia) and the Queensland Parks and Wildlife Service. SMERF can be accessed at infonet.org.au/smerf-crc/ and can be used to: monitor the effects of fires through a multitude of effects models; analyse the effects of past fires, through the assessment of an extensive fire history; and improve planning capacity through analysis of past fire effects. Specifically, this project has used SMERF to inform distribution and effects of fires on tropical savanna and rangeland habitats across northern Australia.

RESEARCH FINDINGS

This research has identified that effective partnerships with remote communities, and cross-sectoral engagement, especially with the environmental sector, is essential for building resilience to natural hazards across northern Australia, and for ensuring effective emergency management delivery in remote community settings.

This research highlights ongoing priorities, as identified by partner agencies and community stakeholders, that require further action-based research and implementation.

Building the capacity of Indigenous ranger groups to deliver effective emergency management in remote community settings

A model for effective engagement and partnership with remote Indigenous communities can be guided through the following salient points:

- Long-term emergency service agency support is required from trained personnel with appropriate understanding of and consideration for social, economic and cultural sensitivities.
- The classic model of volunteerism has limited applicability in remote Indigenous communities for various social, economic and cultural reasons.
- Support needs to build on foundations of mutual respect.
- A collaborative model of managing emergency management in remote communities, developed in consultation with local community members, is vital to improve the current situation.
- It is important to implement a multi-sector targeted approach for generating new opportunities to reduce the risk of natural hazards in remote settings, offering a cost-effective way to mitigate and manage natural hazards.
- Emergency management can be conducted as part of other activities that address broader landscape and community management.
- Emergency service agencies need to be patient in their support for, and provide regular, flexible and appropriate training, mentoring and resourcing assistance.
- Significant efficiencies can be gained through developing contracted, fee-for-service arrangements – especially where agencies have limited or no capacity to deliver required services in remote locations themselves.

Full accounting of the real costs of natural hazards in the Northern Territory

A detailed assessment of total direct and indirect costs associated with natural hazards in the Northern Territory suggests that:

- natural hazards in the Northern Territory have resulted in total losses of $156 million on average per annum for the 10 years from 2010 to 2019, with direct losses comprising only $53 million per annum and indirect losses estimated at $103 million per annum (accounting mainly for bushfires and cyclones). Indirect losses are largely omitted in current natural hazard-related assessments and policies.
- minor yet frequent events, such as monsoon troughs and floods, cost more than $7 million per annum for the Northern Territory and need to be considered in national datasets.

HOW IS THE RESEARCH BEING USED?

This project has had a significant impact on informing emergency management issues in remote northern communities, both for emergency management agencies and Indigenous stakeholders, including:

- initiating a dialogue between emergency management agencies (the Northern Territory Emergency Service, the Department of Fire and Emergency Services WA and the Queensland Fire and Emergency Service) and Community

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Elders (from the Northern Territory and north Queensland) to look for community-based solutions to effectively manage and mitigate natural hazards in the region
- encouraging discussions among Indigenous stakeholders to consider emergency management issues and realise that their involvement is valuable and critical for their own communities
- informing emergency management agencies, particularly the Northern Territory Emergency Service, to learn directly from the Indigenous Ranger Groups in remote communities about various emergency management issues they face
- providing detailed cost analyses, including direct and indirect losses from bushfires and all the major and minor natural hazards from 2010–2019, directly informing agencies in the Northern Territory
- providing fire severity mapping and SMERF monitoring products that are proving valuable for a wide range of northern land managers, including pastoralists, Indigenous and conservation land managers
- enhance fire severity mapping to better informing the National Greenhouse Gas Inventory
- generating detailed information both for emergency management agencies and remote community partners to enhance collaborative emergency management across the sparsely settled northern savannas.

▲ **Above:** RESEARCHERS GATHER WITH THE NGUKKURR COMMUNITY FOR A WORKSHOP. PHOTO: NATHAN MADDOCK, BUSHFIRE AND NATURAL HAZARDS CRC.

END-USER STATEMENT

"The scenario planning project has focused on opportunities for engaging with and utilising the emerging capacities of Indigenous ranger groups in emergency management in remote community settings. As a rural fire management agency, Bushfires NT can foresee many benefits flowing from greater involvement of trusted and skilled local personnel in all phases of emergency management in remote communities. To that end, we recognise the importance of emergency management agencies providing appropriate, long-term support for remote communities and ranger groups, including provision of regular, flexible and appropriate training and resourcing, and respectful collaboration with community leaders and Traditional Owners. We also commit to encouraging development of fee-for-service arrangements within the shire councils, agencies and other land owners/managers to help support Indigenous ranger groups.

The research team have performed well, having published papers of international significance, and patiently working towards the development of remote Indigenous community resilience. They have provided insights into the potential for Indigenous Ranger Group involvement in remote community emergency management activities, and assisted rangers to better understand their aspirations in this space."

Kenneth Baulch, Director of Policy and Planning, Bushfires NT

FUTURE DIRECTIONS

This project has expanded on identified community-based research needs commenced in the first round of the CRC's research program. Ongoing priorities identified by partner agencies and community stakeholders requiring further action-based research and implementation include:
- understanding the full costs and benefits of engaging with Indigenous Ranger Groups in the delivery of effective emergency management in remote community settings
- full accounting of the costs of natural hazards in northern Australia , especially in remote communities
- ongoing development of tools to assist savanna fire managers, for example, fire behaviour models, improved fire severity mapping and curing mapping
- further facilitation of case-based dialogue between emergency management agencies and remote communities to promote enhanced emergency management arrangements.

A first of its kind cross-sectoral workshop, bringing together senior representatives from north Australian end-user emergency management agencies and Indigenous remote community stakeholders, the Australian Red Cross, and other partners, was organised in November 2020. There was a mutual agreement among the emergency management representatives and Indigenous stakeholders to develop effective partnerships for building resilience for managing emergencies in the future.

The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

HAZARD **NOTE**

bushfire&natural HAZARDSCRC

ISSUE 50 AUGUST 2018

TOPICS IN THIS EDITION | INDIGENOUS COMMUNITIES | NORTHERN AUSTRALIA | RESILIENCE

REMOTE INDIGENOUS COMMUNITIES WELCOME TWO-WAY TRAINING

ABOUT THIS PROJECT

The *Northern Australian bushfire and natural hazard training project* is part of the Understanding and enhancing resilience research cluster. It draws on current assets, such as skills and capacities, to increase confidence, competence and resilience through training programs in remote northern Australia.

AUTHOR

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SUMMARY

This unique project has developed a pilot program for natural hazards training in Indigenous northern Australia. With national significance, the project has highlighted the need for greater awareness of the profound cultural differences between bureaucracies and Indigenous people, and the desire by communities to have non-Indigenous emergency management training that builds on Indigenous knowledge and delivery of hazard management practices. This includes respecting and observing cultural arrangements, such as following local structures for decision making and the inclusion of family in the training, as well as the inclusion of the understanding and practices of Indigenous people. It suggests that dialogue about those differences can lead to better outcomes for resilience development.

▲ **Above:** THE IMPORTANCE OF INCLUDING THE WHOLE COMMUNITY IN TRAINING HAS BEEN A KEY FINDING FROM THIS PROJECT. PHOTO: BEV SITHOLE.

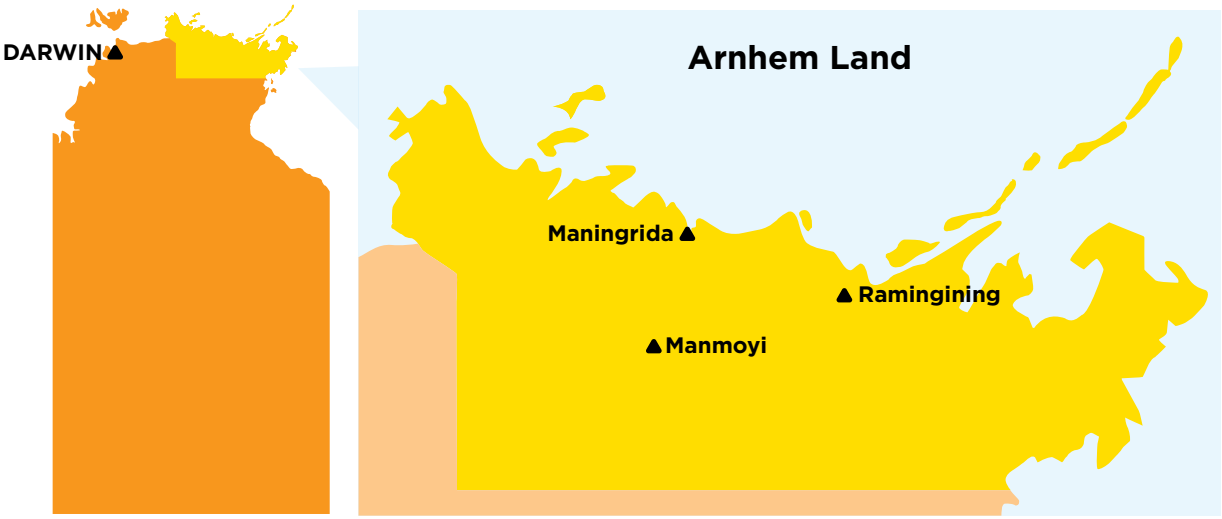
CONTEXT

Although Australia's National Strategy for Disaster Resilience seeks equity in the delivery of fire and emergency management across the nation, remote communities in northern Australia are at a severe disadvantage when it comes to managing natural hazards. Inadequate infrastructure unsuited to wet season conditions, combined with remoteness, isolates communities for up to six months per year. Additionally, socioeconomic measures show that remote community inhabitants are in the lowest tiers of Australian health, education and income. Y*et all* remote communities are expected to contribute to the 'shared responsibility' for disaster risk reduction. In Australia's far north, however, many communities have never had an effective dialogue with government agencies. This has led to profound misunderstandings on both sides about capacities and responsibilities.

BACKGROUND

This project responds to concerns expressed by Indigenous people in some remote Northern Territory communities about the inadequacy of fire and emergency management training in northern Australia. Following informal conversations initiated by Indigenous people, the researchers have consulted community members in three Arnhem Land communities: Ramingining in Central Arnhem Land; and Maningrida and Manmoyi, both in West Arnhem Land. The objective was to document the issues and develop training that meets their requirements and aspirations. For many Indigenous participants, it was the first time they had been consulted by a non-Indigenous person about Indigenous understanding of natural hazards, resilience, leadership and decision making.

The project, which began in July 2015 and is now in its utilisation phase, is one of several CRC projects that investigate how to strengthen community resilience in northern Australia. It focuses on understanding the risk and vulnerability of remote, mostly Indigenous, communities and takes into account their existing and emerging capacities. A key component has been to scope community members' understanding of their risk profile and resilience. Remarkably, this research found that many of the participants had never heard of 'natural hazards management'.



▲ **Above:** LOCATION OF PARTICIPATING ARNHEM LAND COMMUNITIES.

▲ **Above:** INTERVIEWS WERE CONDUCTED WITH DUE ATTENTION TO LOCAL CULTURAL SENSITIVITIES. PHOTO: BEV SITHOLE.

NEED TO KNOW

ARPNet (Aboriginal Research Practitioners Network): a coordinated Indigenous team which has been trained in Participatory Action Research. Members are contracted to conduct research, evaluation and planning activities using qualitative and quantitative research methods. For each project, ARPNet members work with the lead researcher to clarify the research objective and frame the approach. ARPNet research is then conducted in the participants' first language, with due attention to local cultural sensitivities.

Balanda: white people; term derived from "Hollander".

Nor did they understand the term 'resilience' in this context, that is, the ability of individuals and communities to adapt to environmental changes and to continue a fulfilling existence on country.

RESEARCH ACTIVITY

The three remote Arnhem Land communities were selected because:

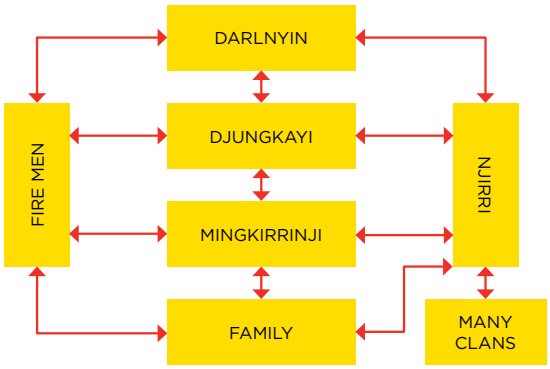
1. They were located near emerging fire and land management projects
2. They were impacted by two cyclones (*Nathan* and *Lam*) in early 2015
3. Community members had strongly advocated for training.

The initial research strategy was to adopt a qualitative approach to determine what local people felt was needed in training. This proved to be a quite specific and limited scope. The strategy subsequently evolved and broadened as the researchers worked with the project's participants. It started with interviews that were unstructured conversations about fire and emergency management and the training that people required to access emerging opportunities in greenhouse emissions abatement and commercial land management in the region. The researchers then held a series of workshops to investigate land management practice and knowledge, which culminated in two workshops targeting leadership and decision making. The workshops were facilitated by practitioners from the ARPNet program (Aboriginal Research Practitioners Network), a coordinated team of Indigenous people who have been trained in participatory action research (see Need to Know box, this page). They used the languages of the community members, as well as English, to generate a deeper understanding of the issues.

The use of ARPNet dramatically improved the project's progress by generating excitement among participants, including people who would usually rarely attend meetings with balanda (white people). Conducting research in participants' first language, with recognition of and deference to Aboriginal cultural settings, indicated

FIGURE 1. LEADERSHIP AND DECISION MAKING MATRIX FOR INDIGENOUS BININJ (PEOPLE) OF CENTRAL/WEST ARNHEM LAND

BININJ FIRE, LAND AND EMERGENCY LEADERSHIP AND DECISION MAKING MATRIX



▲ **Above:** Figure 1 shows a model decision making matrix for Bininj, the generic name for people in Central and West Arnhem Land. Bininj covers various language groups that are similar to tribes. For Bininj, individuals are required to fulfil a complex series of interactions in specific roles attending the decision making process. The Darlnyin is 'the big boss', but must refer to both the 'Djungkayi', (title referring to the manager by matrilineal descent, and the 'Mingkirrinji', (the title for owner by patrilineal descent) and also the wider family when taking a decision. If the decision relates to fire then the 'fire men' – senior men with totemic affiliations and deep practical knowledge of fire – are critical players. The 'Njirri' is like an auditor and ensures that proper protocols are observed. Unlike western auditors, however, the Njirri may also affect punishment for breaches of protocol. All this is observed by the Clans, who will object loudly if significant breaches of dreaming law occur.

An equivalent, although not identical, non-hierarchical system might be expected to function in all of Indigenous Australia.

Both the Bininj and the researchers aspire to having this matrix function as part of the fire plans for remote communities in Central and West Arnhem Land.

to participants that the researchers were committed to addressing each community's training needs. In particular it emerged that the limited scope of the research was, in fact, itself constrained by the preconceptions of the research team and that there was a much deeper set of lessons in the research findings.

RESEARCH FINDINGS

This project has identified lessons for all interactions between emergency management agencies and Aboriginal people. The researchers found that effective training should respect the local Indigenous culture by working within the non-hierarchical, decision-making matrix of each community. Figure 1 shows the matrix for the Central and West Arnhem Land communities that participated in the research. (Note: their term for 'people' is Bininj). In this system, no individual has the authority to make a decision regarding land or hazard management; input from key members across the matrix, which might include different language groups, is usually sought. A key insight is that Indigenous people believe that only a person born of the country should be able to make decisions about country.

With regard to the training itself, the Indigenous participants wanted to continue the existing training, with its focus on safety and non-Aboriginal conceptions of fire and response. However, they also expressly required that training include their own understandings of fire and practices and use their own 'professors' – senior community members with ceremonial and practical qualifications in fire and land management. The training should integrate with their existing wisdom to build a wider, intersecting understanding of their role in fire and emergency management.

Indigenous participants preferred to have training conducted on their community lands ('on country'), rather than in towns or cities, and use a mix of interactive techniques to operationalise knowledge. The training structure would ideally combine action, discussion and review in their language, led by elders as well as with balanda. It should be part of a cyclic training program spread over days (a week would be best). Where technology is used (for example, GPS, GIS), it should be introduced and reviewed in ways that allow individuals to become comfortable with their use. For example, familiarising themselves with the technology during breaks or in the evening over a family discussion.

The training should target those people, such as local rangers, who will conduct the on-ground work, and training must also be provided to their extended family or clan (parents, grandparents, children and cousins). The inclusion of this latter group is

END-USER STATEMENT

Elders who attended a training pilot in 2017 have provided end-user feedback. For cultural reasons, they have not been identified.

"Family they saw what I was doing with all them projects, I bin go here and get that training and that training, this bin different from any other training workshop."
– Elder 1, Malnyangarnak

"I bin invite im yous mob [the trainers] to come and I just need to keep talking to families because this is important. They gotta come and see and hear for themselves, im need that knowledge, im fire is everything for us mob. I bin cry for this. Old man tell me go bla to school, but I bin stupid one, I bin caught by im police. Then one day im good spirit tell me to go read and write. Come on family you gotta come, ngayam, we sing im look after our people and our land."
– Elder 2, Malnyangarnak (Translation follows)
"I have invited the trainers to come, I just need to keep talking to the families because this is important. They have to come and see and hear for themselves, they need that knowledge, that fire is everything for us. I have been crying for this. The old men told me to go to school but I was the stupid one, I was caught by the police. Then one day a good spirit told me to go and learn to read and write. Come on family you must come, ngayam, we sing for country and look after our people and our land."

▲ **Above:** RESEARCH IN ACTION.
PHOTO: BEV SITHOLE.

vital. It builds a pyramid of comprehension of the training and fosters a discussion that bridges 'new' knowledge and existing traditional frameworks. It also establishes a broader, deeper understanding in the general community that will support the rangers in times of stress or conflict.

The inclusion of this extended learning group in the training also supports the maintenance of traditional leadership and decision making frameworks (see Figure 1). Proper decision making about land and natural hazards in remote Indigenous communities relies on a complex governance structure that balances matrilineal and patrilineal hereditary ownership and authority with multiple threads of totemic and practical knowledge (of fire, for example). Introducing 'new' knowledge to selected trainees would destabilise community understanding and lead to conflict and sub-standard decisions. Inviting the wider clan group to training ensures that a community can develop its own version of 'shared responsibility' without damaging social aspects of their resilience.

HOW IS THE RESEARCH BEING USED?

The project's findings are being applied to refine both the content and style of the delivery of training for Indigenous people in communities in Central and Western Arnhem Land. This training is tailored to the respective communities and would need to be adjusted to suit other regions, after preliminary discussions with local people.

FUTURE DIRECTIONS

At the time of publication the project has just completed a second training pilot and detailed feedback is being sought from participants. When finalised, this important refinement of the program will be incorporated into a compendium resource for use by remote north Australian communities.

FURTHER READING

Gould J, Sithole B, Campbell A, James G and Sutton S, (2014) Building community resilience to natural hazards in Northern Australia, Research proceedings at the Bushfire and Natural Hazards CRC & AFAC Conference, Wellington, New Zealand

Sithole B, (2012) *The ARPNet Dilly Bag: A Practical Field Guide to Participatory and Other Research Tools for Use by Aboriginal Research Practitioners in Australia*. ARPNet at RIEL, Charles Darwin University

Sithole B, Hunter-xenie H, Yibarbuk D, Daniels C, Daniels G, Campion O, Narmarnyilk S, Narorroga E, Dann O, Dirdi K, Nayilibibj G, Phillips E, Daniels K, Daniels G, Turner H, Daniels CA, Daniels T, Thomas P, Thomas D, Rami T and Brown C, (2017). Living with Widdijith – protocols for building community resilience. pp. 268-88 in *Disaster Resilience: An Integrated Approach* (2nd Ed.), Paton D and Johnston D eds. Springfield Illinois: Charles C Thomas

The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

Infrastructure and Impact

HAZARD **NOTE**

bushfire&natural HAZARDSCRC

ISSUE 74 JUNE 2020

TOPICS IN THIS EDITION | EXPOSURE | FRAMEWORK | RESILIENCE | INFRASTRUCTURE

THE AUSTRALIAN EXPOSURE INFORMATION PLATFORM: UNCOVERING NATIONAL EXPOSURE

ABOUT THIS PROJECT

This project builds on research from the Natural Hazard Exposure Information Modelling Framework, conducted by the Bushfire and Natural Hazards CRC as part of the *Natural hazard exposure information modelling framework* project.

AUTHORS

Mark Dunford, Con Charalambou, Richelle Spry and Russell Hay, Geoscience Australia. Contact mark.dunford@ga.gov.au

SUMMARY

Understanding what is exposed during hazard events is a highly valuable starting point for a variety of sectors. Within a web-based platform that was designed with, and specifically for, emergency management, this project aligns Geoscience Australia's National Exposure Information System (NEXIS) and spatial data capabilities with a range of key elements from the Natural Hazard Exposure Information Modelling Framework. The new Australian Exposure Information Platform (AEIP) quickly and easily allows users to generate exposure reports needed for decision making before, during and after hazard events anywhere in Australia. The customised reports provide a detailed statistical summary of the number of people, dwellings, other buildings and structures, businesses, agricultural and environmental assets, within a user-defined area. Since the beta version was launched in 2018, the AEIP has been used regularly by more than 240 users, from agencies such as emergency management and local government, to produce thousands of reports each month.

▲ Above: THE AUSTRALIAN EXPOSURE INFORMATION PLATFORM HELPS GOVERNMENT, INDUSTRY AND RESEARCH AGENCIES UNDERSTAND WHAT IS EXPOSED IN AN AREA, TO INFORM BETTER DECISIONS BEFORE, DURING AND AFTER EMERGENCIES.

CONTEXT

The Australian Exposure Information Platform (AEIP) can be used to help estimate the potential impacts of natural or human-induced hazards or critical infrastructural failures on Australian communities. An understanding of what is exposed at any location can be used for mitigation and operational decision making for any hazard within a defined area. Decision makers now have easy 24/7 access to nationally consistent exposure information anywhere in Australia.

BACKGROUND

In 2002, Geoscience Australia began the development of the NEXIS project, in response to the Council of Australian Governments reform commitment on Australia's ability to manage natural disasters and other emergencies.

NEXIS provides comprehensive and nationally consistent exposure information to enable users to understand the elements at risk. Exposure information is produced by sourcing the best publicly available information, including statistics, spatial and survey data, such as demographics, building, business, agriculture, institutions, infrastructure and environmental elements. Public access to NEXIS has been limited to products based on Local Government Areas or Australian Bureau of Statistics (ABS) Statistical Areas.

Since 2012, Geoscience Australia has been providing support and advice to the insurance sector, as well as local, state and government agencies, industries and universities. In 2013, the Bushfire and Natural Hazard CRC and Geoscience Australia led a three-year research project in collaboration with the University of Melbourne and the University of Canberra to create a comprehensive Natural Hazard Exposure Information Framework. The objective was to fully describe and categorise exposure information elements into a consistent framework, specifically to meet the needs of the emergency management sector.

With further support from the CRC in 2018, the project began development of a nationally consistent exposure information platform – one that provided easy access to a robust, reliable and operational system. The platform and underlying system could be used to understand what is exposed for disaster preparedness, planning, response and recovery, at all levels of government, industry and research.

BUSHFIRE AND NATURAL HAZARDS CRC RESEARCH

After consulting with stakeholders, the main need identified was the ability to quickly gain a holistic understanding of what is potentially exposed within a hazard event area or any area of interest. In response, Geoscience Australia designed the exposure report, comprising a collation of selected key exposure information elements, presented in a clear and consistent layout enabling timely emergency response and recovery decision making.

Prior to this project, the ability to generate exposure reports, although largely automated, still relied on manual intervention and was only accessible via Emergency Management Australia's Crisis Coordination Centre. The AEIP allows anyone to generate a report for any area of Australia at any time, combining the extensive work from the NEXIS and exposure reports with the comprehensive Natural Hazard Exposure Information Framework. For the first time, users have direct access to nationally consistent exposure information through a user driven, on-demand interface.

Web mapping application and API

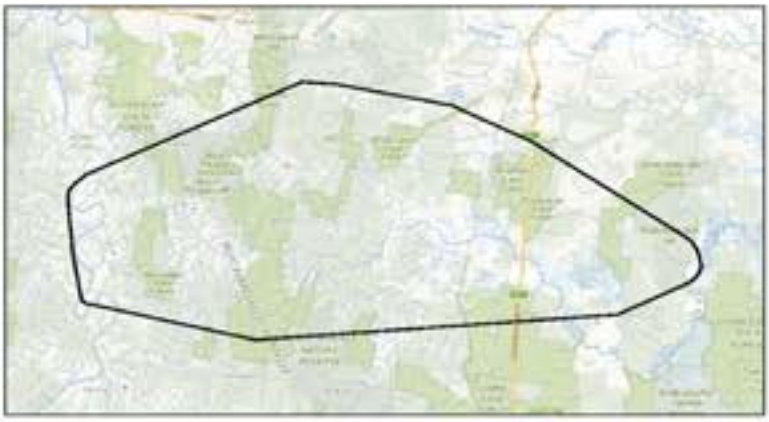
The web platform includes an interactive map for area selection and report request, and an Application Programming Interface (API) to allow requests to be sent from other web-mapping applications. The mapping application enables users to upload or draw an area of interest, select the type of exposure data themes they would like, and provide contextual information (such as report title). They are then delivered the resulting report via email within five to ten minutes depending on the size and complexity of the areas of interest. The API is a key feature of the platform. It allows external users to integrate the platform into their own existing or new applications. Users can request reports without having to leave their system (such as those being used by New South Wales Rural Fire Service).

Geoscience Australia - Exposure Report

Event name: 350684
Event type: Bushfire
Report Date: 29-11-2019 11:44:13 (AEST)

Australian Government
Geoscience Australia

LGAs within the event footprint: Richmond Valley (A), Clarence Valley (A), Kyogle (A)
Localities within the event footprint:
Footprint data source: Sapphire database



Building Exposure, V10 January 2019	
Residential	**Event**
Population count	305
Dwelling count*	153
Building count	153
Pre 1980 construction count	4
Pre 1990 probable asbestos containing products**	47
Reconstruction value	$84,590,000
Contents value	$11,800,000
Commercial	
Building count	-
Reconstruction value	$-
Industrial	
Building count	8
Reconstruction value	$60,740,000
2016 SEIFA IRSAD*	
Dwellings in area with a SEIFA decline 10 score (most advantaged)	-
Dwellings in area with a SEIFA decile 9 score	-
Dwellings in area with a SEIFA decile 8 score	-
Dwellings in area with a SEIFA decile 7 score	-
Dwellings in area with a SEIFA decile 6 score	-
Dwellings in area with a SEIFA decile 5 score	-
Dwellings in area with a SEIFA decile 4 score	4
Dwellings in area with a SEIFA decile 3 score	-
Dwellings in area with a SEIFA decile 2 score	6
Dwellings in area with a SEIFA decile 1 score (most disadvantaged)	143
Dwellings in area without a SEIFA score	-

Dwelling estimates where residents:		
Demographic*	**Event**	**NSW(Av)**
Are all aged 65 or over	16.3%	18.7%
Includes persons aged 14 years and under	14.8%	26.4%
Includes an Indigenous person	12.8%	4.5%
Are a single parent family	6.2%	6.5%
Are in need of assistance for self-care activities	22.3%	11.5%
Include persons not proficient in English	0%	1.9%
Do not have access to a motor vehicle	2.7%	11.5%
No one has completed Year 12 or higher	38.3%	16.6%
Moved to the region in the last 1 year	6.4%	12.1%
Moved to the region in the last 5 years	19.6%	31.1%
Top 5 employing industry*:		
Agricultre Forestry Fishing, Manufacturing, Health Care Social Assistance, Consultation, Administrative Supportive Services		
Economic*	**Event**	**NSW(Av)**
Are low income ($1-$499/week)	51.2%	24.9%
Are medium income ($500-$1,499/week)	43.2%	52.2%
Are high income ($1,500+/week)	3.7%	24.5%
Are in public housing	5.2%	7.9%
Are all unemployed	3.3%	1.6%

** Demographic information is based on 2016 Census. Residential demographic and economic information is not provided for dwelling counts less than 20 or when the population count is zero*
*** Buildings may contain asbestos cement materials, especially in the eaves, internal and external wall cladding, ceilings (particularly in wet areas such as bathrooms and laundries), corrugated products (roofing and cladding) and fences*

Institution Exposure			
Education	**Event**	**Government Facilities**	**Event**
School - Pre/Primary	1	Federal Court	-
School - Secondary	-	Medicare Office	-
School - Tertiary	-	Centrelink Office	
School - Other (Combined, Special)	-	Diplomatic Facility	-
Health and Welfare		Consulate Facility	-
Hospital - Public	-	Major Defence Facility	-
Hospital - Private	-	Correctional Facility	-
Nursing Home	-	Immigration Detention Facility	-
Retiremnet Home	-	Local Government Offices	-
Emergency Services			
Police Station	-		
Fire Station	3		
Ambulance Station	-		
SES Facility	-		
Emergency Management Facilities	-		

Infrastructure Exposure			
Utility/Energy	**Event**	**Transport**	**Event**
Power Station - Major Renewable	-	Airport - Major Areas	-

▲ Figure 1: EXAMPLE OF AN EXPOSURE REPORT GENERATED BY NSW RURAL FIRE SERVICE CERBERUS ENSEMBLE FIRE SIMULATOR DURING THE 2019/20 BUSHFIRE SEASON, USING THE AEIP API.

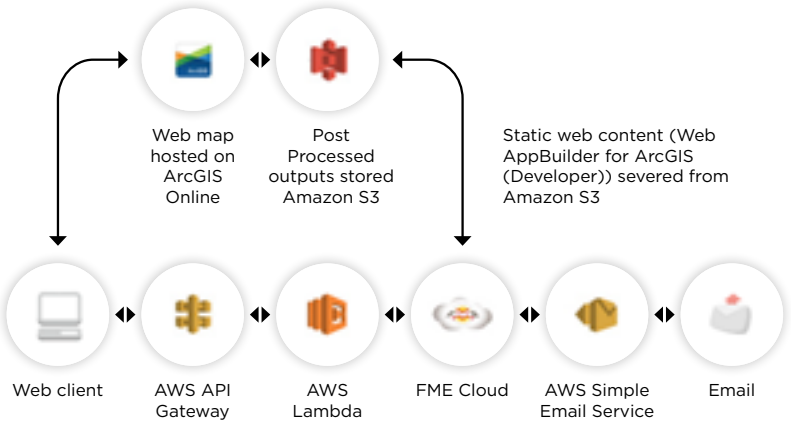
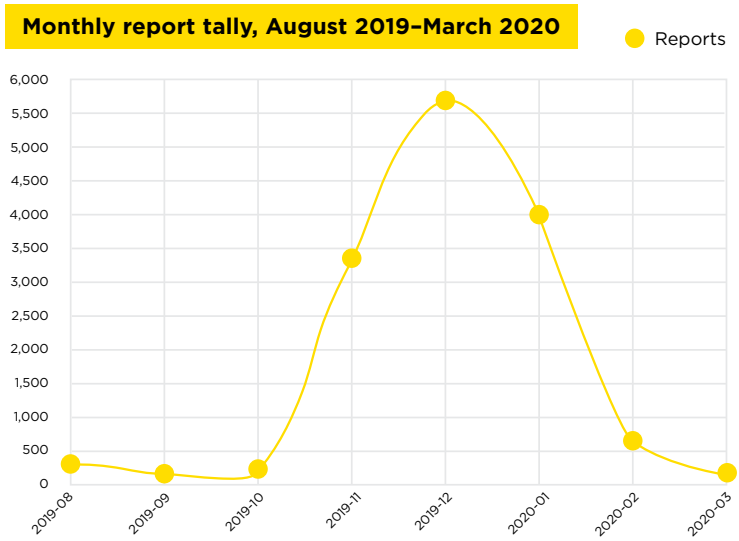


Figure 2: OVERALL WORKFLOW FROM THE AEIP RECEIVING A REQUEST TO USER NOTIFICATION OF COMPLETED REPORT.



Large requests by separate server

700,000 reports

generated for Western Power

15,000 reports

generated for Queensland Fire and Emergency Services.

Figure 3: NUMBER OF EXPOSURE REPORTS PRODUCED VIA AEIP BY MONTH, FROM AUGUST 2019–MARCH 2020, REFLECTING SEASONAL VALUE

END-USER STATEMENT

"The Australian Exposure Information Platform (AEIP) Application Programming Interface (API) was integrated into the NSW RFS Cerberus Ensemble Fire Simulator workflow during the 2019/20 bushfire season. Cerberus is able to simulate where a fire is likely to move in the next 24 hours and the simulation polygon extent generated can now be automatically consumed by the AEIP API to generate an exposure report. This capability allows NSW RFS to quickly assess what is in the path if the fire is not controlled and therefore helps to plan and prioritise emergency responses. The ability to integrate AEIP into Cerberus provides an excellent triage capability to support decision makers in times of rapidly changing events as experienced in the unprecedented bushfire season of 2019/20."

– Stuart Matthews, Principal Project Officer, Operational Services/Planning and Predictive Services, NSW Rural Fire Service

"During *Cyclone Veronica* (March 2019), we were able to use AEIP to understand exposures in the towns in the Pilbara that were under threat. This enabled us to determine vulnerabilities in structures and populations. It enabled recovery coordination to have an appreciation of the reconstruction values if *Cyclone Veronica* had impacted any of these coastal communities. It has also been very useful with conducting risks assessment for multiple hazards and assisting with long-term capability analysis. Our Community Preparedness Branch now uses AEIP for identifying vulnerable communities and to consider broader demographics towards tailoring the type of community engagement they apply."

– Steve Gray, A/Manager, Hazard Intelligence and Risk Reduction, Department of Fire and Emergency Services, WA

When a request is sent to the API, Amazon Web Services (AWS) and Feature Manipulation Engine (FME) services are utilised to process, extract and aggregate information, and provide a download location for the final tabular data and html report. When the results are ready for download, the AWS email service notifies the end-user that the job is completed and where the results can be found.

RESEARCH FINDINGS

Before the AEIP, during an emergency, users had to wait for Geoscience Australia to manually create exposure reports during an emergency. Geoscience Australia guaranteed a two-hour turnaround per report request during business hours. With the AEIP, users can now quickly and easily make their own customised exposure reports by using the web mapping application or the API. With exposure information now easily accessible and available at any time, it is possible for decision makers to readily utilise exposure information as a key piece of intel for critical pre-planning, or on-the-fly scenario event assessments, anywhere across Australia.

Figure 4: END-USER AREAS OF INTEREST (MORE THAN 14,000) FOR DECEMBER 2019 TO MARCH 2020. THIS MAP SHOWS THAT EXPOSURE REPORTS WERE GENERATED FOR BOTH SMALL AND LARGE AREAS, COVERING ALL STATES AND TERRITORIES. DARK-BLUE AREAS SHOW MULTIPLE AEIP QUERIES, CORRELATING WITH EXTREME WEATHER EVENTS E.G. 2019/20 BUSHFIRES.

FURTHER READING

Power L, Charalambou C, Orr K, Dunford M & Hay R (2017) Australia exposed: exposure information for ensuring Australia's community safety, FIG Working Week conference presentation (8883), FIG, 29 May – 2 June 2017.

Nadimpalli K, Mohanty I & Kalantari M (2014) Natural hazards exposure information modelling framework, Geoscience Australia, Canberra.

Nadimpalli K, Mohanty I, Vidyattama Y, Kalantari M & Rajabifard, A (2017) Australian natural hazards exposure information framework: guidelines for national consistency and comprehensive information, Bushfire and Natural Hazards CRC, Melbourne.

HOW IS THE RESEARCH BEING USED?

A beta version of the AEIP was released in August 2018 at the AFAC18 powered by INTERSCHUTZ conference in Perth, for use during the 2018/2019 fire season (October–March). During that season, more than 1,500 exposure reports were produced by more than 200 users, which may have taken up to four months to produce before AEIP (two hours per report), if these were submitted as individual requests. Based on user feedback, improvements were made to the AEIP before the platform went live at AFAC19 in August 2019.

During the north Queensland flooding in December 2018, more than 400 exposure reports were created in one week by government agencies – helping them make faster and smarter decisions to reduce loss of life and economic impact.

With an unprecedented early and dramatic start to the 2019/20 bushfire season, the number of exposure reports produced from the AEIP was in excess of 14,000 by more than 200 individual users (90+ domains; 1 August 2019–31 March 2020). Users such as NSW RFS have integrated the API with their own applications and have been producing thousands of valuable reports each month, particularly during the devastating 2019/20 fire season. Western Power, a WA-based energy provider, has recently utilised the platform to create 700,000 reports.

What these usage patterns show is that during a crisis, when demand for information to inform decisions is extremely high, the AEIP is invaluable. By speeding up the delivery of vital exposure information in an automated format, its nationally consistent and easily accessible approach to data ensures that information and decision making across jurisdictional borders can be done in a way that is comparable and quantifiable.

FUTURE DIRECTIONS

The tool is becoming an important part of planning for community preparedness and improving safety. To date, more than 300 users have been surveyed on their experience using the AEIP, and recommendations for future improvements are ongoing. Future suggestions will be considered to ensure AEIP continues to meet users' needs. Potential improvements may include (but are not restricted to):

- ongoing updates and maintenance of data
- the ability to create exposure reports across state and territory borders
- the addition of national comparative demographic statistics
- the ability for drawn areas of interest to receive the spatial data with the report, allowing users to repeat the request and/or distribute to other users
- the ability for users to select existing geographies, such as Local Government Areas, Bushfire Forecast Districts and the ABS Statistical Geographical Standard digital boundaries
- the ability to batch a number of areas of interest in a single process.

The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

HAZARD **NOTE**

bushfire&natural HAZARDSCRC

ISSUE 66 OCTOBER 2019

TOPICS IN THIS EDITION | INFRASTRUCTURE | MODELLING | RISK ANALYSIS

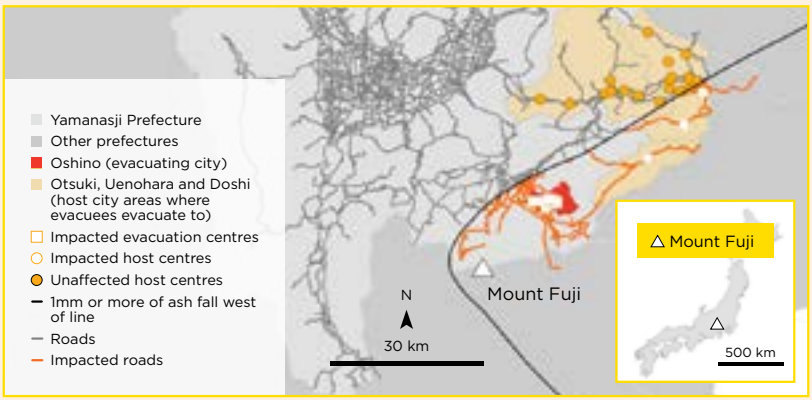
CAN GRAPH THEORY HELP PREPARE FOR LIFELINE FAILURE DURING A DISASTER?

ABOUT THIS PROJECT

This research was a PhD study, *Modelling the impact of lifeline infrastructure failure during natural hazard events*, which was part of the Bushfire and Natural Hazards CRC project *Using realistic disaster scenario analysis to understand natural hazard impacts and emergency management requirements*.

AUTHORS

Dr Emma Singh, Macquarie University. Dr Singh completed her CRC PhD in 2019. Contact emma.a.singh@gmail.com
Emma is now a Catastrophe and Climate Risk Consultant at Willis Towers Watson in London.



Above: THE POTENTIAL IMPACT OF 1MM OR MORE OF ASH FALL FROM A FUTURE 1707 TYPE ERUPTION AT MOUNT FUJI ON HOST CITIES (OTSUKI, UENOHARA AND DOSHI), THE EVACUATED LOCATION (OSHINO), AND ROAD ACCESS FOR EVACUATED RESIDENTS TO RETURN HOME (OSHINO) AFTER THE ERUPTION. NOTE ROAD INFRASTRUCTURE CAN BE IMPACTED BY LESS THAN 1MM OF ASH FALL ACCUMULATION, SUCH AS OBSTRUCTION OF ROAD MARKINGS AND REDUCED TYRE TRACTION.

SUMMARY

Not only is it important to make lifelines – infrastructure that communities rely on each day such as roads, bridges, power and water – more resilient to disruption from natural hazard shocks, there is also a need to better prepare communities and emergency services to cope with service outages. This research combined natural hazard modelling, GIS analysis and graph theory tools to gain a better understanding of the impacts of lifeline failure during natural hazards and assess the usefulness of graph theory techniques in aiding disaster mitigation, emergency response and community recovery. Mount Fuji in Japan was used as a case study as Australian data was not readily available, however the findings are still applicable to Australian emergency managers. Overall, with adequate information on lifelines and the populations that rely on their services, graph theory can be a useful tool for investigating lifeline failure in a disaster context by helping to envisage network exposure, the flow on effects of lifeline failure and network recovery.

CONTEXT

The continual and growing presence of populations and infrastructure within natural hazard prone areas, combined with climate change, has the potential to intensify the exposure and vulnerability of lifelines to natural hazard shocks. Consequently, future lifeline failure, of varying degrees of seriousness, may simply have to be expected. It is therefore necessary to understand how lifelines and their functionality may be impacted when subjected to disruption from disasters, and furthermore, the social and economic costs of lifeline failure for at-risk populations.

BACKGROUND

The cascading nature of lifeline failure represents an emergent risk, in that natural hazards can now have complex and far-reaching impacts due to our reliance on interdependent and interconnected systems. Although not entirely unforeseen, lifeline failure during disasters has yet to be fully incorporated into disaster plans. There is currently inadequate community education and engagement about what lifelines are, their failure in a disaster, limitations at the local government level to strengthen lifeline infrastructure and mitigate service failure, limited access to sensitive lifeline information, and a lack of holistic disaster scenarios including input from critical infrastructure sectors. Graph theory (see breakout box, page 2) could be used as a disaster planning tool to model and envisage future lifeline failure scenarios.

BUSHFIRE AND NATURAL HAZARDS CRC RESEARCH

Most methods for assessing the vulnerability of critical infrastructure systems have involved mathematical modelling approaches, such as graph theory. Although this area of research is not new, the majority of literature focused on network topologies, interconnections and robustness to random failure and targeted attacks. Limited work has been undertaken on the impact of natural hazards on lifeline systems and the flow on effects from failure on disaster response and recovery. This research sought to go beyond network exposure and vulnerability by modelling lifeline disruption in a real-world disaster context.

This research was unable to include an

Australian case study, as information on critical infrastructure networks and their vulnerabilities to natural hazards was not readily available. Instead data was sought from Japan. This project was able to collaborate with prefecture governments, research centres and lifeline companies in Japan to develop end-user driven research. Field visits uncovered that the potential disruption of road transportation from volcanic ash fall was currently under investigated.

To address this gap, this study combined ash dispersal modelling and GIS tools with graph theory techniques to assess the exposure of major roads to volcanic ash from a future eruption at Mount Fuji, Japan, and to understand what impact road closures could have on emergency response and recovery, with a focus on Yamanashi Prefecture.

RESEARCH FINDINGS

An in-depth description of all findings, including modelling results, from this research can be found in Singh (2019). In short, this study found that, in this particular scenario:

- Ash fall accumulation, only after a couple of hours from the onset of an eruption, may inhibit the ability of residents to evacuate safely or unassisted.
- Ash induced road closures cut off access to some evacuation centres and resulted in long detours for others, affecting current evacuation plans for Yamanashi Prefecture.
- Ash fall deposits can also impact the return of evacuees to their homes, once the eruption has ended, by either blocking roads or damaging buildings (see Figure 1, page 1).
- Approximately 700 km of roads in Yamanashi Prefecture would need to be cleared of ash and likely require repeated cleaning due to ash remobilisation.
- Apart from motorways, roads that connected different cities within Yamanashi Prefecture were found to be the most important for evacuation and resident return. These roads could be prioritised for clean-up.

HOW COULD IT BE USED?

Graph theory techniques are useful for identifying critical components important to the functioning of networks. With additional supporting information to appropriately weight network connections there is great potential for graph theory techniques to add value in the disaster management space when combined with other tools – such as natural hazard modelling and GIS – and integrated into holistic scenarios that incorporate inputs from all stakeholders.

The results of this study will be disseminated to the Japanese collaborators to better inform the prefecture government of the feasibility of their evacuation plans and to provide them with methods for further risk assessment.

Although this research had an overseas focus, the methods developed in this scenario can also be applied in an Australian context. Moreover, modelling lifeline disruption and the flow on affects of service outage can be of use throughout the entire disaster management process, from mitigation to response and recovery. Knowing what areas could be cut off from lifelines such as power or water would enable populations to prepare for service outages. Emergency services would be able to determine transportation access for emergency response and evacuation and, in the aftermath of a disaster, determine which routes to open first for optimal recovery.

FUTURE DIRECTIONS

This research could be applied in an all hazard context where lifeline exposure and potential failure could be examined and compared between hazard types. There is also scope to take this research further by including lifeline interdependences and modelling the potential propagations of service failure between lifeline networks. Another direction would be to include economic data to allow for a monetary value to be placed on lifeline disruption. In any case, any future research in this area will require the input and expertise of the lifeline sector. To become truly resilient to disruption from natural hazards, interagency collaboration is vital.

WHAT IS GRAPH THEORY?

Graph theory is the study of networks through graphical representations. Graphs are mathematical structures made up of nodes and edges, which are used to represent network components and the connections between them. Various algorithms can be used to investigate network structure, evolution and robustness.

END-USER STATEMENT

"The effects of climate change mean that Emma's work has important implications for the critical infrastructure sector. Australian organisations in the critical infrastructure sector regularly prepare for the potential impacts of natural hazards. Preparedness activities, such as exercising, allow organisations to simulate how they can maintain a continuation of supply to the community during and after a disaster. The ability for decision makers to enhance their visualisation of the possible network disruptions using graph theory will certainly add value to any type of future scenario modelling."

– Dr Steven Curnin, Member of the Resilience Expert Advisory Group for Critical Infrastructure Resilience

FURTHER READING

Singh, E. A. (2019) *Modelling the impact of lifeline infrastructure failure during natural hazard events*. Doctoral dissertation, Macquarie University, Faculty of Science and Engineering, Department of Environmental Sciences http://hdl.handle.net/1959.14/1268491.

The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

HAZARD **NOTE**

bushfire&natural HAZARDSCRC

ISSUE 52 OCTOBER 2018

TOPICS IN THIS EDITION | FORECASTING | FLOOD | MODELLING

NEW FLOOD MODEL TAKES RAPID, REGIONAL APPROACH

ABOUT THIS PROJECT

The *Using realistic disaster scenario analysis to understand natural hazard impacts and emergency management requirements* project is part of the Scenarios and Loss Analysis cluster. By analysing past emergencies to fully understand their impacts, this project has helped emergency managers plan for natural hazards that might have a similar impact in the future. It is now in its utilisation phase.

AUTHOR

Dr Thomas Mortlock, Risk Frontiers.
Contact thomas.mortlock@riskfrontiers.com

SUMMARY

A rapid, regional-scale modelling approach to estimating flood hazard and exposure in Australia has been developed. Its application will help overcome a national void in vital information about flood risk. At present, this information is largely confined to areas where detailed flood modelling has already been undertaken and is constrained by the computational limitations of hydraulic-based models when operating over large spatial scales. This fine-resolution modelling depends on good quality baseline data, which is lacking in many rural areas. The model is based on a practical, reduced-physics approach, with nationally available datasets that estimate flood risk over large areas. This approach relies on less detailed but more critically important physical calculations, and suits less complex floods. The model is also innovative in the way it couples existing modelling components and tailors them to the needs of emergency managers. The model could be applied to emergency planning and resource allocation on a national scale.

Above: THIS RESEARCH HAS DEVELOPED A NEW MODEL FOR ESTIMATING FLOOD RISK, AND TESTED IT BY RUNNING A CASE STUDY ON A 1986 FLOOD IN THE HAWKSEBURY-NEPEAN VALLEY. PHOTO: NSW STATE EMERGENCY SERVICE.

CONTEXT

This project used a reduced-physics approach to investigate how exposure to river flooding in Australia can be estimated rapidly and over large spatial scales. Its findings support emergency response and planning requirements.

BACKGROUND

The impact of severe rainfall is often measured in terms of flood risk at the peak of the storm. Less attention is given to how flooding evolves during a storm. Asymmetric or staggered flooding across a wide region can pose a significant challenge to emergency services, and local-scale (albeit high resolution) flood modelling provides a limited platform for preparedness in this regard.

To address this, this project has developed a regional-scale modelling method that can predict the time-varying exposure to flooding over large areas, while still accounting for local variations in catchment and river channel properties. It used the Hawkesbury-Nepean catchment in western Sydney as a case study to test the model. This area is well studied in terms of flood risk; it is data-rich, flood-prone and constitutes one of the largest coastal catchments in New South Wales, taking in roughly 20,000 square kilometres, with approximately 70,000 people living in flood-prone areas (NSW Office of Water, 2014). This made it an ideal test ground to develop the model.

▲ Figure 1: FLOW CHART ILLUSTRATING MODELLING APPROACH.

▲ Figure 2: AN EXAMPLE OF THE SEMI-DISTRIBUTED RAINFALL-RUNOFF APPROACH SHOWING SUB-CATCHMENTS, OUTLET POINTS (BLACK DOTS), RIVER CHANNEL AND FLOW DIRECTION. IN THIS MODEL, HYDROGRAPHS (SHOWING THE DISCHARGE OVER TIME) AT EACH OUTLET ARE AGGREGATED IN THE FLOW DIRECTION.

BUSHFIRE AND NATURAL HAZARDS CRC RESEARCH

Most metropolitan areas in Australia already have detailed flood studies and management plans in place, and it was important that this project did not replicate these. After consultation with the NSW State Emergency Service, it became clear that a regional-scale, rapid assessment of flood risk was needed in NSW.

A modelling approach was developed to address this. Accordingly, a coupled rainfall-runoff model/river system model/LiDAR-based (Light Detection And Ranging) flood model framework was developed (Figure 1, above).

A rainfall-runoff model combines rainfall data and simple descriptors of catchment physical properties (slope, soil type, land use, area and shape) to estimate the river discharge response to rain falling on the catchment. Here, a semi-distributed, curve-number based rainfall-runoff model was used, which divides the catchment into a series of sub-catchments, thus accounting for spatially varying rainfall which are particularly important for large catchments (see Figure 2, above right).

The rainfall-runoff model also incorporates a simple, river system model, which simulates accumulated flows between adjacent sub-catchments and base flow. River discharge is then converted to equivalent river heights according to a synthetic rating curve method, at each sub-catchment outlet point. The LiDAR-based flood model then interpolates a sloped flood plane between each outlet point. This is intersected with the underlying topography, and hydraulically constrained to the river channel, to produce an estimate of the flood hazard extent (Figure 3, page 3).

The result is a flood surface that can be superimposed on an aerial image and intersected with geolocated asset data for mapping and risk assessment at each timestep through the storm.

The model was applied to the Hawkesbury-Nepean catchment in western Sydney. After consulting NSW SES, the researchers decided to construct a flood scenario around the August 1986 East Coast Low, which caused widespread flooding in the Nepean Valley.

The rainfall intensity of the 1986 storm was up-scaled to an annual exceedance probability of approximately one per cent (that is, a one per cent chance of a flood occurring in any year) while the spatial pattern and progression of the rain front across the catchment was retained. Flood hazard and exposure information was output at six-hourly intervals through the storm.

Information can be presented in two forms for the end-user. First, as a set of zonal flood maps with accompanying infographics that visualise the estimated extents of flooding (Figure 4A, page 3) and the number and type of properties at risk from flooding, at each timestep through the storm (Figure 4B, page 3).

The static data in figure 4 can also be presented in animation form, where the user selects different areas and animates the evolution of the flood height at these locations. Figure 5 (page 4) shows a still of such an animation for four locations in the Nepean Valley at midnight on 7 August 1986.

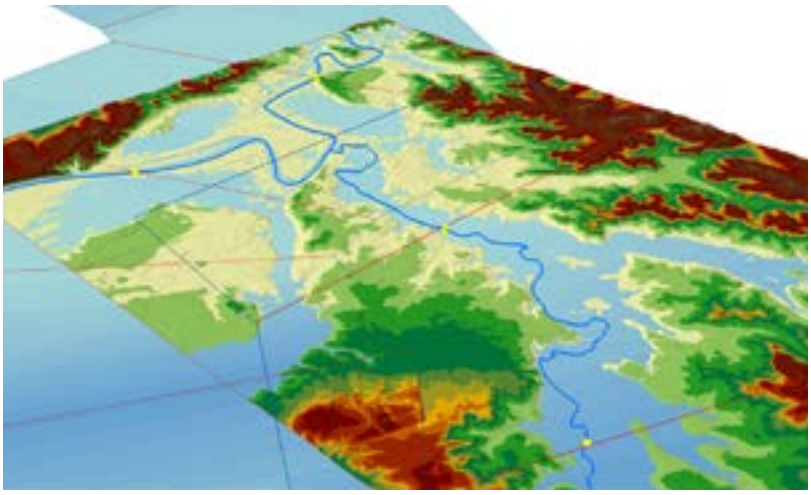
RESEARCH FINDINGS

Scenario evaluation

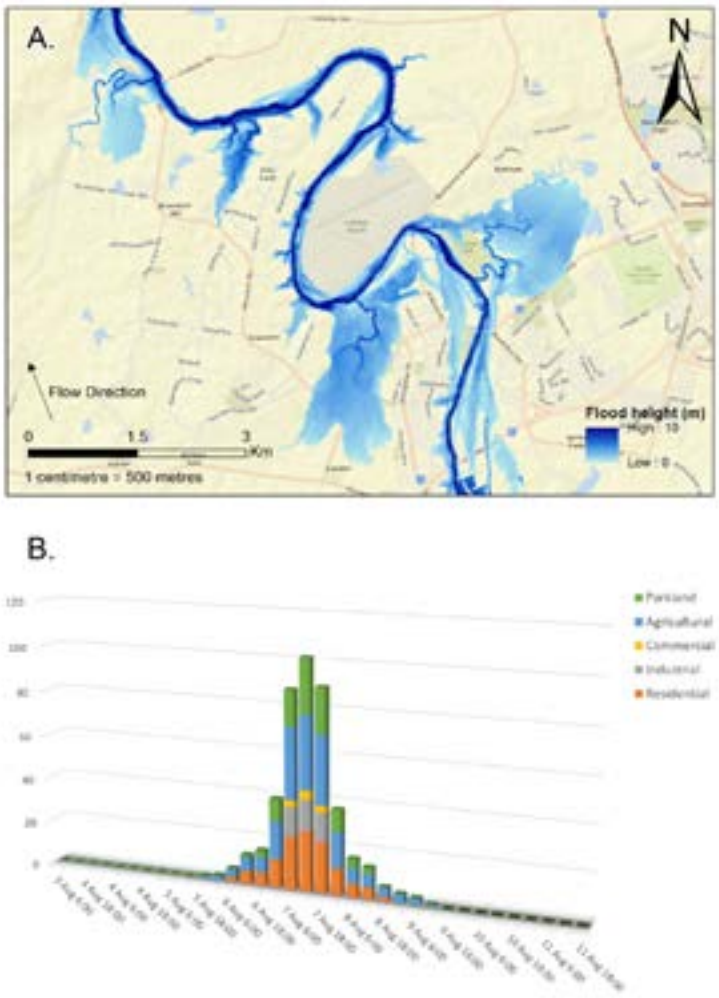
This modelling approach allows plausible flood scenarios to be generated over a large scale, and the risk to be explored through the life cycle of the flood. The scenario assumed drawdown from the Warragamba Dam consistent with historical events, and average baseflow conditions prior to the storm. Only riverine flooding was considered.

Three key findings from this scenario highlight the importance of a time-dependent and regional-scale approach to flood risk management:

1. Flooding can occur in different places at different times throughout a storm, because of the different causes of local flooding (for example, direct surface runoff or floodwater routed from rainfall upstream);
2. There can be a significant lag time between the end of rainfall and end of flooding. Likewise, there can be a significant lead time between the start of rainfall and elevated river levels. Both have risk management implications and – in this case – both resulted from the effect of stormwater routing from upstream sub-catchments that were separated a large distance away from the downstream valley;
3. This can lead to staggered flooding. In the scenario developed, by the time the Hawkesbury-Nepean catchment began to flood, over 700 addresses were already flooded from South Creek and associated tributaries.



▲ Figure 3: A LIDAR-DERIVED DIGITAL TOPOGRAPHY IS INTERSECTED WITH A SLOPE FLOOD PLANE, INTERPOLATED BETWEEN LINES (RED) PERPENDICULAR TO DISCHARGE OUTPUT POINTS (YELLOW DOTS), TO DERIVE FLOOD EXTENTS THAT HAVE A HYDRAULIC CONNECTION TO THE MAIN RIVER CHANNEL.



▲ Figure 4: (A) EXAMPLE FLOOD MAP FOR A SECTION OF THE NEPEAN RIVER AT THE PEAK OF THE FLOOD SCENARIO, AND (B) A TIME SERIES OF THE NUMBER OF ASSETS AT RISK OF FLOODING THROUGH THE EVENT, SHOWN PER ASSET TYPE.

END-USER STATEMENT

In areas impacted by East Coast Lows where there is limited or no flood information, NSW SES will be able to utilise outputs from this flood modelling technique to inform prevention, planning and response. The broad view of an entire catchment that this technique provides better enables the timing and varied consequences throughout a catchment to be considered.

NSW SES would support testing on another catchment against a historic storm or flood, as well as further verification and calibration of this technique.

– Ailsa Schofield, Acting Manager, Emergency Risk Management NSW State Emergency Service

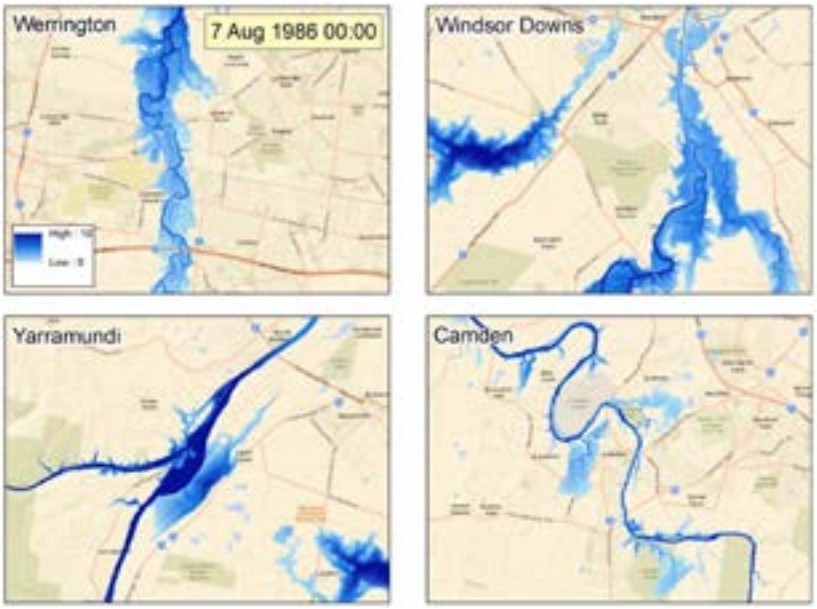
Method evaluation

This model system can indeed be a valuable, regional-scale tool for flood risk assessment, but it requires significant preparation time for any one catchment prior to implementation. Once configured for individual catchments, the flood response and exposure estimates can be obtained across a wide region (tens of thousands of square kilometres) within minutes – making large-scale flood modelling achievable, even with modest computational resources.

However, the model's reduced-physics approach does not account for dynamic aspects of flooding, such as non-linear flows, backwater effects or bank erosion. This makes it unsuitable for localities where such processes may dominate. Away from complex topographies, however, models similar to the one developed by this research have been shown to produce comparable results to 2D hydraulic-based models (Teng *et al.*, 2015).

Only limited validation was possible within the time constraints of the project. Comparisons with gauged flood heights indicated the model replicated observed discharge and flood levels reasonably well (within 10 to 15 per cent in the Nepean Valley during the 1986 flood). However, further validation and calibration is undoubtedly required.

The research team found that the most sensitive component of the modelling process was the conversion of river discharge to overbank flood heights. This is dependent on the river-channel cross-sectional area



▲ Figure 5: A STILL OF AN ANIMATION OF THE FLOOD EVOLVING AT FOUR SEPARATE LOCATIONS IN THE NEPEAN VALLEY THROUGH THE STORM, SHOWING MODELLED CONDITIONS AT MIDNIGHT ON 7 AUGUST 1986.

because it controls the in-channel capacity to store floodwaters. However, in most cases, channel depth is unknown. As a result, the cross-sectional area can only be estimated empirically or by extrapolation from the nearest surveyed section, and remains a major calibration parameter.

HOW IS THE RESEARCH BEING USED?

This modelling approach makes a simplified and large-scale assessment of flood risk based on rainfall, physical catchment properties and exposure information. While it is not the first time such model components have been applied to flood risk assessment, the way in which the model couples each component and presents information for the user maximises benefit for emergency management requirements. Because all the required datasets are nationally available, and minimal computational effort is needed, the method can be applied to any catchment, or set of catchments, in Australia.

The model is currently being used to look at the role of cross-catchment flood correlations in determining regional to national-scale flood risk. As one catchment floods, there is a conditional probability that another catchment will also flood to a similar, or different, magnitude. An improved understanding of these inter-dependencies between neighbouring, or even geographically disparate catchments, could significantly help statewide emergency services in dealing with flood risk and resource allocation.

FUTURE DIRECTIONS

The research team is discussing with NSW SES how this research could support their planning and resource allocation for riverine flooding over large areas. There is scope for further research comparing these results to the detailed flood studies already conducted across the Hawkesbury-Nepean valleys.

From a research perspective, the impact of clustered storms, rather than large magnitude flooding in isolation, is generating greater interest. The occurrence of a series of lower-intensity storms separated by only short intervals can lead to a greater cumulative hazard than expected, and may result in lower preparedness. The impact of clustering on flood risk – and how storm clustering may change with a changing climate – is an area that requires more research attention.

This model also has potential applications for the insurance industry, government agencies and other organisations involved in flood risk and land use planning. For example, the development of an interactive tool as the model is rolled out nationally could provide more accurate, timely assessments of flood impacts.

Finally, this method may also be of use for assisting first-pass mapping of rural floodplains where little baseline information is currently available.

FURTHER READING

Mortlock TR (2017) *Event-based modelling of flood hazards and impacts during extreme east coast low storms utilising a rapid, regional-scale approach*, Bushfire and Natural Hazard CRC.

NSW Office of Water (2014) *Hawkesbury-Nepean Valley Flood Management Review — Stage One: Review Report*. Sydney NSW: NSW Department of Primary Industries, Office of Water.

Teng J, Vaze J, Dutta D and Marvanek S (2015) Rapid flood modelling in large floodplains using LiDAR DEM, *Water Resources Management*, 29, 2619-2636.

The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

HAZARD **NOTE**

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ISSUE 40 OCTOBER 2017

TOPICS IN THIS EDITION | ECONOMICS | ENGINEERING | FLOOD | MITIGATION

COSTS AND BENEFITS OF FLOOD MITIGATION IN LAUNCESTON

Above: FLOODWATERS IN ROYAL PARK, LAUNCESTON, DURING THE JUNE 2016 FLOOD. PHOTO: UPSTICKSNGO_CREW CC BY 2.0.

ABOUT THIS PROJECT

This flood risk mitigation assessment for Launceston was conducted as part of the *Cost-effective mitigation strategy for flood-prone buildings* project. It was carried out in collaboration with the City of Launceston, the Launceston Flood Authority, the Tasmanian Department of Premier and Cabinet, Northern Midlands Council, Tasmania State Emergency Service and Geoscience Australia.

Download the full report at www.bnhcrc.com.au/hazardnotes/40

AUTHORS

Dr Tariq Maqsood, Martin Wehner, Dr Itismita Mohanty, Neil Corby and Mark Edwards, Geoscience Australia.

SUMMARY

With Launceston experiencing severe flooding in June 2016, this project reviewed the costs and benefits of mitigation work (upgraded levees) which began in 2010. Flood mitigation is an expensive exercise, and this research highlights the benefits through avoided impacts of the flood levee mitigation program, against the cost of construction.

Findings show that the upgrading of the levee system, completed in 2014, resulted in avoiding losses of about $216 million (had the pre-existing levees failed), which is approximately four times the total investment in the new levee system. This investment in building the new levee system was found to be a sound economic decision based on the estimated costs at the time of decision making, alongside improved estimates of benefits from this study. The actual benefits of these mitigation works to the community extend beyond the direct benefits as assessed in this project, to the intangible and indirect benefits that have not been included.

It was found that sea level rise scenarios would only have a limited impact on building losses. However, the combined impact of sea level rise and increased rainfall intensity due to climate change on the total losses may be significantly greater and could be further investigated.

CONTEXT

The nature of recent flood mitigation works and the specific nature of the June 2016 flood provide a sound opportunity to assess the cost benefits of the Launceston levee system. This assists in developing an evidence base for future investment in mitigation.

BACKGROUND

Located within the Tamar River floodplain at the confluence of the Tamar, North Esk and South Esk Rivers in Tasmania, Launceston is a flood-prone city. There have been 35 significant floods, with the 1929 flood considered the worst. In the 1960s, a ten kilometre flood levee system was constructed to mitigate the risk. The levee system was upgraded from 2010 to 2014, expanding to 12 kilometres of earth levee, 700 metres of concrete levee and 16 floodgates. Following significant flooding in June 2016, this project conducted a cost benefit analysis of this new levee system.

BUSHFIRE AND NATURAL HAZARDS CRC RESEARCH

This study assessed many factors related to the flood risk in Launceston:

- What was the avoided damage costs as a result of the 2010 to 2014 levee upgrade?

- How many people would be displaced because their home was flooded, ranging from a 20 year annual recurrence interval, up to the probable maximum flood height?
- What was the avoided building damage in the June 2016 floods as a result of the 2010 to 2014 levee upgrade?
- What would have been the long term cost to Launceston from floods prior to the mitigation works?
- What are the long term costs to Launceston from floods following the mitigation works?
- Undertake a cost benefit analysis of the investment in the 2010 to 2014 levee upgrade.

TABLE 1: ADOPTED CONDITIONAL PROBABLITY OF FAILURE FOR EXISTING AND NEW FLOOD LEVEES

AVERAGE RETURN INTERVAL (Years)	CONDITIONAL PROBABILITY OF FAILURE OF PRE-2010 LEVEES	CONDITIONAL PROBABILITY OF FAILURE/OVERTOPPED OF CURRENT LEVEES
100,000	100%	100%
1,000	100%	100%
500	100%	10%
200	75%	0%
100	40%	0%
50	5%	0%
20	0.05%	0%

RESEARCH FINDINGS

Avoided damage costs

The results indicate that during the 2016 flood (a 50 year annual return interval event for the North Esk River), the reconstruction of the levee system resulted in avoiding losses of about $216 million (had the pre-existing levees failed). The losses that would have been experienced should the old levee have failed would be approximately four times the investment in the new levee system.

Estimated affected population

Estimates of the number of people displaced by flooding are based on the assumption that the new levee system would provide protection up to flood heights expected to occur on average every 200 years (see Table 2, page 3).

Residential building damage

Residential building damage was estimated using 15 vulnerability models for residential buildings developed by Geoscience Australia. Each residential building (1,980 in total) was assigned an appropriate vulnerability model based on the building attributes, such as the type of foundation, wall material, age, number of stories, and presence of a garage. Losses to ancillary structures such as fences, swimming pools, garden sheds and detached garages were not considered.

The damage index (ratio of repair cost to replacement cost), was assessed for each residential building for different flood levels, ranging from the 20 year average return interval, up to the maximum probable flood height based on the inundation depth above ground floor level.

The total repair cost for each flood level was calculated as the summation of the product of the damage index, the updated unit replacement rate, the number of stories and the ground floor area of each affected residential building.

It is estimated that the investment in the new levee system reduced the total losses related to residential buildings by $1.28 million per year.

END-USER STATEMENT

By engaging and partnering with the Bushfire and Natural Hazards CRC, the City of Launceston reaffirmed its wise decision to invest in upgrading the flood levees in 2010, further backed by a robust ongoing maintenance program for the levees. The coordinated effort with the scientists gives confidence to the safety of the Launceston community from the impact of significant flood events, which also result in reduced levels of economic losses to the city.

By engaging with the Bushfire and Natural Hazards CRC we have managed to refine our data by acquiring better information and knowledge which should benefit future choices in effective flood management within the urban drainage catchments.

– Felix Chigama, Hydraulics Advisor, City of Launceston

Long term cost

The average annual loss from floods in the residential and non-residential sectors was calculated for a number of different scenarios:

- No levee system at all (potential loss in table four, page 3)
- The older, pre-2010, levee system, taking into account the likelihood that the levee would fail (conditional loss – before mitigation in table four, page 3)
- The new levee system, taking into account the likelihood that the levee would fail (conditional loss – after mitigation in table four, page 3)

Findings show that the average annual loss from flooding with the old levee system would be $3.95 million, but that the new levee system reduced this annual loss to $1.04 million per year. This reflects a saving of $2.91 million per year due to the investment in mitigation (see Table 4, page 3).

Cost benefit analysis

This aspect investigated the dollar benefits of the new levee system, compared to the old system. The project life was considered to be 80 years, and five annual discount rates (ranging from three to seven percent) were used to assess the sensitivity of the results to investment capital cost. Typically in Australia a seven percent discount rate has been used within government for investment decisions, as it represents the longer term opportunity cost of capital. However, for climate change studies, discount rates as a low as 3.5% have been used (e.g. in the UK) to assess long-term benefits of adaptation, as the future climate-related impacts and benefits tend to disappear in economic assessments when high discount rates are used.

The actual investment cost comprised an initial construction and land acquisition cost of $58 million in 2016 dollars. The ongoing maintenance cost consists of $181,000 annually, with an additional $250,000 every five years for the first twenty years. For the calculation of the benefit cost ratio, it was assumed that the maintenance cost would be

TABLE 2: ESTIMATED AFFECTED NUMBER OF PEOPLE IN RESIDENTIAL SECTOR

AVERAGE RETURN INTERVAL (Years)	ANNUAL PROBABILITY OF EXCEEDANCE	NUMBER OF AFFECTED RESIDENTIAL PROPERTIES	NUMBER OF AFFECTED PEOPLE	
			Before Mitigation	After Mitigation
100,000	0.00001	1,853	4,262	4,262
1,000	0.001	989	2,275	2,275
500	0.002	864	1,987	199
200	0.005	786	1,356	0
100	0.01	707	650	0
50	0.02	627	72	0
20	0.05	551	1	0

TABLE 3: ESTIMATED BUILDING REPAIR COST (RESIDENTIAL SECTOR)

AVERAGE RETURN INTERVAL (Years)	TOTAL POTENTIAL LOSS ($ M)	CONDITIONAL PROBABILITY OF FAILURE		CONDITIONAL LOSS ($ M)		AVERAGE ANNUAL LOSS ($ M)	
		Before Mitigation	After Mitigation	Before Mitigation	After Mitigation	Before Mitigation	After Mitigation
100,000	466.06	1	1	466.06	466.06	1.769	0.486
1,000	218.23	1	1	218.23	218.23		
500	192.27	1	0.1	192.27	19.23		
200	149.53	0.75	0	112.15	0		
100	127.35	0.4	0	50.94	0		
50	106.23	0.05	0	5.31	0		
20	75.39	0.0005	0	0.04	0		

TABLE 4: ESTIMATED TOTAL LOSS ($) BEFORE AND AFTER MITIGATION

AVERAGE RETURN INTERVAL (Years)	ANNUAL PROBABILITY OF EXCEEDANCE	POTENTIAL LOSS ($ M)	CONDITIONAL LOSS ($ M)		AVERAGE ANNUAL LOSS ($ M)	
			Before Mitigation	After Mitigation	Before Mitigation	After Mitigation
100,000	0.00001	972.2	972.2	972.2	3.95	1.04
1,000	0.001	476.5	476.5	476.5		
500	0.002	430.2	430.2	43		
200	0.005	324.8	256.4	0		
100	0.01	278.4	111.2	0		
50	0.02	232.4	11.9	0		
20	0.05	165.8	0.08	0		

the same for both the existing and new levee. Therefore, this cost was not included in the cost benefit analysis.

Results show that the benefit cost ratio remains less than one for the discounted rates of five to seven percent when the actual project costs are used (see table 5, page 4). However, the benefit cost ratio improves considerably if the original estimated cost of the project used for decision making is used. This was assessed to be $22 million in 2006 ($27.9 million in 2016 dollars), but was exacerbated later due to increases in the cost of construction and land acquisition. The original estimated cost yields a benefit cost ratio greater than one for all discount rates.

These findings show that under most discount rates for the estimated and actual cost, the benefit of the mitigation work is greater than the cost of the levee construction.

▲ **Above:** FLOODWATERS AT CATARACT GORGE NEAR LAUNCESTON. PHOTO: DANIEL SALLAI CC BY-NC-ND 2.0

TABLE 5: COST BENEFIT ANALYSIS FOR SELECTED DISCOUNT RATES

COST BASIS	TOTAL INVESTMENT (2016 $ M)	AVOIDED LOSSES (2016 $ M)					BENEFIT COST RATIO (BCR)				
		3%	4%	5%	6%	7%	3%	4%	5%	6%	7%
Actual cost	58.4	88	69.7	57.1	48.1	41.4	1.51	1.19	0.98	0.82	0.71
Estimated cost	27.9	88	69.7	57.1	48.1	41.4	3.15	2.49	2.04	1.72	1.48

HOW IS THIS RESEARCH BEING USED?

This research continues to add to the national and international evidence base for the benefits of investing in mitigation over response and recovery. It provides support for the further development of the Launceston flood mitigation program.

This project also revealed that despite the difficulties in quantifying intangible benefits to support flood mitigation, good evidence-based scientific research is progressing in Australia to narrow this knowledge gap. Quantification in monetary terms of the social and environmental impacts resulting from flooding may come as a relief for those communities who would otherwise be excluded from flood mitigation projects. Note, that for the purpose of economic analyses, avoidance or reduction in flood risk is defined as a 'benefit'.

The City of Launceston hopes that any outcomes from further research in intangible benefits will assist it and its partners in future decision making.

FURTHER READING

Fullard A (2013), Launceston – a city on a floodplain, protecting Launceston from a 1 in 200 ARI flood. Floodplain Management Association National Conference; 19pp.

Maqsood T, Wehner M, Mohanty I, Corby N and Edwards M (2017), Launceston flood risk mitigation assessment, Bushfire and Natural Hazards CRC.

The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

HAZARD **NOTE**

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ISSUE 29 MAY 2017

TOPICS IN THIS EDITION | FLOOD | FORECASTING | HYDROLOGY | REMOTE SENSING

REMOTE SENSING OFFERS BETTER FORECASTING OF RIVERINE FLOODS

Above: THE RESEARCH TEAM USES A RIVERSURVEYOR ACOUSTIC DOPPLER PROFILER TO MEASURE THE TOPOGRAPHY OF THE CLARENCE RIVER UPSTREAM OF GRAFTON. PHOTO: STEFANIA GRIMALDI

ABOUT THIS PROJECT

This research is being conducted as part of the *Improving flood forecast skill using remote sensing data* project, which is increasing Australia's capacity to understand, forecast and monitor flooding.

AUTHORS

A/Prof Valentijn Pauwels, Prof Jeffrey Walker, Dr Stefania Grimaldi, Dr Yuan Li, Ashley Wright, Monash University. Contact valentijn.pauwels@monash.edu

SUMMARY

Accurate flood predictions are critically important for limiting the damage caused by floods. Flood forecasting systems are based on models that require large volumes of data, such as rainfall forecasts, detailed measurements and high-resolution topography. However, flood forecasts are prone to uncertainty due to a lack of detailed measurements, and possible errors or oversimplifications in the models and/or data sets. Remote sensing is the science of obtaining information about objects or areas from a distance, typically from aircraft or satellites. This research is integrating this type of data on soil moisture and flood extent with rainfall and runoff models, which will lead to more accurate flood predictions. It will develop a remote sensing-aided methodology that can eventually enable forcasting models that predict the volume of water entering the river network to be applied anywhere in Australia.

CONTEXT

Flood forecasting systems require large data sets, some of which are scarce or unavailable in the large Australian river basins (for example, detailed precipitation or bathymetric data). The project is investigating how remote sensing data are best used to solve this issue and produce better flood predictions.

BACKGROUND

Flood forecasting systems consist of two parts: i) a hydrologic model that predicts the volume of water entering the river network, and ii) a hydraulic model that computes flood extent and water level. At the start of the project in May 2014, the Bureau of Meteorology operated hydrologic models for about 100 catchments, but was not yet applying hydraulic models. The models were not using remote sensing data. The team is developing hydrologic and hydraulic models and algorithms to integrate soil moisture and flood extents from remote sensing data, which will be incorporated by Geoscience Australia into its Water Observations from Space product.

BUSHFIRE AND NATURAL HAZARDS CRC RESEARCH

The team set up a forecasting system for two test basins: the Clarence in northern New South Wales and Condamine-Balonne-Maranoa in southern Queensland. Both areas were chosen because they are prone to frequent flooding. The researchers have determined the parameters of the hydrologic model using discharge data and remotely sensed soil moisture data and are developing strategies to correct model outputs automatically. The hydraulic model calibration and incorporation of remotely sensed data is ongoing. Specifically, the project is developing a method to determine effective river cross-sections because it is difficult to measure the river bathymetry (riverbed topography) in a detailed way for large basins. The team has acquired river cross-section data in strategic locations on two field visits.

RESEARCH FINDINGS

For the hydrologic model, it was found that joint calibration using discharge and soil moisture leads to more robust results than traditional calibration using only discharge data. In other words, the model degraded slightly during the calibration period but improved during the validation period. Including soil moisture in the calibration improved the simulations for the ungauged sub-basins.

Because rainfall is highly uncertain, streamflow data was used to estimate the rainfall volumes for the duration of the flood.

The team have also completed a preliminary analysis of a proposed new method for improving the detection of flooded areas in densely vegetated catchments. It involves using simplified river geometries that are based on a combination of limited field data sampled at strategic locations, global databases and remote sensing data.

HOW IS THIS RESEARCH BEING USED?

A workshop at Geoscience Australia was held in October 2016, streamlining the use of the remote sensing techniques developed in this project for the Geoscience Australia Water Observations from Space product. Geoscience Australia will use the method developed in this project to classify the areas monitored as being flooded or not flooded. This will start in the second phase of the project, from July 2018. The research team will meet regularly with the end-users to ensure that the outcomes continue to address their needs. The Bureau of Meteorology will also use the project's recommendations in their operational system.

By improving real-time flood prediction, this research is expected to improve the accuracy of flood warnings, resulting in a decrease in flood damage and potentially loss of life.

▲ **Above:** MODEL SIMULATIONS SHOWING THE EXTENT OF FLOODING IN THE GRAFTON AREA FOR JANUARY 29, 2013. PHOTO: NSW LAND AND PROPERTY INFORMATION.

FUTURE DIRECTIONS

The researchers are completing phase one of the study and have a broad program planned for phase two. It includes a comparison of different remote sensing-based, soil-moisture products, such as surface soil-moisture retrievals and root-zone, and soil-moisture analysis, for hydrologic model updating. The team will also develop a model-data fusion algorithm for a hydrologic forecasting system to optimally use both remotely sensed soil moisture and stream-flow measurements.

The project will validate rainfall estimations using remotely sensed soil-moisture observations. It will also develop a remote sensing-aided methodology to derive effective river-transect data for large catchments, and to improve the accuracy of digital elevation models for large catchments. This methodology will eventually enable hydraulic models to be applied anywhere in Australia.

END-USER STATEMENT

This research will provide a way to help predict the magnitude and timing of flood peaks to enable Geoscience Australia to better target satellite image acquisitions. It will also fill the gaps in satellite coverage and flood extent determination where satellite images are either unavailable or obscured by clouds.

– Norman Mueller, Emergency Response Coordinator, Geoscience Australia

The project will provide a vehicle to test the utility of now increasingly available remotely sensed data in predicting flood movement. Improved remotely sensed data with much improved latency and better spatial and temporal resolution, such as from the Himawari-8 satellite, will allow the Bureau to look at ways to improve its flood forecasting capability in areas where sufficient ground observations are not available. The hydrologic and hydraulic modelling capacity being developed will complement the current capabilities.

– Soori Sooriyakumaran, Manager Flood Policy Unit, Bureau of Meteorology

FURTHER READING

Grimaldi S, Li Y, Pauwels VRN, Walker JP (2016), Remote sensing-derived water extent and level to constrain hydraulic flood forecasting models: opportunities and challenges, *Surveys in Geophysics*, **37**(5), pp. 977-1034.

Li Y, Grimaldi S, Walker JP, Pauwels VRN (2016), Application of remote sensing data to constrain operational rainfall-driven flood forecasting: a review, *Remote Sensing*, **8**(6), 456, doi:10.3390/rs8060456.

The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

HAZARD **NOTE**

bushfire&natural HAZARDSCRC

ISSUE 26 JANUARY 2017

TOPICS IN THIS EDITION | ENGINEERING | MITIGATION | CYCLONE | EARTHQUAKE | FLOOD

STRENGTHENING INFRASTRUCTURE FOR NATURAL HAZARD IMPACTS

ABOUT THESE PROJECTS

This is an overview of the *Hardening buildings and infrastructure* cluster of Bushfire and Natural Hazards CRC research projects. This cluster has five linked studies:

1. **Cost-effective mitigation strategy development for building-related earthquake risk –** Prof Michael Griffith, Prof Mark Jaksa, A/Prof Abdul Sheikh, Dr Mohamed Ali, Dr Togay Ozbakkaloglu, Dr Alex Ng, Dr Phillip Visintin, University of Adelaide; A/Prof Nelson Lam, A/Prof Helen Goldsworthy, University of Melbourne; Prof John Wilson, Prof Emad Gad, Dr Hing Tsang; Swinburne University; Mark Edwards, Dr Hyeuk Ryu, Martin Wehner, Geoscience Australia. Contact michael.griffith@adelaide.edu.au
2. **Cost-effective mitigation strategy development for flood prone buildings –** Dr Tariq Maqsood, Martin Wehner, Dr Ken Dale, Geoscience Australia. Contact tariq.maqsood@ga.gov.au
3. **Improving the resilience of existing housing to severe wind events –** Dr David Henderson, A/Prof John Ginger, Dr Daniel Smith, James Cook University; Martin Wehner, Dr Hyeuk Ryu, Mark Edwards, Geoscience Australia. Contact david.henderson@jcu.edu.au
4. **Enhancing the resilience of critical road infrastructure: bridges, culverts and floodways –** Prof Sujeeva Setunge, Prof Chun Qing Li, Prof Darryn McEvoy, A/Prof Kevin Zhang, Dr Jane Mullett, Dr Hessam Mohseni, RMIT University; Prof Priyan Mendis, Dr Tuan Ngo, Dr Nilupa Herath, University of Melbourne; Prof Karu Karunasena Dr Weena Lokuge, Dr Buddhi Wahalathantri; University of Southern Queensland; Prof Dilanthi Amaratunga, University of Huddersfield. Contact sujeeva.setunge@rmit.edu.au
5. **Natural hazard exposure information modelling framework –** Dr Krishna Nadimpalli, Geoscience Australia; Dr Itismita Mohanty, Dr Yogi Vidyattama, University of Canberra; Dr Mohsen Kalantari, Prof Abbas Rajabifard, University of Melbourne. Contact krishna.nadimpalli@ga.gov.au

CONTEXT

This cluster is assisting communities, builders, governments and emergency services make informed decisions about how they can mitigate the risk of building and road damage from natural hazards. Focusing on existing high risk components of the built environment, the research is investigating the vulnerability of buildings and key infrastructure across a range of natural hazards, including earthquake, flood, cyclone and bushfire. The overall aim is to provide cost-effective solutions that will reduce damage, injury, community disruption and the future cost of natural hazards, as well as how new construction can be more appropriate for mitigating risks.

COST-EFFECTIVE MITIGATION STRATEGY DEVELOPMENT FOR BUILDING-RELATED EARTHQUAKE RISK

BACKGROUND

The risk posed by earthquakes to buildings in Australian cities is significant, with the World Insurance Market rating a modest magnitude 6 earthquake in Sydney to be in their top 10 financial risks worldwide. This is because Australia did not design buildings for earthquake-induced forces until 1995, so a large portion of buildings are vulnerable.

Drawing upon and extending existing research and capability within both academia and government, this study is developing information that will inform policy, business and private individuals on their decisions concerning reducing building vulnerability. It will also draw upon New Zealand initiatives

▲ **Above:** TECHNICIAN JOHN AYOUB WORKING AT THE EXPERIMENTAL SITE IN ADELAIDE. THIS RESEARCH IS HELPING TO STRENGTHEN THE CONSTRUCTION OF BUILDINGS.

that make use of local planning as an instrument for effecting mitigation.

RESEARCH ACTIVITY

This study is investigating the relative vulnerabilities to earthquake for the most common forms of building construction across the country, as well as learning from the Christchurch experience to find out what retrofitting techniques did and did not work. These Christchurch examples will be used as a starting point to develop economically feasible retrofitting options for Australian buildings. Proof of concept testing has been conducted on some of the most promising retrofit techniques.

Damage and economic loss models have been used to undertake a risk assessment case study of the Melbourne metropolitan area. Recommendations for retrofit guidelines and policy will be developed based on the evidence gathered.

While the overall focus of the project is on buildings, many of the outputs will also be relevant for other infrastructure such as bridges, roads and ports.

RESEARCH OUTCOMES

At the invitation of the South Australian Department of Planning, Transport and Infrastructure the team was provided access to test brick cavity walls and chimneys in four unreinforced masonry houses that have since been demolished as part of the South Australian Government's South Road Corridor project in Adelaide. Information collected from the testing will enable fragility curves to be developed for such buildings.

Studies on lightly reinforced concrete walls are also being conducted. Experimental works have been undertaken to assess the global out-of-plane buckling and the local buckling of vertical reinforcement failure mechanisms of reinforced concrete walls, and the general instability failures of lightly reinforced concrete walls. An analytical study is currently being undertaken to develop a model for the fragility of such walls.

Results from this project are being utilised by the *Decision support system for assessment of policy and planning investment* project, led by Prof Holger Maier, which will aid in the development of consistent national policies for the application of seismic design of new buildings and retrofit of existing buildings.

COST-EFFECTIVE MITIGATION STRATEGY DEVELOPMENT FOR FLOOD PRONE BUILDINGS

BACKGROUND

During the 2011 and 2013 Queensland floods, many buildings were damaged due to inappropriate development on floodplains and a legacy of high risk building stock in flood prone areas. While the vulnerability and associated flood risk is being reduced for newer construction by adopting new building standards, building controls and land use planning, existing buildings are still prone to flood damage. This project is targeted at assessing mitigation strategies to reduce the vulnerability of these existing residential buildings, and is developing the evidence base required to inform decision making on the mitigation of the flood risk posed by the most vulnerable houses. This evidence base will assist both government policy makers and property owners by providing information on the cost-effectiveness of mitigation strategies involving alterations to existing buildings.

Left: MANY OF OUR HOUSES ARE LOCATED IN FLOOD PRONE AREAS, AND THIS STUDY IS DEVELOPING MITIGATION STRATEGIES FOR DIFFERENT BUILDING TYPES.
PHOTO: VICTORIA SES

RESEARCH ACTIVITY

Existing building schema have been assessed, both national and internationally. This led to the development of a new building classification schema to categorise residential buildings into a range of typical storey types. This is a fundamental shift from describing the complete building as an entity to one that focuses on sub-components. The proposed schema divides each building into the sub-elements of foundations, bottom floor, upper floors (if any) and roof to describe its vulnerability. This approach makes it possible to assess the vulnerability of structures with different usage and/or construction material used in different floors, and also to assess the vulnerability of tall structures with basements where only basements and/or bottom floors are expected to be inundated.

A further literature review investigated existing mitigation strategies, looking at evaluating strategies that will suit Australian building types and typical catchment behaviours. The mitigation options assessed were elevation, relocation, dry flood-proofing, wet flood-proofing and flood barriers. Costing of mitigation options for a number of building types have also been undertaken.

RESEARCH OUTCOMES

A flood-proofing matrix has been developed to assess appropriate strategies for the five selected building types. Elevation of a structure is one of the most common mitigation strategies, while relocation of a building is the most dependable. Unsurprisingly, relocation is generally the most expensive.

Dry flood-proofing consists of measures to seal the portion of a structure that is below the expected flood level to make it substantially impenetrable to floodwaters. Dry flood-proofing is generally not recommended in flood depths exceeding one metre, and may also be inappropriate for light timber frame structures, structures with raised timber floors and structures which are not in good condition that may not be able to withstand the forces exerted by floodwater.

Wet flood-proofing includes modifying the building by replacing existing building components with more water-resistant materials, adapting to the flood hazard by raising key services and utilities to a higher level and installing flood openings to equalise the pressure exerted by floodwaters on the interior and exterior of the building – reducing the chance of building failure.

Flood barriers can be permanent or temporary, and are built around a single building. Flood barriers may be inappropriate for structures with raised floors because of the high cost of barriers for height more than 1m.

All appropriate strategies have been costed for the selected building types through the engagement of quantity surveying specialists.

HAZARD **NOTE**

IMPROVING THE RESILIENCE OF EXISTING HOUSING TO SEVERE WIND EVENTS

▲ **Above:** THE TEAM ON DEPLOYMENT NEAR COOKTOWN IN QUEENSLAND TO ASSESS CYCLONE *NATHAN* IN 2015. PHOTO: DANIEL SMITH.

BACKGROUND

Typically, older Australian houses built prior to the mid 1980s do not offer the same level of performance and protection during severe wind as houses constructed to contemporary building standards. Given that these older houses will represent the bulk of the housing stock for many decades to come, practical structural upgrading solutions based on the latest research will make a significant improvement to housing performance and to the economic and social well-being of the community.

This project is developing the evidence base for risk mitigation by devising simple practical and economic upgrading options for existing houses. The outcomes will promote retrofit investment by homeowners and provide a basis for incentives to encourage this action through insurance and government initiatives. The importance of homeowners incorporating mitigation measures to reduce risk has been highlighted with the release of the Northern Australia Insurance Premiums Taskforce's report in March 2016.

RESEARCH ACTIVITY

A number of cyclones and thunderstorms have been analysed, with the team conducting reports following cyclones *Nathan*, *Marcia* and *Olwyn* in 2015, as well as a severe thunderstorm in Brisbane in November 2014.

Storms outside of the tropics are also the focus of the study, with the team conducting surveys in Adelaide and Canberra. In Adelaide, 16 houses that were due to be demolished were surveyed and their connection details and structural systems recorded, providing valuable data. The performance of aged timber connections is not well understood, and examples were collected to be performance tested in the laboratory.

The geometry of houses in south east Australia is the least understood, and to address this the team undertook a desktop examination using aerial imagery and Google Street View of 467 houses in Canberra to determine the most common geometries from houses constructed in the 1960s. Houses that are obviously constructed at a later date or original houses that have undergone obvious alterations, such as extensions, were excluded.

The team has also collaborated with the insurance company Suncorp to analyse 25,000 insurance claims from cyclones *Larry* (2006) and *Yasi* (2011), with the purpose of gaining a better understanding of the drivers of cyclone damage.

RESEARCH OUTCOMES

For cyclones *Nathan*, *Marcia* and *Olwyn*, observed wind speed was lower than the speed housing is designed for in each area in most cases, but significant structural damage occurred from *Marcia* and the Brisbane thunderstorm. Hail damage was considerable in Brisbane, while water entry caused the most damage during *Olwyn*.

Wind loads on the roof of representative houses were obtained from a wind tunnel model study carried out in a boundary layer wind tunnel. The pressure fluctuations on the roof system (e.g. batten to rafter and rafter to top plate) are being analysed and tested in detail to inform understanding of roof performance, potential failure modes and opportunities to implement retrofit options.

A webinar series has also been piloted, allowing home owners to understand the importance of of making appropriate decisions at various stages of the building process, and providing information on various aspects of building to resist wind loads for builders, certifiers and designers to become aware of issues that have caused failures previously.

ENHANCING RESILIENCE OF CRITICAL ROAD INFRASTRUCTURE: BRIDGES, CULVERTS AND FLOODWAYS

BACKGROUND

Natural hazards cause major damage to road networks, with hundreds of millions of dollars spent in recent years to repair damage. A major gap in the current research is the lack of assessment techniques and tools to inform assessment of the vulnerability of this infrastructure, and to focus resilience efforts to enhance both community and structural resilience. This project is developing tools and techniques to enhance the resilience of roads to floods, bushfires and earthquakes.

RESEARCH ACTIVITY

The study is undertaking research to:

- Advance the understanding of the factors required for quantifying impact of hazards on road structures.
- Understand failure mechanisms under different hazards and vulnerable structural forms, with structures grouped according to vulnerability.

Case studies have been completed and numerical analyses have been conducted to understand the vulnerability of roads to different hazards.

RESEARCH OUTCOMES

Case studies have been utilised to develop and demonstrate vulnerability modelling methodology to road infrastructure.

Left: KAPERNICKS BRIDGE IN THE LOCKYER VALLEY, QUEENSLAND, HAS BEEN ASSESSED FOR ITS VULNERABILITY TO EARTHQUAKES, AS WELL AS RETROFITTING OPTIONS. PHOTO: HESSAM MOHSEN.

Flood, bushfire and earthquake have been investigated, with two case studies on bridges, and one on floodway failure. The bushfire case study focused on a bridge in Victoria, constructed in 1958, and found that if the bridge was exposed to fire for less than 90 minutes, it could be repaired to its pre-fire standard. After 120 minutes of fire exposure, however, all bridge columns would require full replacement. For earthquake, a concrete girder bridge in Queensland constructed in 1976 was analysed for 24 different types of earthquake. The most vulnerable section was the deck joint, and retrofitting techniques can be applied improve the strength of these joints. For flood, 64 floodways damaged by the 2013 flood in the Lockyer Valley were considered. Scour downstream of the floodway was the onset of the failure of the structure and the cut off wall was the most vulnerable element.

Australian design standards for bridges and floodways have been examined and a comparative study of international standards undertaken, along with an analysis of design standards and applied loads on road structures under extreme events. A field study was also undertaken to understand the social and economic impact due to failure of road structures during Queensland's Lockyer Valley floods in 2011 and 2013.

The next stage of the study will expand the vulnerability modelling and develop a GIS tool which can be used to demonstrate the benefits of the approaches developed.

END-USER STATEMENT

This research will assist stakeholders, from governments and emergency management agencies, through to individuals, make informed decisions about how they can best mitigate damage to buildings and crucial road infrastructure. Incorporating flood and storm vulnerability, the research will provide an important evidence base about the most cost-effective ways to reduce damage to buildings and ensure our roads can withstand natural hazards, allowing local communities to resume business as usual as quickly as possible. For earthquake, our most vulnerable infrastructure is unreinforced masonry and low ductility reinforced concrete frames, and testing will achieve practical outcomes to strengthen our buildings.

– Leesa Carson, Branch Head Community Safety, Geoscience Australia

NATURAL HAZARD EXPOSURE INFORMATION MODELLING FRAMEWORK

BACKGROUND

This project is identifying the fundamental data requirements and modelling framework to derive exposure information to enable a better understanding of the vulnerability of people, buildings and infrastructure to different hazards. It is a significant step towards developing national exposure information capabilities in Australia. The framework will support impact assessments on people, economy, infrastructure and the environment caused by bushfires, floods, cyclones and earthquakes.

RESEARCH ACTIVITY

A number of nationally consistent frameworks are being developed, which will help a diverse range of end-users. The frameworks include:

- Built environment exposure – considers the attributes of assets to assess their vulnerability to natural hazards. The building exposure considers usage, type, structural system, number of storeys, size, age, attachments, replacement value and contents value. The infrastructure sectors considered are transportation, energy, communication, urban water supply, waste management, hazardous substances and major industries. The primary industries considered are agriculture, fishing, forestry and mining sectors.
- Business and economics exposure – consists of business definitions, assets and activities which are deemed necessary for assessment of business continuity, disruption, resilience and recovery indicators in disaster management.

RESEARCH OUTCOMES

The project has reviewed current exposure information provision capabilities to identify key issues, needs, gaps, overlaps and deficiencies. An extensive literature review has been undertaken, along with stakeholder consultations to identify comprehensive list of information requirements. A survey with end-users identified significant gaps in the availability of existing data and the translatation into meaningful information for evidence based disaster decision making.

The built environment exposure information framework has been completed. To reduce the complexity, it categorises the information into three levels depending on the requirements of the user: policy and planning; response and recovery; research and analysis.

The framework presents the fundamental characteristics of exposed assets to natural hazards as components, elements and attributes. The exposure components considered in the framework are buildings, people, businesses and infrastructure.

The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

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HAZARD **NOTE**

bushfire&natural HAZARDSCRC

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TOPICS IN THIS EDITION | RISK ANALYSIS | MODELLING | MULTI-HAZARD

ABOUT THESE PROJECTS

This is an overview of the *Scenario and loss analysis* cluster of Bushfire and Natural Hazards CRC research projects. This cluster has two linked studies:

1. **An analysis of building losses and human fatalities from natural disasters** – Dr Katharine Haynes, Lucinda Coates, Andrew Gissing, Dr Deanne Bird, Dr Rob van den Honert and Dr Ryan Crompton, Risk Frontiers, Macquarie University.
2. **Using realistic disaster scenario analysis to understand natural hazard impacts and emergency management requirements** – Dr Felipe Dimer de Oliveira, Dr Paul Somerville, Dr Valentina Koschatzky, Dr Kevin Roche, Dr Deanne Bird, Professor John McAneney, Dr Rob van den Honert, Dr Katharine Haynes, Andrew Gissing, Risk Frontiers, Macquarie University, and Dr Matthew Mason, University of Queensland.

For more information, contact haynes.katharine@gmail.com

CONTEXT

This cluster focuses on understanding the historical costs to Australia from natural disasters and how we can develop scenarios for future planning. The understanding of historical losses and human fatalities is a fundamental first step to enabling efficient and strategic risk reduction.

In turn, the development of a series of natural disaster scenarios allows a quantification of their impacts on society, critical infrastructure, lifelines and buildings, and where possible, the natural environment. This enables understanding of the possible implications, supporting the emergency management sector to better prepare for, or mitigate impacts of, events beyond current experience.

LEARNING FROM THE PAST, PLANNING FOR THE FUTURE

▲ **Above:** FLOODING IN BRISBANE IN JANUARY 2011. PHOTO: ISTOCK

AN ANALYSIS OF BUILDING LOSSES AND HUMAN FATALITIES FROM NATURAL HAZARDS

BACKGROUND

This project is measuring and gaining a greater understanding of the impacts of natural hazards in terms of the toll of human life, injuries and building damage in order to provide an evidence base for emergency management policy and practice. Trends over time will be interpreted in the context of emerging issues (e.g. ageing population, population shifts, building codes). Research will also provide an analysis of building damage by hazard and state/territory.

RESEARCH ACTIVITY

This project covers all hazards, but to date has focused on floods. This has involved examining coronial inquests for each state and territory, as well as visiting various archives and coronial offices in order to add more data around the circumstances of each fatality. Work is also concentrating on updating the data on the physical characteristics of the floods where a fatality occurred.

RESEARCH OUTCOMES

Research has so far uncovered 1,131 fatal flood events, accounting for 1,854 fatalities. The names of the deceased for 1,635 of these fatalities are now known. Flood data (names of the deceased and circumstances around each fatality) is complete for the following jurisdictions:

- Up to 1953 for South Australia.
- Up to 1962 for New South Wales.
- Up to 1978 for Queensland.
- Up to 1985 for Victoria.
- Up to 2014 for Tasmania.

Obtaining and analysing data for Western Australia, the ACT and the Northern Territory is ongoing, as is updating the data to as current as possible for the above states.

Although the focus has been on floods, work updating data for other hazards, particularly in terms of the names of fatalities, has also been conducted. Those states and territories with smaller numbers of deaths (Tasmania, South Australia and the Northern Territory) enabled information to be collected for all hazard fatalities during visits to various records offices.

A general overview of heatwave fatalities has also been completed. It was found that between 1844 and 2010, extreme heat has been responsible for a least 5,332 fatalities, more than the combined total number of deaths for all other natural hazards. Over 30% of these fatalities occurred during just nine extreme heat events.

HAZARD **NOTE**

USING REALISTIC DISASTER SCENARIO ANALYSIS TO UNDERSTAND NATURAL HAZARD IMPACTS AND EMERGENCY MANAGEMENT REQUIREMENTS

BACKGROUND

Realistic disaster scenarios can be used to facilitate response planning and policymaking. They allow emergency managers to visualise the impacts of plausible events before they happen. For this study, the scenarios are classed as realistic because they have not occurred previously, but have a high likelihood of occurring and causing extensive damage. As many details as possible are taken into account, such as likely infrastructure damage, likely injuries and fatalities, loss of essential services and utilities and short- and long-term impacts of the disaster.

RESEARCH ACTIVITY

In consultation with end users, the study has so far conducted two scenarios: a major earthquake with its epicentre beneath Adelaide, and a severe tropical cyclone off the Queensland coast (this scenario is currently being finalised).

Catastrophe loss models (CAT-models) are used to determine the impact of the scenarios. These are mathematical representations of natural disasters, and are developed from statistical analysis of past event data, guided by engineering and technical knowledge and expert judgement. CAT-models consist of three modules: a hazard module, which expresses the probability and intensity of natural processes leading to damage; a vulnerability module, which calculates the amount of human or material loss due to a natural hazard; and an exposure module, which provides the location and quantity of assets at risk.

The next stage of the research will investigate:

- The long-range effects of natural disaster damage, e.g. how damage to roads will affect hospitals. A series of floods in New South Wales will be modelled for this scenario.
- Vulnerable populations, e.g. the elderly, the very young, low socio-economic status, recent migrants etc. This will be modelled using the example of a heatwave affecting one or more Australian metropolitan regions.

Above: TO HELP AGENCIES PREPARE FOR FUTURE DISASTERS, RESEARCH IS MODELLING THE POTENTIAL IMPACT OF DISASTERS THAT ARE BEYOND OUR EXPERIENCE, SUCH AS A MAJOR EARTHQUAKE AFFECTING A CAPITAL CITY. PHOTO: JOHN MCCOMBE, NEW ZEALAND RURAL FIRE SERVICE

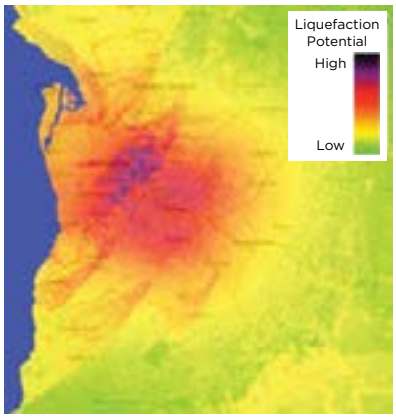
RESEARCH OUTCOMES

Adelaide is situated on and near a number of faults. Its largest recorded earthquake was in 1954, with a magnitude of 5.6. Fortunately its epicentre was far from populated areas, however today this area is densely populated. What would happen if a similar earthquake took place in Adelaide today?

Research modelled a magnitude 6 earthquake occurring on the Para Fault at a depth of seven kilometres, with an epicentre seven kilometres from the Adelaide CBD. The scenario considered the impacts if the earthquake occurred at 2am and 2pm, as these times were expected to result in the highest casualties.

It is predicted that an earthquake like this would result in a large number of homes being destroyed or unsuitable for occupation. For both time periods, casualties could be in excess of 300, with over 100 life-threatening injuries expected. Basic medical aid that could not be self-treated is estimated to be required for approximately 5,000 people.

Worst-case scenarios such as this will help emergency services plan and prepare for natural disasters beyond our current experience.



Above: RESEARCH MODELLED THE POTENTIAL IMPACT OF AN EARTHQUAKE ON ADELAIDE. THIS IMAGE SHOWS THE LIQUEFACTION POTENTIAL.

END USER STATEMENT

Both projects are proof of concepts for unleashing data and modelling for emergency planning. These projects will provide a useful repository of information that can be used as an evidence base across many hazards.

A lot of data already exists on fatalities, and much more needs to be updated. So we need to look at how we will exploit this data better. One area is how historical analysis will allow agencies to look at trends in deaths to see what the implications for community safety policies are – measuring the effect of current polices and developing updated polices and approaches.

Scenario modelling of large scale disasters will allow a range of assumptions to be tested against how we plan and respond. The data developed and the ways we explore to present it will provide crucial insights for agencies, allowing us to plan for these worst case scenarios.
– Simon Opper, Senior Planning Officer (Knowledge and Intelligence), New South Wales State Emergency Service.

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Managing the Landscape

HAZARD **NOTE**

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ISSUE 87 DECEMBER 2020

TOPICS IN THIS EDITION | FIRE | PRESCRIBED BURNING | RISK MANAGEMENT

THE PRESCRIBED BURNING ATLAS: A NEW SYSTEM TO PLAN EFFECTIVE PRESCRIBED BURNS

ABOUT THIS PROJECT

Backed by five years of research measuring the effects of almost one million fire simulations, the Prescribed Burning Atlas is the key product of the *From hectares to tailor-made solutions for risk mitigation: systems to deliver effective prescribed burning across Australian ecosystems* project. The project investigated the implementation of tailor-made prescribed burning strategies to suit the biophysical, climatic and human context of bioregions in southern Australia, both now and in the future using climate change projections. The Prescribed Burning Atlas will inform prescribed burning strategies and help fire and land managers tailor their approaches to outcomes that will best reduce residual risk in a target area within available budgets.

You can access the Prescribed Burning Atlas at **https://prescribedburnatlas.science/**

▲ **Above:** THIS RESEARCH DEVELOPED THE PRESCRIBED BURNING ATLAS, A WEBSITE TO HELP FIRE AND LAND MANAGERS TAILOR THEIR PRESCRIBED BURNING STRATEGIES TO THE LOCAL ENVIRONMENT AND BUDGET. PHOTO: NSW NATIONAL PARKS AND WILDLIFE SERVICE.

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SUMMARY

The Prescribed Burning Atlas is a new tool backed by research to assist fire and land management agencies by presenting options for their prescribed burning strategies. Accessible via https://prescribedburnatlas.science, the Atlas incorporates almost one million prescribed burning simulations across varied landscapes and under different weather conditions, to explore the effects of different rates and locations of prescribed burning treatments on subsequent bushfire behaviour.

Researchers examined the residual risks across a range of management values and south eastern Australian landscapes, including the cost-effectiveness of different strategies. The Atlas provides new insights into the effectiveness of prescribed burning in reducing the likelihood of life loss, property loss and environmental values.

By estimating the risk mitigation achieved, the Atlas will help find the most cost-effective prescribed burning strategies. It will assist fire and land managers by showing specific risk reduction benefits and costs, depending on the desired outcome, for broad scale landscape burning or smaller strategic edge burns, in different types of landscapes across New South Wales, the ACT, Victoria, Tasmania, South Australia and Queensland. Crucially, the project employs a consistent methodology which provides a level playing field for comparisons and a basis for a national system of treatment and risk accounting. The Atlas also shows the effects of climate change on prescribed burning effectiveness into the future.

While there are specific findings for different landscapes types, the Atlas shows that there is not a 'one size fits all' approach to prescribed burning. In most cases, increasing the rate of prescribed burning reduces the risk of area burnt by bushfire, life loss, house loss, damage to roads and damage to powerlines. However, there are thresholds for various landscapes types that, once reached, the costs will increase with only negligible benefits in risk reduction. This cost-effectiveness can vary widely between different regions, mostly relating to the locations of local assets (e.g. housing) and native vegetation.

The Atlas also shows the environmental benefits, and importantly, potential damages, from too much or not enough fire in particular landscapes. In most cases, increasing rates of prescribed burning treatment can be harmful to the ecosystem, as it places more areas at risk of being burnt too frequently (that is, below the minimum tolerable fire interval).

HAZARD **NOTE**

CONTEXT

Prescribed burning is a central feature of contemporary fire management around the world, yet a quantitative basis for understanding and comparing its effectiveness at mitigating risk across different regions is lacking. This project addressed this gap and the Atlas will provide critical support to fire and land management agencies across southern Australia by undertaking a systematic investigation of the drivers of prescribed burning effectiveness.

BACKGROUND

There is widespread use of fire to reduce the amount of fuel (vegetation) in forests and grasslands across Australia. The intentions of these programs are to:

- reduce the amount of combustible vegetation as a means of reducing the intensity and slowing the progression of bushfires, and to decrease the number of spot fires. In combination, these outcomes can increase opportunities to suppress and extinguish those fires and reduce the risk to communities and structures.
- ensure that landscapes that require fire for ecological health are exposed to appropriate fire regimes.

With land management agencies moving toward planning future systems based on risk reduction, the Atlas can be used by prescribed burning practitioners and planners as both a learning and planning support tool.

The information available through this Atlas supports the following priorities and actions for the National Disaster Risk Reduction Framework:

Priority 1: Understand disaster risk

- Identify and address data, information and resource gaps
- Address technical barriers to data and information sharing and availability
- Integrate plausible future scenarios into planning

Priority 2: Make accountable decisions

- Consider potential avoided loss (tangible and intangible) and broader benefits in all relevant decisions
- Build the capability and capacity of decision-makers to actively address disaster risk in policy, program and investment decisions

BUSHFIRE AND NATURAL HAZARDS CRC RESEARCH

The Atlas provides an ability for users to understand the likely cost, benefits and overall risk reduction for landscapes across south eastern Australia, and to compare the outcomes based on different prescribed burning strategies – for instance, different combinations of landscape and edge-based burning approaches (where the edge is defined as a locations where flammable vegetation meets communities and the built environment).

The research was divided into two phases: fire behaviour accounting and risk accounting.

Fire behaviour accounting

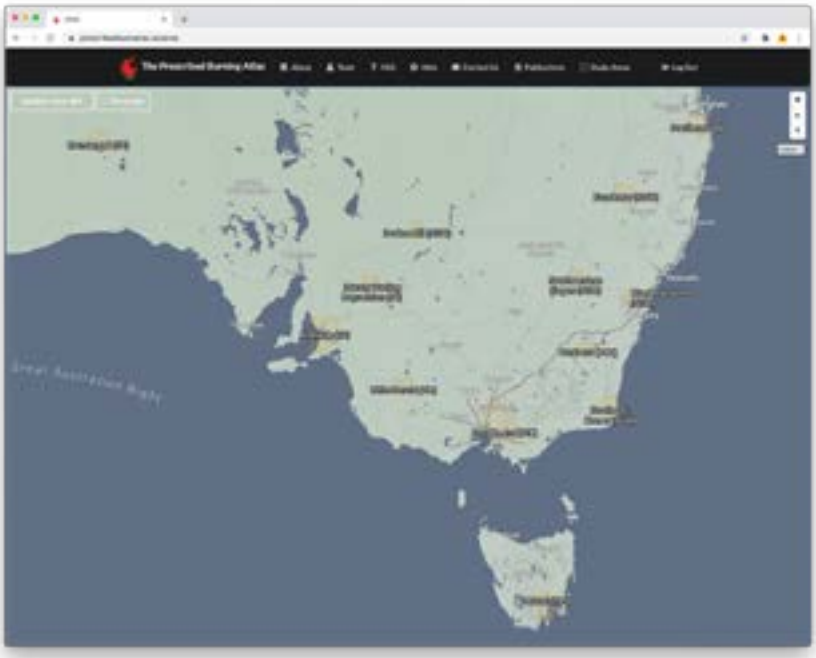
At the heart of the project is predictive modelling of the effect of prescribed burning on unplanned bushfire behaviour.

Researchers used the simulation modelling tool PHOENIX RapidFire (Tolhurst et al. 2008), which is widely used by fire agencies in operations and risk planning. The model was loaded with different inputs – terrain, vegetation types, weather, ignition location, fire history – to predict bushfire properties such as rate of spread, flame height, ember density, convection and intensity. The vegetation types that were assessed included temperate forests, grasslands, savannas, deserts, woodlands and scrub.

Researchers used close to one million fire simulations across 13 case study landscapes across New South Wales, the ACT, Victoria, Tasmania, South Australia and Queensland – comprising the urban interface, remote bushland, arid grassland and sub-tropical bush (see Figure 1 below) – and estimated residual risk for management values, including loss of life, loss of property, length of road damaged, environmental impacts, length of powerline damaged and area burnt.

Risk accounting

Statistical models – specifically Bayesian decision networks – were used to estimate the risk mitigation, including cost, that can be achieved using different prescribed burning strategies in each region. The models learn the probable distributions of fire weather conditions and bushfire incidence for each location and generate risk estimates for each prescribed burning strategy. By incorporating the entire range and probability of local conditions, this process produces 'full' estimates of risk that can be compared between local regions. This is important, because a key objective for fire managers that will use the Prescribed Burning Atlas is the identification of effective risk reduction options.



▲ **Figure 1:** RESEARCHERS USED FIRE SIMULATIONS FROM 13 AREAS ACROSS AUSTRALIA: SOUTHEAST QUEENSLAND; NANDEWAR, BROKEN HILL, SOUTHWESTERN SLOPES, BLUE MOUNTAINS AND SOUTHEAST CORNER, NSW; CANBERRA, ACT; LITTLE DESERT AND EAST CENTRAL, VICTORIA; HOBART, TASMANIA; MURRAY DARLING DEPRESSION, ADELAIDE AND MAMUNGARI, SOUTH AUSTRALIA.

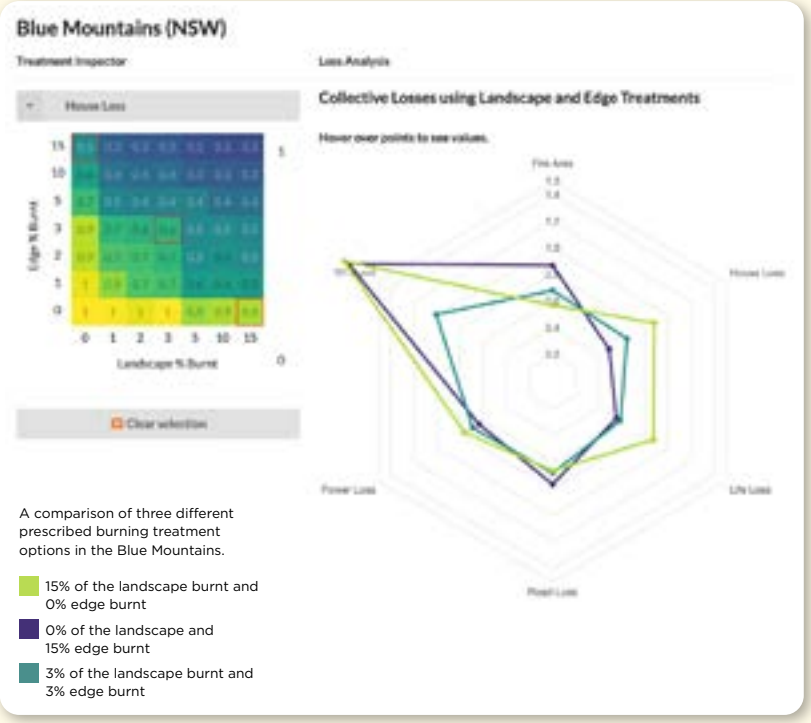
RESEARCH FINDINGS

The technical outputs from this project are layered, allowing for multiple levels of interrogation and interpretation, including

ASSESSING THE EFFECTIVENESS OF PRESCRIBED BURNING IN THE BLUE MOUNTAINS USING THE PRESCRIBED BURNING ATLAS

By conducting edge burning in the Blue Mountains, the risk of losing lives and houses during a bushfire is reduced when compared to conducting only landscape scale prescribed burning. However, the effect of edge burning on reducing the size of a bushfire is less than landscape scale prescribed burning. There is little difference between these two treatment options on reducing damage to roads and powerlines, or tolerable fire interval.

The option of conducting moderate amounts of both edge and landscape burning (that is, the aqua line) represents a compromise between the first two more extreme options. It leads to a major decrease in the risk of the ecosystem being burnt too frequently, while yielding subtle but sometimes significant changes in the risk to other values such as house loss and area burnt.



A comparison of three different prescribed burning treatment options in the Blue Mountains.

- 15% of the landscape burnt and 0% edge burnt
- 0% of the landscape and 15% edge burnt
- 3% of the landscape burnt and 3% edge burnt

high-level summaries, underlying data, raw data, or analysis of all three layers combined. This allowed researchers to explore the raw risk estimates, compare different combinations of case study landscapes and landscape treatments, and explore drivers and other features of risk reduction.

The findings of the project illustrate that there is no 'one size fits all' solution to prescribed burning. That is, the effectiveness of prescribed burning at mitigating risk of damage by bushfire varies considerably across landscapes. This has major implications for fire managers, suggesting that tailored prescribed burning solutions are possible and preferable, as long as they are based on the unique risk mitigation profile for the specific landscape being assessed. Other findings, from the analysis of the 13 case study landscapes, include:

- In most cases, increasing the rate of prescribed burning treatment reduces the risk of area burnt by bushfire, life loss, house loss, damage to roads and damage to powerlines, but in many cases there are thresholds beyond which any increased rates of prescribed burning do not lead to a significant increase in benefits.
- In most cases, increasing rates of prescribed burning treatment can be harmful to the ecosystem, as it places more areas at risk of being burnt too frequently (that is, below the minimum tolerable fire interval).
- The cost-effectiveness of prescribed burning varies widely between regions, with variations relating mostly to the spatial configuration of assets and natural vegetation.
- There are interesting comparisons across different landscapes:
  - In Hobart, prescribed burning significantly reduces the costs associated with loss of housing, but the aggregate costs (including cost of burning and cost of other losses) remain relatively constant.
  - In Canberra, the most cost-effective solutions involve treatments focused at the edge rather than landscape.
  - In south east NSW, prescribed burning significantly increases the costs of fire prevention, but has only a modest impact on reducing losses from bushfires.
- Lastly, climate change is expected to reduce the positive effects of prescribed burning, due to increased frequency of extreme fire weather conditions.

END-USER STATEMENT

"It is expected that this project will trigger a significant change in the way fire management agencies deliver their hazard reduction programs and proposed fuel management activities. The ability to quantify risk and cost to life and property, as well as environmental impact and infrastructure damage under a range of different scenarios, will lead land managers to optimised burning strategies for wildfire risk mitigation. This project will support agencies to make more robust evidence-based decisions and tailor their burning programs to optimise risk reduction and cost benefits according to their needs. The results emerging from this project will be used by a broad range of stakeholders with multiple objectives. The Atlas will strengthen the narrative that the reduction in risk from prescribed burning varies depending on management value and local variations in landscapes and vegetation communities across south-eastern Australia."

Dr Felipe Aires, Fire Incident Management Section, National Parks and Wildlife Service, Department of Planning, Industry and Environment, NSW

HOW COULD THIS RESEARCH BE USED?

Prescribed burning remains a critical component of contemporary fire management in Australia and elsewhere. Researchers developed the Prescribed Burning Atlas for systematically comparing the prescribed burning effects on risk mitigation across different landscapes and management values.

The Atlas was designed to provide an easy-to-access interface to the research findings, and enable fire agencies to respond in a credible way to demands for transparent accounting of the costs and benefits of their activities. It does this by combining methodologies for assessing the effects of prescribed burning on fire behaviour and risk to management values, including costs.

The Atlas is strategic rather than tactical in nature, analysing long-term, landscape-scale effectiveness of prescribed burning (considering the unique mix of vegetation, climate, ignition probability, weather and assets), rather than pros and cons of burning individual blocks at specific dates. Further development of the Atlas could generate these fine scaled tactical insights. The Atlas is a decision support tool and is expected to be used alongside other knowledge in the development of prescribed burning programs.

The findings of this research can be accessed via the Atlas website at https://prescribedburnatlas.science. This dedicated website is for fire managers, researchers and anyone else interested in research and data to support their planning, decision making and communication. It is a geographically based summary of risk for decision makers in an accessible, user-friendly format. It is unique because the key focus from the start has been the design and delivery of this new approach to understanding the costs and benefits of different prescribed burning strategies across multiple landscapes – allowing users to compare different approaches as they develop their plans.

FUTURE DIRECTIONS

While this project represents an important step forward in bushfire risk management research, a number of challenges remain to maximise its value. To address this, additional landscape types will be added to the Atlas in 2021, identify similarities between the case study landscapes, and expand the regions covered by identifying similarities between the case study areas and other locations across southern Australia.

The modular approach that has been used to build the Atlas means that there are opportunities to add new values (e.g. agricultural impacts, human health impacts from smoke) to the Atlas or to modify existing values if appropriate. The ongoing active involvement of end-users will be crucial in ensuring uptake and translation into outcomes for fire and land management agencies.

The Atlas may also have beneficial value as a tool to support internal and external communications and education, aside from its core role in strategic planning and risk assessment. Project outputs can be used to educate stakeholders and increase knowledge about the relationships and trade-offs between biophysical drivers, planned and unplanned fires and associated costs and losses.

Finally, as the understanding of bushfire risk and the effects of bushfire management improves, it may be possible to transition from cost effectiveness analyses to a cost-benefit analyses, moving from an appraisal of costs of different management options to an assessment of their net benefit to society.

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The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

HAZARD **NOTE**

bushfire&natural HAZARDSCRC

ISSUE 67 NOVEMBER 2019
TOPICS IN THIS EDITION | COASTAL | FLOOD | STORM SURGE

ADAPTION PATHWAYS TO MANAGE INCREASING COASTAL FLOOD RISK

ABOUT THIS PROJECT

This research was conducted as a PhD study, *Improving adaptation planning for future sea level rise and coastal flooding*, under the broader Bushfire and Natural Hazards CRC project *Resilience to clustered disaster events on the coast – storm surge*. The framework described in this *Hazard Note* is available at bnhcrc.com.au/hazardnotes/67

AUTHORS

Dr Timothy Ramm, University of Tasmania. Dr Ramm completed his Bushfire and Natural Hazards CRC PhD in 2018 and now works at the Australian Antarctic Division. Contact timothy.ramm@utas.edu.au

SUMMARY

Coastal communities are locked into a future of rising sea levels that will cause more frequent extreme hazards such as storm surge, tidal flooding and permanent inundation of low-lying areas. This will place increasing pressure on governments, businesses and residents to identify preventative strategies that minimise the exposure and vulnerability of people, properties and the environment to coastal flooding.

Whilst future consequences are unknown, along with the rate (mm per year) and height of sea level rise, adaptation pathways can support coastal decision makers to plan a range of alternative actions that keep future impacts within acceptable limits. Through mapping out flexible plans and monitoring early warning indicators, decision makers can anticipate changing risks and act before impacts become unacceptable to the community, i.e. before adaptation tipping points are reached.

▲ **Above:** TEMPORARY EROSION AT KINGSTON BEACH, TASMANIA. PHOTO: TIM RAMM

CONTEXT

Climate change adaptation is a wicked problem that adds complexity to long-term planning and decision making. These problems are challenged by knowledge uncertainty, contested stakeholder goals, social power inequalities, differing risk perceptions and short-term political cycles.

Informed planning decisions are needed from all levels of government as choices made today shape urbanisation and coastal use patterns over the coming decades. Poor planning decisions can result in costly impacts if those choices increase the exposure and vulnerability of communities to coastal flood events.

BACKGROUND

Adaptation pathways enable dynamic planning under conditions of uncertainty. This allows decision makers to take short-term actions and keep future options open, so that they can adjust their plans as conditions change over time.

Whilst adaptation pathways offer a promising way to deal with irreducible uncertainty, there are two notable challenges not yet explored. The first is how computational modelling that simulates changing hazard, exposure and vulnerability risk factors can help to better understand what changes will cause adaptation tipping points to be reached. The second is how social values information can be incorporated into the adaptation planning process, to provide more socially oriented adaptation plans that better align with the well-being of residents and their way of life.

BUSHFIRE AND NATURAL HAZARDS CRC RESEARCH

Key elements of the adaptation pathways process were developed using theoretical case studies in Tasmania and Victoria.

Geographic information system (GIS) software and open source programming tools were used to analyse community impacts across many future what-if scenarios. This uncovered what changes those communities were most sensitive to and therefore what amount of change would cause adaptation tipping points to be reached for those communities.

Social and cultural values were obtained using a mail-out survey in Kingston Beach, Tasmania. The survey uncovered what values were important to the everyday lives of residents in the coastal suburb and the extent

to which this information could be used in the adaptation pathway planning process. A total of 961 surveys were issued with 322 survey responses received (a response rate of 34 per cent).

RESEARCH FINDINGS

The final outcome of this research was an adaptation pathway planning framework, which draws upon three important lessons learned from the Tasmanian and Victorian case studies.

The first innovation was an improvement to the way adaptation tipping points are described, by modelling multiple scenarios and accounting for time-varying risk factors. This was critical to understanding how impacts to people and property are influenced by the rate of environmental change and the rate at which coastal communities can adapt.

Second, social values provided insights on what communities' value in their everyday coastal lives, where values were attributed to natural landscapes and manmade infrastructure, and for whom sea level rise and other climate change impacts are likely to cause the greatest disruption. This information has potential applications in the selection of adaptation objectives, design of adaptation options, evaluation of alternative pathways and identification of indictors to monitor changing risk.

Thirdly, GIS software and open source programming were used to illustrate how readily available tools can provide a lower-cost entry point for resource constrained local governments to undertake adaptation planning.

HOW COULD THIS RESEARCH BE USED?

Local government are at the forefront of coastal climate change adaptation decision making and will face increasing pressure to ensure the sustainability of their communities, whilst minimising costly impacts from increasing coastal floods.

This research can support coastal decision makers to identify long-term adaptation plans to manage future flood risks. The framework provides a process for local government to further engage with communities to identify values that are important to the wellbeing of residents and how those values might be preserved in a changing world.

A consultative process supports local knowledge sharing and alignment of planning objectives. This is important in dealing with complex wicked problems by building trust amongst participants.

An improved ability to describe adaptation tipping points helps coastal decision makers understand questions like 'how vulnerable are existing communities to future changes?', 'what changes would cause unacceptable flood impacts?' and 'how effective are different adaptation responses?'. This enables decision makers to consider more broadly how societal development, land use and existing building regulations might exacerbate coastal flood impacts, and what responses could mitigate flood risk and enhance community wellbeing.

A better understanding of adaptation tipping points can facilitate more targeted data collection and coastal monitoring activities when resources are constrained. Early warning indicators provide a mechanism for communities to observe local changes to risk and validate decisions for adaptation action.

FUTURE DIRECTIONS

Further work is needed to apply the complete adaptation pathways planning process to pilot studies and evaluate the extent to which residents reach consensus on the objectives, risk tolerance, planning actions and monitoring systems.

The application of the framework to other natural hazards, not just coastal flooding, could be investigated with an intention to work towards a more standardised national approach to long-term climate change adaptation.

END-USER STATEMENT

"The principle of adaptation pathways and their practical consideration in a real life situation has been of significant benefit to Kingborough Council. The complexity of potential inundation risk data and issues for a coastal community such as Kingston Beach are daunting, especially with the predicted exasperation of impacts into the future due to climate change.

"The use of adaptation pathway principles provides a structured means of progressing risk management and adaptation planning, as well as stimulating meaningful dialogue between key stakeholders and potentially impacted community members."

– Jon Doole, Manager – Environmental Services, Kingborough Council, Tasmania

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Hazard Notes are prepared from available research at the time of publication to encourage discussion and debate. The contents of *Hazard Notes* do not necessarily represent the views, policies, practises or positions of any of the individual agencies or organisations who are stakeholders of the Bushfire and Natural Hazards CRC.

HAZARD **NOTE**

bushfire&natural HAZARDSCRC

ISSUE 46 MARCH 2018

TOPICS IN THIS EDITION | FIRE SEVERITY | LAND MANAGEMENT | MODELLING | PRESCRIBED BURNING

STRENGTHENING FIRE MAPPING FOR IMPROVED FIRE MANAGEMENT AND CARBON ABATEMENT IN NORTHERN AUSTRALIA

ABOUT THIS PROJECT

This research was conducted as part of the *Tools supporting fire management in Northern Australia* project. It is part of a far-reaching program of mostly web-based fire management information, derived from satellites, to assist land managers in fire planning, monitoring and evaluation across very large tracts of land.

AUTHORS

Professor Jeremy Russell-Smith and Dr Andrew Edwards, Charles Darwin University. For more information contact jeremy.russell-smith@cdu.edu.au

SUMMARY

A national approach is under development that provides a standardised assessment of fire regimes across Australia's savannas and rangelands. This Savanna Monitoring and Evaluation Reporting Framework will gather all aspects of the research to date and provide users with the ability to monitor their fire management and evaluate its effects, providing a single point to assess and compare the outcomes of fire management across 70 per cent of the continent.

Above: AN EARLY DRY SEASON BURN CONDUCTED NEAR DARWIN. PHOTO: NATHAN MADDOCK, BUSHFIRE AND NATURAL HAZARDS CRC.

This research builds on dynamic up-to-date web-based fire mapping which the team has been involved with since 2002. Over the last three years the mapping has become more sophisticated, incorporating actual fire effect, not just basing effects on fire seasonality. Displayed on the North Australia Fire Information (NAFI) website, the information is used for fire management operations, planning and suppression, and is analysed to describe past and present fire regimes.

CONTEXT

Extensive field information and local knowledge provide models of fire effects in the fire prone tropical savannas of northern Australia. Fire modelling can be applied to fire mapping to describe the effects of fire regimes across the whole landscape. This research compares past and present fire regimes to better understand the effects of various fire management practices.

BACKGROUND

Northern Australia is an extensive area with a small population and limited infrastructure. There is considerable summer rain (the wet season) and almost no winter rain (the dry season). In the wet season, grass and trees grow prolifically, producing abundant fine fuel for fires. The temperature is relatively high all year, so that when the rain stops at the end of the wet season, the fine fuels dry quickly and are extremely fire prone – large tracts of the region burn annually. One simple ignition in the latter half of the dry season can create a bushfire that will burn for months, even if the area had burnt in the previous year. However, prescribed burning is very effective at limiting the spread of bushfires.

Fires are monitored through the North Australia Fire Information website. Evaluation of fire regimes is undertaken at a very rudimentary level in most organisations,

HAZARD **NOTE**

SAVANNA MONITORING AND EVALUATION REPORT FRAMEWORK EXAMPLE

This assessment is made to compare a savanna burning project that has an improved fire regime. A baseline period is the 10 (or 15) year period before the project started where fire management was not undertaken properly; the project period is the period since the project started until now. In figure 1, The calculations of various fire metrics for the most recent year (2015 in this example) of the project are compared to the baseline (2000-2009) and the previous project years (2010-2014).

Fire metrics

1. **Area** – The objective is to reduce the total amount of country that is burnt each year.
2. **Time of year (season)** – The objective is to have more country burnt by early season fires and less by late season fires. Late season fires are more likely to kill plants and animals and damage cultural sites.
3. **Long unburnt areas (three or more years)** – Needed to ensure refuges for many species, and are an important factor for biodiversity. Objective is that the total area of long unburnt country increases.

   In figure 2 the total area of long unburnt country is calculated for the baseline, the previous project years (2010-2014), the current year (2015), the difference between the total pre and post project, and a comparison between 2015 and the previous project years (2010-2014).
4. **Patches on long unburnt country** – It is important that not all of the long unburnt country is just in one big patch, as one fire could burn it all.

FIGURE 1: A COMPARISON OF THE % AREA BURNT IN THE EARLY AND LATE DRY SEASON

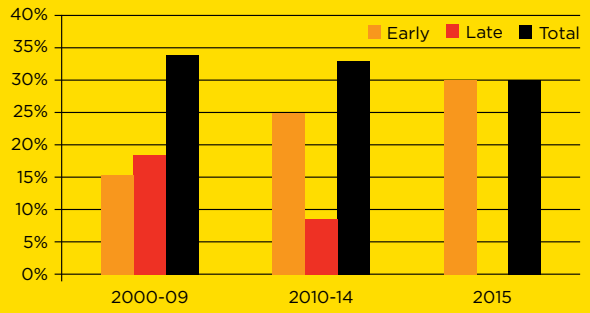
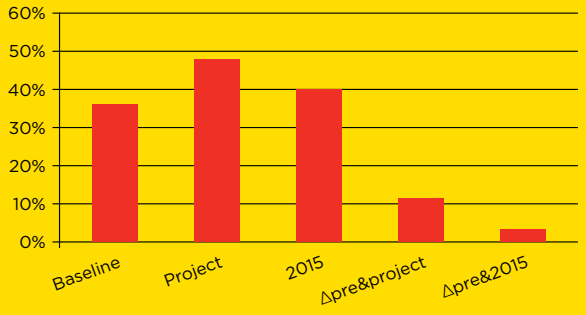


FIGURE 2: THE TOTAL PROPORTION OF LONG UNBURNT (3+ YEARS) AREA



if reported at all, taking into account simple calculations of the area burnt, the seasonality and the frequency of fire.

Some groups such as the Kimberley Land Council, Kakadu National Park and the West Arnhem Land Fire Abatement project provide information to stakeholders regarding the efficacy of their fire management in sophisticated reports that assess the effects of the past year's fire against previous years; and a set of key performance indicators related to ecosystems and biodiversity.

Many other groups in north Australia aspire to this level of sophistication in their own monitoring and evaluation, however, it is analytically demanding, requiring an experienced spatial scientist to derive the various fire layers; create and collate the underlying vegetation or habitat information; and undertake the spatial calculations.

Through an extensive consultation process with many stakeholders, a suite of metrics are being identified, and will be made available to land managers, Indigenous rangers and pastoralists to choose from to meet different reporting requirements.

END-USER STATEMENT

The savanna mapping tools currently available are critical to all aspects of fire management and are used daily by Bushfires NT and stakeholders for planning, mitigation, suppression, monitoring, and evaluation and reporting. The Bushfires Council of the NT, a statutory representative body, has identified ongoing funding for the continuation of products available on the North Australia Fire Information website as one of the highest Territory-wide risks for effective fire management. With the emergence of new industries such as carbon farming, bushfire management is rapidly changing, requiring decisions to be prioritised based on risk. The Savanna Monitoring and Evaluation Report Framework will provide a suite of science-based information to help identify and communicate risk between stakeholders. Bushfires NT wholeheartedly supports the project.

– Andrew Turner, Director of Strategic Services, Bushfires NT

BUSHFIRE AND NATURAL HAZARDS CRC RESEARCH

Sophisticated and informative metrics of fire impacts can only be useful for land management if it can be mapped across the landscape. Since 2014, this study has supported the development of more sophisticated fire mapping and modelling of fire severity, as well as other fire metrics, such as the frequency of wild or managed fire, and fuel age and load.

Fire seasonality in northern Australia provides inferred information regarding the effect of a fire. That is, a fire in the late dry season is generally known to be much hotter than a fire in the early part of the dry season. However, in the middle of the season the ratio of low to high severity is not so clear. Currently, a cut-off date has been selected between the early and the late dry season (31 July), as the early dry season period encompasses the majority of low intensity prescribed burning activities. The 31 July date is a north Australian average derived from years of data. There are as yet no published data that would enable different dates to be applied across different regions of north Australia.

In the savanna burning methodology for greenhouse gas emissions abatement,

The objective is that the number of long unburnt patches (>100ha) increases (see figure 3).

5. **Distance from burnt to long unburnt patches** – Long unburnt areas should be spaced out. The objective is that the distance (maximum and average) between burnt and long unburnt areas decreases. The results of the fire management program have decreased the average distance from burnt to long unburnt patches by more than half in each of the project areas (see figure 4).
6. **Fire frequency (how often an area gets burnt)** – The objective is to reduce the average fire frequency for country in the project area. Fire frequency has increased to near, or greater than, baseline averages. This is due to the increased amount of low intensity, patchy, early dry season fire. Even a high frequency of early dry season fires has shown to have little or no effect on the number and diversity of plant species, compared to a very poor effect from one or two late dry season fires.

FIGURE 3: THE NUMBER OF LONG UNBURNT PATCHES (3+ YEARS)

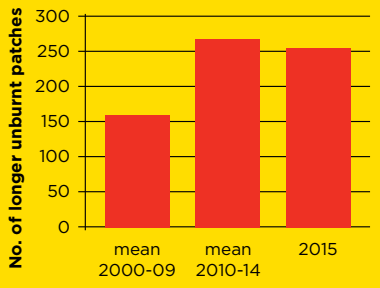


FIGURE 4: THE AVERAGE DISTANCE FROM BURNT TO LONG UNBURNT AREAS

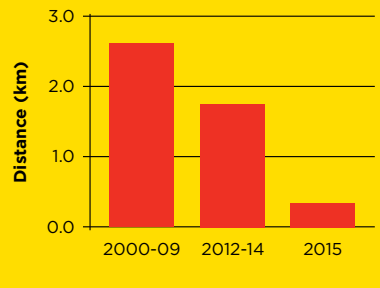
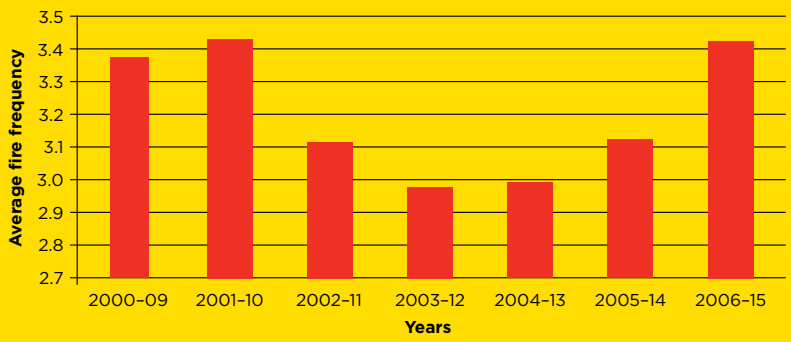


FIGURE 5: THE FREQUENCY OF FIRES



late dry season emissions are nearly double early dry season emissions. The method developed by this research assesses the project area's emissions for the current year, which should be less with improved fire management, compared to a much higher 10 or 15-year baseline period. It calculates the difference, and refers to it as greenhouse gas emissions abatement. Emissions abatement is worth hundreds of thousands of dollars, therefore the seasonal cut-off is crucial to the carbon credits an abatement project can earn.

Fire severity mapping developed through this research is crucial to many of the descriptions of fire effects in savanna and rangeland habitats, and in particular for the development of a new, more appropriate, greenhouse gas emissions abatement methodology. This new methodology would map actual fire effect instead of using fire seasonality, as in the current methodology. Fire severity is currently mapped savanna-wide with overall accuracies of approximately 70 per cent. This is in contrast to burnt area mapping, which achieves accuracy greater than 90 per cent across the savannas. To apply the new savanna burning methodology developed by this research, a similar level of accuracy is required.

RESEARCH FINDINGS

This study has compiled satellite-derived fire and habitat mapping to describe the extent, occurrence and severity of fire at various scales to assess fire effect in various habitats. These models have been developed from extensive long-term field sampling from a suite of permanent sites across the Kimberley, Cape York, the western Top End, and the Gulf of Carpentaria region around the Northern Territory/Queensland border, that describe species change, fuel accumulation and tree growth with respect to fire regimes.

Data from the long-term fire monitoring plots were analysed to look at trends in fire effects on various vegetation communities, indicator plant species and functional groups. The team interpreted the fire history for each site from the biannual plot photographs, including the fire severity based on the scorch height on vegetation.

The analyses indicated a suite of key indicators, significantly affected by different fire metrics, encompassing a range of savanna habitats. Key indicators include:

- **Sandstone uplands,** which are extensive in northern Australia and include the Mitchell Plateau in the Kimberley, the Arnhem Land Plateau in the Top End, and the Heathlands in the far north east of Cape York. These are rugged areas, contain some of the highest biodiversity in the region and comprise a diversity of mainly obligate seeder taxa (species that only grow from seed) mostly with juvenile periods of less than three years, but with a proportion of species requiring longer fire-free intervals for maturation. This leads them to be highly susceptible to short intervals between fires, leading to local extinction, and up to wide-spread extinction if large bushfires occur.
- **Savanna and sandstone trees** occur in woodlands. Small and old trees are vulnerable to intense fires; however, the evidence is unclear on the effects of fire frequency on tree saplings. Diversity of non-eucalypt tree species, that are typically smaller in stature, is relatively susceptible to severe fires. The key indicator species Cypress Pine is a long-lived obligate seeder,

occurring in stands within the savanna matrix, with juvenile periods likely to exceed 10 years. Saplings and adult trees are susceptible to high severity fire.

- **Monsoon rainforests** occur typically in rugged broken terrain, affording some level of fire protection. There are many large resprouter tree species, often fire scarred and hollowed by termites, and hence vulnerable to fire especially on patch boundaries. However, the death of the larger stems releases saplings.

HOW IS THE RESEARCH BEING USED?

The fire mapping information and models developed through this research support various programs including: the CRC's *Enhancing remote north Australia community resilience* project and the Bushfires NT risk and hazard mapping framework, both detailed further below.

The project *Enhancing remote north Australia community resilience* is developing community-based scenario planning workshops. These involve a level of participatory planning that will rely heavily upon a number of mapping tools developed from simple fire metrics such as fire frequency, including the fire severity maps and the many models derived from fire severity mapping.

Risk and hazard mapping by Bushfires NT relies upon the fire mapping information developed within this research. It can be shared with rural fire agencies and other land management agencies, particularly in Queensland, Western Australia and South Australia.

There are many beneficiaries of a new savanna burning methodology, including the federal Department of Environment and Energy, countless Indigenous resource agencies, all the northern land councils, the Indigenous Land Corporation, numerous pastoral lease holders, Queensland Parks and Wildlife Service, the Department of Biodiversity, Conservation and Attractions WA and the Parks and Wildlife Commission NT. Currently northern Australia is generating over $30 million annually in this new carbon sector on over 330,000 km², which is still only 40 per cent of the potential extent for these projects. The new methodology will open the industry up to more of these stakeholders, particularly in East Arnhem Land and on Cape York, with a later beginning to the dry season.

The Savanna Monitoring and Evaluation Reporting Framework will gather all aspects of the research to date and provide users with the ability to monitor their fire management and evaluate its effects through time. It will provide a single point to assess and compare the outcomes of fire management across 70 per cent of the continent. See an example of the framework on pages 2 and 3.

▲ **Above:** AN EXAMPLE OF VEGETATION JUST AFTER AN EARLY DRY SEASON BURN. PHOTO: NATHAN MADDOCK, BUSHFIRE AND NATURAL HAZARDS CRC.

FURTHER READING

Murphy B, Edwards A, Meyer C and Russell-Smith J (2015). Carbon Accounting and Savanna Fire Management. Melbourne, CSIRO Publishing

Russell-Smith J, Whitehead P and Cooke P (2009). Managing fire regimes in north Australian savannas – ecology, culture, economy. Rekindling the Wurrk tradition. Canberra, Australia, CSIRO Publishing

FUTURE DIRECTIONS

The Savanna Monitoring and Evaluation Reporting Framework will be developed by a spatial web-enabling business, coordinated through this project. While the conceptual framework and many of the metrics have been determined, the exact funding avenues have not. Please contact the authors if you are interested.

A series of workshops have been undertaken across Queensland, the Northern Territory and Western Australia to determine the content for the framework. As user input is key, the team has designed strategies for projects to further develop user engagement, such as the Natural Disaster Mitigation Program, amongst others.

The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

HAZARD **NOTE**

bushfire&natural HAZARDSCRC

ISSUE 31 JUNE 2017

TOPICS IN THIS EDITION | COASTAL | HYDROLOGY | MODELLING | STORM SURGE

NEW TECHNOLOGIES TO BETTER MANAGE COASTAL EROSION

ABOUT THIS PROJECT

This research is part of the *Resilience to clustered disaster events at the coast: storm surge* project, and builds on research from *Hazard Note* 16, May 2016.

AUTHORS

Dr Scott Nichol, Dr Gareth Davies, Dr Andrew McPherson, Dr Jane Sexton, Geoscience Australia; Dr Uriah Gravois, Prof Tom Baldock, Dr Dave Callaghan, University of Queensland. Contact scott.nichol@ga.gov.au

SUMMARY

Coastal erosion is an ongoing problem for some populated areas of the Australian coast. The fundamental processes that cause erosion during storms are generally well understood and management strategies are available. However, the response of beaches to successive storms (storm clusters), such as those that damaged Australia's east coast in 1974, is not well understood or managed, with the response of any given beach depending on its physical characteristics. Because of this, the likely effectiveness of a given management strategy may not be clear, such as beach nourishment (a remedial process where sand is added to a beach to restore its shape). This project has developed an analytical toolkit for coastal managers to better understand beach response to clustered storms and to place this in the context of the geological and oceanographic setting for a given part of the Australian coast.

▲ **Above:** ERODING SECTION OF OLD BAR IN NEW SOUTH WALES SHOWING EXPOSED ROCK AT THE FOOT OF THE DUNE. THE GROUND-PENETRATING RADAR IMAGE ON PAGE 2 WAS COLLECTED ALONG THE BEACH AT THIS LOCATION.

CONTEXT

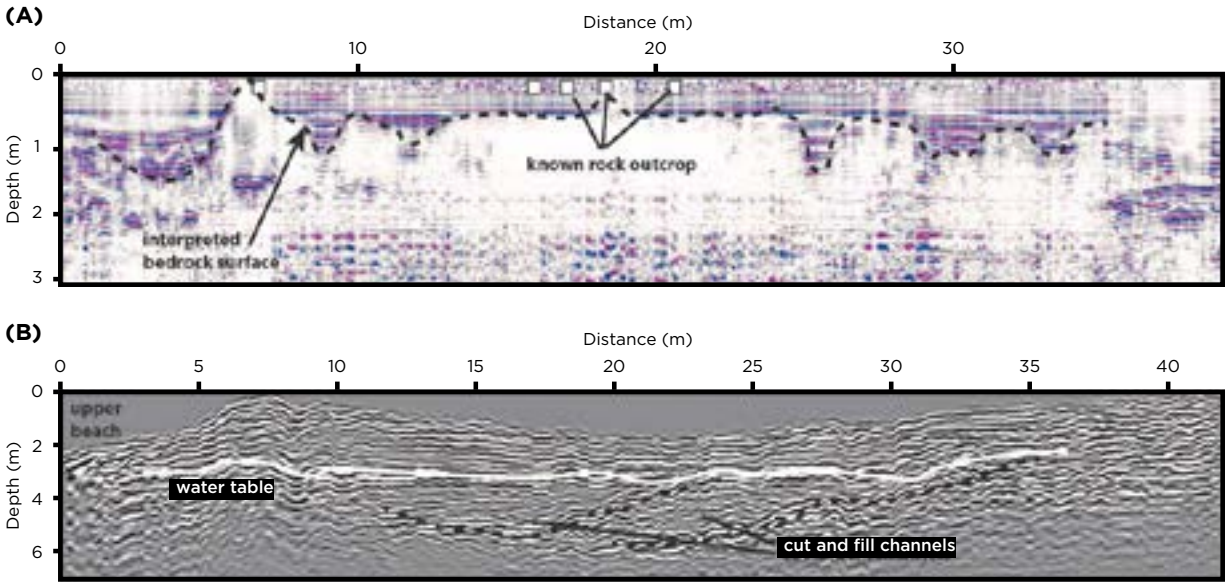
This project aims to investigate how clusters of storms can be modelled and their impact on beach erosion determined.

BACKGROUND

The physical processes that cause coastal erosion are reasonably well understood at the fundamental level and are built into a range of numerical shoreline response models. However, modelling the response of a particular beach under specific conditions, such as clustered storms, remains a challenge. This project sets out to develop a methodology and demonstrate it through two case study sites, which had different oceanographic and geological settings. The methodology combined expertise in statistical modelling, hydrodynamics, coastal geology, hazard mapping and impact analysis. The project aimed to integrate these approaches to develop tools, information and methods that can be used by others nationally.

BUSHFIRE AND NATURAL HAZARDS CRC RESEARCH

In late 2014, in consultation with end-users, two case studies were selected: Old Bar on the New South Wales mid north coast (between Newcastle and



▲ **Above:** IMAGES OF THE SUB-SURFACE STRUCTURE OF OLD BAR FROM GROUND-PENETRATING RADAR (GPR) SURVEY. (A) PROFILE COLLECTED IN AN ALONGSHORE DIRECTION SHOWING LAYERS OF BEACH SAND (HORIZONTAL RED AND BLUE LINES) OVERLYING AN UNEVEN ROCK LAYER (DOTTED BLACK LINE). THE BEACH SAND IS ABOUT ONE METRE THICK AND THE ROCK EXTENDS TO A DEPTH OF MORE THAN THREE METRES, AND EXTENDS ALONG THE BEACH A DISTANCE OF AT LEAST 30 METRES. PRIOR TO THE GPR SURVEY THE LOCATION OF BURIED ROCK AT OLD BAR WAS UNKNOWN, APART FROM SMALL AREAS OF EXPOSED ROCK (SEE PAGE 1 PHOTO). (B) PROFILE COLLECTED ACROSS THE NORTHERN END OF OLD BAR AND DUNES SHOWING SAND IS AT LEAST 4 M THICK. THIS INFORMATION IS INVALUABLE FOR UNDERSTANDING COASTAL EROSION PROCESSES AND IS BEING USED TO RE-ASSESS HAZARD LINES IN THE COASTAL MANAGEMENT PLAN FOR OLD BAR.

Port Macquarie) and the Adelaide metropolitan beaches in South Australia. These beaches were identified as key localities where erosion is an ongoing issue and where field studies and modelling would provide new insights into the problem. Fieldwork completed in early 2015 collected site data that set the context for the subsequent shoreline modelling. This included the innovative use of ground-penetrating radar to estimate the thickness of beach sediment that can be mobilised during storms.

To model beach response to clustered storm events required the development of an artificial set of storm waves to best represent storms through time. This was achieved through advanced statistical modelling based on measured (and hindcast) waves at each study site. The storm event data was in turn used to model shoreline response, incorporating site-specific information on water depth offshore and sediment type. The two case studies revealed that differences in wave data led to modifications in the approach to modelling; this demonstrated the utility of the method.

For Old Bar, a 30-year record of wave data measured by an offshore wave-rider buoy was used to model storm waves from different directions. In contrast, for Adelaide the absence of wave buoy data required use of the wind record to reconstruct wave direction and height.

The final stage in the work involved impact and risk assessments that required geospatial data describing the exposed assets at each site. At both Old Bar and Adelaide, assets include houses, commercial property, roads and access stairways.

All field data is openly available online at the Geoscience Australia website. Computer code for statistical modelling of storm waves will be published as open source in December 2017.

END-USER STATEMENT

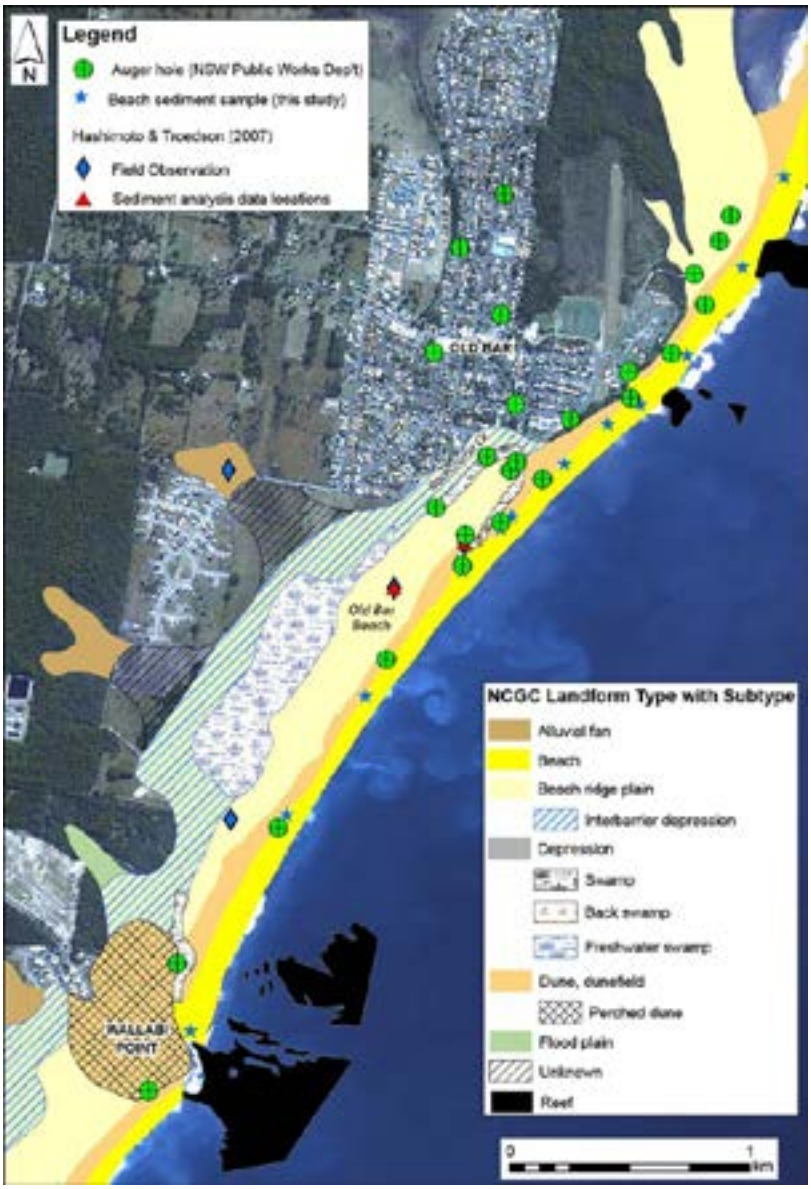
This project has played an important role in building the body of knowledge around shoreline response to clustered storms. The new data, modelling tools and summary information for case study sites are essential reference materials for coastal managers. This allows agencies like my own to take a more informed approach to future coastal management strategies. For example, as the agency responsible for implementing the South Australian Government's Adelaide's Living Beaches Strategy, DEWNR will use the outcomes of this research to refine our annual beach replenishment program, which is used to maintain adequate storm buffers for the protection of infrastructure along the Adelaide coast.

– James Guy, Team Leader Coastal Programs, Department of Environment, Water and Natural Resources, South Australia.

RESEARCH FINDINGS

For Old Bar, the research found that erosion and property loss are centred on a section of coast where sand cover is limited by shallow bedrock and offshore reefs. This means that the potential for natural beach recovery is hindered by a finite local sand supply, and modelling indicates that further shoreline retreat is possible. Other parts of the beach are more stable due to larger sand reserves onshore and offshore, as evidenced by sand dunes up to 200 metres wide. These findings support previous observations and are consistent with independent hydrodynamic modelling for Old Bar that shows erosion associated with a near-shore circulation cell under storm conditions.

For the Adelaide metropolitan beaches, erosion is managed effectively through an established beach-nourishment program. This project demonstrated that nourishment strategies could be fine-tuned and made more cost-effective by



▲ **Above:** A MAP OF OLD BAR AND HINTERLAND SHOWING COASTAL LANDFORMS AS MAPPED USING THE NATIONAL COASTAL GEOMORPHOLOGY CLASSIFICATION SCHEME (HAZELWOOD *ET AL.*, 2013). THIS INFORMATION PROVIDES COASTAL MANAGERS WITH AN OVERVIEW OF THE LOCATION AND EXTENT OF LANDFORMS THAT MAY BE EXPOSED TO COASTAL EROSION (FOR EXAMPLE, BEACH OR DUNE).

mapping beach thickness using ground-penetrating radar. At the time of fieldwork (February 2015) the narrow southern beaches of Adelaide were less than two metres thick in places, whereas northern beaches were greater than four metres thick and tens of metres wider. This rapid assessment method provides land managers with reliable data to quantify sand volumes on individual beaches and, in turn, gauge the scale of ongoing beach-replenishment work.

HOW IS THIS RESEARCH BEING USED?

As part of the project's utilisation plan, a workshop was held with end-users in April 2017. The workshop focused on two aspects: the software that enables statistical modelling of storm events and the preliminary results from shoreline modelling at Old Bar. Feedback from end-users was centred on the value of improving on-the-ground knowledge regarding the processes driving coastal erosion at case study sites and the potential for end-users to make use of data and software modelling tools. It was noted that coastal managers would likely engage consultants to undertake future modelling, as was typically the practice in state agencies.

While the modelling to date has focused on Old Bar in New South Wales, the South Australian end-users wish to compare the current beach management strategies with the modelling results and make changes

GPR INSIGHTS

Ground-penetrating radar (GPR) surveys were conducted at both study sites in early 2015 to define the thickness of sediment that could be potentially eroded during a storm. Figure 1 (page 2) shows an example of a GPR image of the beach thickness at Old Bar Beach. This data can be used in conjunction with the National Coastal Geomorphic Classification (Hazelwood *et al,* 2013) and the Australian Coastal Sediment Compartments (McPherson *et al,* 2015) to characterise landforms in the coastal zone and to provide site-specific information for detailed shoreline response modelling.

FURTHER READING

Hazelwood M, Nicholas WA and Woolf M, (2013), National Coastal Geomorphology Information Framework: Discovery and Distribution. Record 2013/35. Geoscience Australia: Canberra. https://d28rz98at9flks.cloudfront.net/74294/Rec2013_035.pdf

McPherson A, Hazelwood M, Moore D, Owen K, Nichol S and Howard F (2015), The Australian Coastal Sediment Compartments Project: methodology and product development. Record 2015/25. Geoscience Australia: Canberra. http://dx.doi.org/10.11636/Record.2015.025

Nichol S, McPherson A, Davies G, Jiang W, Howard F, Gravois U, Callaghan D, and Baldock T (2016), A framework for modelling shoreline response to clustered storm events: A case study from south east Australia, *Journal of Coastal Research Special Issue*, **75**, pp. 1197-1201. http://www.jcronline.org/doi/pdf/10.2112/SI75-240.1

▲ **Above:** ASSESSING OLD BAR AFTER THE APRIL 2015 EAST COAST LOW. PHOITO: UNIVERSITY OF QUEENSLAND.

if required. South Australian coastal managers are also planning similar studies for other beaches using the methodology showcased in this project.

In New South Wales, the project results will be part of a broader conversation about how to manage the coastal erosion hotspot of Old Bar. For instance, the sub-surface investigations using ground-penetrating radar are being used by the New South Wales Office of Environment and Heritage to re-assess hazard lines as it develops a coastal management plan for the area.

For all end-users, seeing the data, methods and tools being published and made open source is a positive step towards enabling others to apply this method at other locations.

FUTURE DIRECTIONS

From a research perspective, understanding the processes that drive coastal erosion requires the integration of modelling across multiple time scales. These range from wave and tide processes operating over hours to days, to sedimentation processes operating over years to decades, and longer. This project has focused on the short term in order to better understand the impact of clustered storms that may occur over periods of weeks to months. Uncertainties in this modelling relate to assumptions made on longer term processes that influence sediment supply to coastal compartments. Future work should therefore be aimed at model refinement to better integrate across short to long time scales, so that coastal managers have a more holistic understanding of the natural behaviour of the coast.

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HAZARD **NOTE**

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ISSUE 16 MAY 2016

TOPICS IN THIS EDITION | COASTAL | CYCLONE | STORM SURGE | TSUNAMI

OCEANS ON THE RISE

ABOUT THESE PROJECTS

This is an overview of the *Coastal management* cluster of Bushfire and Natural Hazards CRC research projects. This cluster has two linked studies:

1. **Developing better predictions for extreme water levels** – Prof Charitha Pattiaratchi, Dr Sarath Wijeratne, Dr Ivan Haigh, Matt Eliot, Dr Ivica Janekovic, Dr Yasha Hetzel, The University of Western Australia. Contact chari.pattiaratchi@uwa.edu.au
2. **Storm surge: resilience to clustered disaster events on the coast** – Dr Scott Nichol, Dr Andrew McPherson, Floyd Howard, Dr Wenping Jiang, Dr Gareth Davies, Duncan Moore, Dr Jane Sexton, Geoscience Australia; Professor Tom Baldock, Dr David Callaghan, Dr Uriah Gravois, University of Queensland. Contact scott.nichol@ga.gov.au

CONTEXT

Around 85% of Australia's population live within 50km of the coast, alongside a significant proportion of key assets and infrastructure. Yet these coastlines are exposed to a range of natural hazards that can cause severe damage. This research will strengthen Australia's capability to make informed decisions for an improved resilience of coastal communities and infrastructure.

DEVELOPING BETTER PREDICTIONS FOR EXTREME WATER LEVELS

▲ **Above:** RESEARCH IS INVESTIGATING WHERE EXTREME WATER LEVELS CAN IMPACT THE COAST AND CAUSE DAMAGE, SUCH AS AT JIMMY'S BEACH IN NSW. PHOTO: NSW SES

BACKGROUND

The potential impacts of extreme water levels along Australia's coasts are increasing. To better prepare, coastal engineers, managers and planners need accurate estimates for extreme water levels. This project is developing better predictions and forecasts for storm surges, surface waves, continental shelf waves, meteotsunamis, mean sea level rise and the transition from tropical to extra-tropical cyclones.

RESEARCH ACTIVITY

Extra-tropical cyclones are cyclones that continue much further south than normal, and differ from tropical cyclones in that their energy source is not a warm ocean, but temperature differences in the atmosphere. Cyclones that undergo extra-tropical transition can interact with approaching cold fronts and extend cyclone-like conditions over a larger area and to latitudes that do not typically experience such storms. A preliminary review of the literature and extra-tropical cyclone tracks has been undertaken, with few studies previously investigating this in Australia.

Continental shelf waves are a lesser known effect of cyclones that make landfall, and can spread along the coast, influencing water levels thousands of kilometres away. In Australia, continental shelf waves travel in an anticlockwise direction. A model is being used to investigate the effects in Western Australia, which has the highest number of continental shelf waves in Australia.

A further model has been developed and tested that combines (couples) waves and storm surge along Australia's entire coast. It was not anticipated that this would be able to be completed when the project began, and it is the first time a coupled model of this nature has been used in Australia.

Meteotsunamis are caused by the passage of thunderstorms. Atmospheric pressure changes and if the propagation of the pressure disturbance matches the speed generated by a wave, then a meteotsunami could occur. Water levels may only change by up to a metre, but when high tide is factored in, this can become significant. WA can be considered a global hotspot for meteotsunamis, with 25 occurring in 2014. In one instance the increased current from a meteotsunami resulted in a container ship in Fremantle Harbour breaking free from its moorings. The ship collided with the Swan River bridge that carries the Perth to Fremantle train line, closing the bridge and train line for two weeks. Initial work in WA has been expanded to cover all states and the Northern Territory, with 13 locations reviewed for meteotsunami activity between 2009 and 2014.

RESEARCH OUTCOMES

Preliminary findings show that in Australia the south west of WA is the area most at risk from extra-tropical transitions of cyclones, late in the cyclone season, when intense cyclones are most likely to interact with approaching cold fronts. These storms are more likely in La Niña years. The general eastward component of movement of tropical cyclones in the South Pacific means that extra-tropical transition is not as likely on the east coast, as many of the storms curve away from the coast as they move south.

Results from the continental shelf wave model show that a cyclone's path, speed and category affect continental shelf wave generation and propagation. Cyclones that travelled parallel to the coast generated continental shelf waves that were faster than the cyclone forward speed and produced higher amplitude waves than those generated by different trajectories. It is recommended that design criteria, modelling studies and inundation risk assessments for coastal regions in WA consider the effects of continental shelf waves.

Several test cases have been completed using the coupled wave and storm surge model; results indicate that including the effects of waves in the model will account for up to 10-50% of simulated surge heights during an extreme event. Further simulations are being completed for historically significant storm surge events.

Meteotsunami analysis has showed that 214 events occurred over the five-year period. The largest number of events, as well as water heights, occurred in WA at Hillarys Harbour, Cape Cuvier Wharf and Esperance, although significant water heights also occurred in Tasmania at Burnie, Victoria at Portland and in New South Wales at Port Kembla.

STORM SURGE: RESILIENCE TO CLUSTERED DISASTER EVENTS ON THE COAST

▲ **Above:** A RESEARCHER USES A GROUND PENETRATING RADAR DEVICE AT OLD BAR BEACH IN NSW TO UNDERSTAND HOW THE BEACH WILL REACT TO A STORM. PHOTO: GEOSCIENCE AUSTRALIA

BACKGROUND

The aim of this project is to develop a new methodology to quantify the impact and risk of clustered storms on the coast, with an initial focus on storm surge, erosion, reshaping of the coastline, and inundation and damage to buildings and infrastructure.

RESEARCH ACTIVITY

Research is being undertaken at two study sites: Old Bar Beach on the NSW Central Coast, and the Adelaide metropolitan beaches. Data collection has been undertaken at both sites, identifying and defining a minimum thickness for beach and dune sediments, along with determining if the sites have any bedrock that may limit the volume of sand that is needed for beach recovery after a storm.

The data collection, along with a geomorphic mapping assessment, are informing the modelling of shoreline response to clustered storms.

A literature review has also been completed to review suitable models and model frameworks, selecting the best one for each study site. Four models were considered, along with three model frameworks.

RESEARCH OUTCOMES

At Old Bar Beach, bedrock outcrop near the shore and higher on the beach has significant implications for modelling of beach response to storm surge, as reefs close to shore may refract wave energy, concentrating it in one area. Considerations for modelling Old Bar Beach need to take into account reefs and the presence of bedrock because these formations also limit the local supply and transport of sand for beach recovery following a storm.

Data showed that the Adelaide metropolitan beaches are susceptible to erosion, due in part to a limited sand supply and shallow bedrock that is exposed in offshore reefs, particularly at Kingston Park. Considerations for modelling the Adelaide beaches should consider the variations in the sea floor and coastal infrastructure such as artificial reef, groins, seawalls and piers.

END USER STATEMENT

This cluster is delivering high quality science to improve our ability to model extreme water levels around the coastline. A range of organisations will benefit from the findings, from federal agencies, to state departments and emergency service agencies. Federal agencies such as Geoscience Australia and the Bureau of Meteorology will benefit from the science and the data that is being produced, while state planning or transport departments need to know where these events might happen along the coast, and how bad they might be. These departments need to know where to zone land for development, and importantly, land to not be developed, along with optimising their planning schemes. Emergency services will be able to use the scenarios presented in the research to plan their response to natural hazards.

– Dr Martine Woolf, Section Lead, Hazard and Risk Infrastructure and Applications, Geoscience Australia

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HAZARD **NOTE**

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ISSUE 14 FEBRUARY 2016

TOPICS IN THIS EDITION | PRESCRIBED BURNING | FUEL REDUCTION | LAND MANAGEMENT | FIRE SEVERITY

RESEARCH FOR BETTER LAND MANAGEMENT

ABOUT THESE PROJECTS

This is an overview of the *Prescribed burning and catchment management* cluster of Bushfire and Natural Hazards CRC projects.

1. **Optimisation of fuel reduction burning regimes for fuel reduction, carbon, water and vegetation outcomes** – A/Prof Tina Bell, Prof Mark Adams, Dr Tom Buckley, Dr Mana Gharun, Ariana Iaconis, Maggie Norton, Dr Malcolm Possell and Dr Tarryn Turnbull, University of Sydney. Contact tina.bell@sydney.edu.au
2. **Savanna fire management for north Australia** – Adj Prof Jeremy Russell-Smith, Dr Andrew Edwards, Dr Samantha Setterfield, Dr Natalie Rossiter-Rachor, Cameron Yates and Kate van Wezel, Charles Darwin University. Contact jeremy.russell-smith@cdu.edu.au
3. **From hectares to tailor-made solutions for risk management** – Prof Ross Bradstock, Michael Bedward, Bronwyn Horsey, Dr Owen Price, University of Wollongong, Dr Matthias Boer, Dr Luke Collins, Western Sydney University, Dr Trent Penman, University of Melbourne, Hamish Clarke, Office of the Environment and Heritage NSW. Contact rossb@uow.edu.au

CONTEXT

Public and professional expectations of fire agencies and land managers have risen considerably and a greater, more transparent understanding of the trade-offs involved in the management of landscape fire and prescribed burning is required. Tools that standardise risk assessment across different vegetation types, management objectives, agencies and communities are useful to ensure threats are recognised and treated in the same way.

OPTIMISATION OF BURNING REGIMES FOR FUEL REDUCTION, CARBON, WATER AND VEGETATION OUTCOMES

BACKGROUND

This project focuses on improving the capability of land managers to use prescribed fire to reduce fuel loads, while at the same time mitigating the risks of loss of water yield and carbon sequestration capacity.

Two underlying problems have shaped the direction of the study:

1. Limited knowledge of the water storage capacity and dynamics of soil profiles.
2. Limited knowledge of the effects of differing fire intensities on soil carbon.

The study is testing the effectiveness of prescribed burns of different sizes in terms of fuel reduction and impacts on carbon, water and biodiversity.

RESEARCH ACTIVITY

Sampling has been undertaken in sites in mixed-species eucalypt forest in southern Victoria, the ACT and western and southern NSW. This sampling will determine the effect of prescribed fire on changes in fuel load, carbon pools and tree water use.

The sampling scheme investigates 'burn units' – pairs of sites that have been measured and compared. The pair of sites can be burnt and unburnt areas near each other, sampled at the same time, or are a single site sampled at different times before and after prescribed burning. Nearly 50 burn units have been sampled across south eastern Australia. The data collected has been used to test if environmental variability is adequately captured for measurements made at different spatial scales and if fire size affects the optimal number of samples required for characterising burnt and unburnt areas.

RESEARCH OUTCOMES

A literature review has been completed reviewing current modelling frameworks to optimise prescribed fires for both risk mitigation of fuel loads and environmental outcomes. From this review, the research team has proposed a model for optimisation of prescribed burning. The model has two modules; one based on current scientific knowledge and technical experience, and the second based on knowledge gaps in operational and ecological issues. The model could be added to an existing spatial decision support system to provide land managers with a detailed product for exploring and optimising management outcomes in terms of managing effects of fuel reduction on carbon, water and vegetation.

Above: ACT PARKS AND CONVERSATION SERVICE STAFF MEASURING COARSE WOODY DEBRIS BEFORE A BURN IN THE COTTER CATCHMENT. PHOTO: UNIVERSITY OF SYDNEY.

Analysis of data from Victoria and the ACT has found that variation in fuel and soil properties was not as affected by the scale at which measurements were collected in burnt areas than in unburnt areas. Prescribed burning introduces discontinuity to vegetation and soil properties so that a larger number of samples is required in burnt areas than in unburnt areas. However, the variability across burnt areas is smaller in large burns than in small burns. It has also been found that sampling in spatially separate burnt and unburnt plots is comparable to sampling the same plot before and after a fire, and that large prescribed burns (more than 2500 hectares) generally require fewer samples to capture variability across the landscape than small prescribed burns (around 500-1000 hectares).

HAZARD **NOTE**

SAVANNA FIRE MANAGEMENT FOR NORTH AUSTRALIA

BACKGROUND

Australia's tropical savannas are extremely fire-prone – approximately 20% of the savanna region (which covers a quarter of Australia) is currently burnt each year. Annual fire occurrence is particularly frequent across the higher rainfall (more than 1000mm) far northern regions, mostly by severe late dry season fires. The current pattern of late dry season fires impacts on a broad range issues, including community safety and health, production (e.g. pastoral enterprise) and environmental (e.g. soil erosion, stream health, biodiversity, greenhouse gas emissions) values.

This project is:

- Describing environmental risks and providing mapping tools for remote community planning purposes.
- Quantifying the risks posed by flammable exotic grasses (e,g, gamba and mission grasses).
- Exploring fire management challenges in the Gulf of Carpentaria region near the Northern Territory and Queensland border.

▲ **Above:** RESEARCH IS ASSESSING FIRE SEVERITY AT DIFFERENT TIMES OF THE DRY SEASON IN THE NORTHERN SAVANNAS. PHOTO: BILL MCLEOD, BUSHFIRES NT.

END USER STATEMENT

The fuel reduction burning research will improve the efficacy of prescribed burning programs by providing more evidence on the impact of burning on biodiversity, surface and groundwater quality and quantity, and carbon sequestration.

Burn program planners and managers are seeking better tools for forecasting the impact of burn programs on the capacity of the soils to deliver the environmental services required. These tools are efficient survey designs and sampling techniques that are integrated with new predictive spatial models. The application of these tools will give fire management agencies more confidence when assessing the cumulative environmental cost and benefits of the burn programs they propose.

– Max Beukers, Fire and Incident Management, Office of Environment and Heritage NSW

RESEARCH ACTIVITY

To date, the team has developed and refined a fire severity mapping algorithm, building upon existing satellite derived modelling and fire history mapping to assess the risk of fire to biodiversity, emissions and ecosystem services. The 2014 northern Australia fire season was assessed using this method, and then compared with the 15-year average, from 2000 to 2014. Finer scale fire mapping analysis has been undertaken around two remote Top End communities; Gunbalanya and Ngukurr. This has included workshops with Indigenous ranger groups to establish the use of existing mapping products and assess community governance issues affecting resilience in the face of recurring natural hazards (cyclones, floods, savanna fires).

Team members have also visited the Indigenous communities of Borroloola and Robinson River in the Gulf region around the Northern Territory and Queensland border to discuss associated research with key local community members.

RESEARCH OUTCOMES

It was found that the 2014 northern Australia fire season was above average, with 41% of the higher rainfall (more than 1000mm), and 27% of the lower rainfall (600-999mm) areas burnt. Across the whole area, 35% of fires were classified as severe (affecting the upper canopy of trees).

Compared with the 15-year average, this was the largest fire season by area burnt in the higher rainfall area, and the 10th largest in the lower rainfall area. There is a notable change in the ratio of early dry season to late dry season fires since 2010 in Western Australia and the Northern Territory, potentially indicating a change in fire management practices. Both jurisdictions have seen an increase in the proportion of the landscape affected by early dry season fires and a decrease in the proportion of late dry season fires, but notably, there has been a decline in the proportion of the landscape affected by fire overall. This is so far not evident in Queensland.

FROM HECTARES TO TAILOR-MADE SOLUTIONS FOR RISK MANAGEMENT

This project has only recently begun. It aims to develop a prescribed burning atlas for southern Australia to guide implementation of 'tailor-made' prescribed burning strategies in different regions.

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HAZARD **NOTE**

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ISSUE 008 JULY 2015

TOPICS IN THIS EDITION | CYCLONE | FUEL REDUCTION | RISK MANAGEMENT

ESTIMATING FUEL LEVELS POST-CYCLONE

▲ **Above:** FUELS READY TO BURN IN AN AREA IMPACTED BY SEVERE TROPICAL CYCLONE *MARCIA*. PHOTO: JIM GOULD.

SUMMARY

This study examined the dynamics of fuel quantity and hazard following Severe Tropical Cyclone *Marcia* in February 2015 in Queensland. The findings have been used to develop a visual field guide that complements the existing fuel hazard guides (Hines *et al.* 2010; Gould *et al.* 2007, 2011). Among the key findings are that increased fuel loading and hazard caused by tropical cyclones can impede access to fire lines and increase fire spread and fire line intensity by 1.5 and 2.5-fold respectively. These additional insights, to be used alongside the existing field fuel hazard guides, are applicable to a variety of fire management applications, including planning hazard reduction burns, pre-season preparedness and suppression strategies for fires burning in cyclone-damaged vegetation. The guide will be an invaluable tool that could be readily adopted by field crews, can be applied quickly and provide data of sufficient accuracy to input into fire models. Information may also be used to assess the potential impacts of other storm-related fire impacts.

ABOUT THIS PROJECT

This *Hazard Note* summarises the research results from a descriptive study commissioned by the Queensland Fire and Emergency Services (QFES). It focused on five cyclone-damaged locations on the central Queensland coast over four weeks in the aftermath of Severe Tropical Cyclone *Marcia*. This study would not have been possible without the field work assistance of QFES staff and volunteers.

AUTHOR

James (Jim) S. Gould, Senior Research Scientist, Fuel and Fire Behaviour with the Bushfire and Natural Hazards CRC and Honorary Fellow with CSIRO.

CONTEXT

The effects of tropical cyclones on bushfire risk and changes in fire behaviour are difficult to interpret. While there are a number of studies that have documented the effects of cyclones on forests, there is limited understanding on the increase in fuel hazard and the behaviour of fires in cyclone-damaged vegetation. Before this project, no framework for assessing the changes in fuel hazard had been developed.

This gap in knowledge constrained the fire and emergency managers charged with devising mitigation and response strategies for cyclone-affected fuels. Other practical factors such as fire weather, smoke management and fire crew safety are also a primary concern when conducting hazard reduction burns and planning suppression strategies in cyclone-damaged fuel. With destructive tropical cyclones (and other storms) in Australia becoming more frequent (Cook and Goyens 2008), emergency managers require a better understanding of how these changes in fuel accumulation and structure affect fire behaviour, in order to be better prepared for subsequent fire seasons.

BACKGROUND

On 15 February 2015, Tropical Cyclone *Marcia* was identified as a category 1 cyclone and, over the next five days, intensified to a category 4–5, with wind speeds of up to 195 km/h and gusts up to 295 km/h. On making landfall on 20 February it caused significant damage to property, infrastructure and forested vegetation to Queensland communities at Byfield, Cawarral and West Yeppoon.

Intense cyclones, such as *Marcia*, cause massive defoliation, uproot trees and snap off stems and branches, resulting in open-canopy conditions and changes in understorey microclimate conditions (Turton and Dale 2007; Pohlman *et al.* 2008). These changes will have an effect in determining the risk and behaviour of bushfires. They can accelerate the amount of surface and coarse, woody-debris fuel available for combustion, which will affect fire spread, flame structure,

fire duration and intensity. Both the load and structure of fuel are important for predicting rate of spread, ease of suppression and threat.

The indicators of cyclone impacts for increasing fuel hazard are:

- increased surface fuel load from leaves and branches, stripped from overstorey canopy,
- reduced canopy cover, which changes the microclimate, allowing more invasive vegetation,
- severely damaged understorey vegetation that creates excessive vertical and ladder fuels, and
- snapped and uprooted trees that impede fire-line construction and increase risks to firefighters.

BUSHFIRE AND NATURAL HAZARDS CRC RESEARCH

In May 2015, approximately two and a half months after *Marcia*, a fuel assessment and data was collected from the areas of Byfield, Cawarral, West Yeppoon, Mount Archer and Mount Morgan, which were in the vicinity of the cyclone's path.

The severity of damage depends on wind speed, tree species, tree size (height and diameter) and topography. This can be assessed visually (i.e., stripped canopy, broken branches, snapped stems, uprooted trees). Such characteristics were used to establish a visual assessment guide, (following the concepts of Turton and Dale (2007) and Pohlman *et al.* (2008)) with five damage categories ranging from 'low' to 'extreme' to provide a subjective assessment of cyclone-damaged forest vegetation (see page 4).

This guide enabled researchers to train local firefighters to assess cyclone damage at 48 sample plots taken from seven vegetation types across the study area.

As part of the process researchers took photographs as examples to help practitioners learn to appraise the different fuel hazard categories. These form a handy guide for fuel hazard in tropical cyclone-damaged forested vegetation.

Other aspects of the research included an assessment of individual tree damage. Fallen trees and branches are a major component of cyclone-damaged vegetation. QFES Predictive Services provided historical fire weather from 1972 to 2010 for the Rockhampton region. This data set was used to investigate the impact of cyclone-damaged fuels on fire behaviour and suppression difficulty.

GATHERING VISUAL AND HISTORICAL DATA

Visual assessment showed that *Marcia* caused large structural changes in both continuous and fragmented forested vegetation, although the amount of damage varied considerably both between and within sites. The major damage included both frequent uprooted and snapping of trees some metres above ground.

As there was limited data on pre-cyclone fuel conditions, cyclone damage fuel score one (low) was used as a benchmark to determine if there was an increase in fuel load and hazard.

The cyclone damage scores did not reflect a change in the surface and elevated fuel hazard scores which were either a score of two or three. The most significant change in the fuel hazard score was the near-surface fuel score of two (moderate fuel hazard rating) with the scattered suspended leaves and twigs in the low cyclone damage score of one. In the very high cyclone damage forest score value of four, there were large amounts of leaves, twigs and bark that obscured logs, rocks and holes resulting in a fuel hazard score of four (extreme fuel hazard rating). Combined surface and near-surface fuel load increased steadily from 11.8 tonnes per hectare (t/ha) to 18.8 t/ha with increasing cyclone damage scores. The fresh tops of fine leaves and twigs from fallen cyclone-damaged branches added to the elevated fuel layer. This additional fuel contributed an extra two to three t/ha of fine fuel in the elevated fuel strata. There was very little difference in the elevated fuel loads between cyclone damage scores and the elevated visual hazard score was predominately two (moderate rating). There was no significant change in fuel depth and height of the surface, near-surface and elevated fuel respectively.

The overall fuel hazard rating (Hines *et al.* 2010) increased from moderate in the low damaged areas to very high in the high and very high cyclone-damaged areas in the native forest vegetation.

RESEARCH OUTCOMES

Fire behaviour

The historic fire weather records from 1972 to 2010 for the Rockhampton region indicate that the 2015 fire season will start in early August. By then, most of the accumulative fine fuels from *Marcia* will be ready for combustion and fine fuel moisture will respond to daily changes (the temperature highs and lows) in ambient weather. The increase in fuel loading, and warmer and windier understorey microclimate, point to fire behaviour that will be quite different to pre-cyclone fuel conditions.

Applying the default (but best guide available) fuel values developed through this research to fire behaviour models estimates that the spread rate and fire-line intensity would increase by 1.5 and 2.5-fold respectively between the 'low' and 'very high' cyclone damage classes.

▲ **Above:** CYCLONE DAMAGED CANOPY TOPS ADDING TWO TO THREE TONNES PER HECTARE OF FINE FUEL. PHOTO: JIM GOULD.

These increases of fuel load and fire behaviour estimates (predictions) will probably be sustained for two to three years after *Marcia*. By then, the fuels will have decomposed to pre-cyclone conditions.

There will be conditions where the observed fire behaviour will differ significantly from the predicted values using the assumed weather and fuel conditions, if, for example, conditions at the fire front are quite different to the predicted values. The spatial variability of cyclone-damaged fuel is high because of the patch-wave nature of cyclones. Fire behaviour analysis that overestimates fire behaviour predictions can be easily readjusted without serious consequences; underestimates of behaviour can be disastrous both to incident controllers and the credibility of the person predicting.

Fire suppression

Changes in potential fire behaviour after a cyclone will depend on both the total quantity of fuel available and the change in the understorey microclimate. In cyclone-damaged forest, where the understorey microclimate is drier and windier (Pohlman *et al.* 2008), these changed conditions may accelerate the rate of fire growth. Fresh cyclone damage to large, downed woody material may restrict the initial development of fires and impede fire-line access. In post-cyclone years, the downed woody material will become combustible and burn out slowly. This additional burning fuel can develop convective centres behind the flame zone, which will draw the local winds along flanks and push the flame towards the burnt ground, thus restricting the lateral development of the fire and increasing the burn-out time and intensity.

In cyclone-vegetation fires, the impeded access to the fire ground and increased fuel hazard make it critical that the first attack is rapid and well resourced. In post-cyclone vegetation, the chances of aerial suppression being successful diminish with delay, as the fire size increases.

USING THE CYCLONE DAMAGE SCORE

The current visual field guides systematically assess fuel hazard in the context of suppression difficulties and predicted fire spread

Ideally, cyclone-damaged forest should be assessed within the first three months after the cyclone. Developing a sampling design to measure the magnitude of change in fuel hazard and loading following cyclones would be difficult, costly and time consuming. However the cyclone damage score developed by this research (see page 4) can supplement these existing field guides in a post-cyclone situation. Visual assessment can be easily taught to field crews, quickly implemented and is accurate enough to use as input for fire models.

This proposed field guide relies on visual assessment and is therefore subject to human error. To minimise this, practitioners should apply these field guides along with a good sampling design.

▲ **Above:** SNAPPED OFF CANOPY AND BRANCHES WITH RESPROUTING LEAVES, TWO MONTHS AFTER *MARCIA*. PHOTO: JIM GOULD.

FURTHER READING

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END USER STATEMENT

Before this research there was significant uncertainty about the increased severity of bushfires in the years after Severe Tropical Cyclone *Marcia*. This project has provided a better understanding of post-cyclone fuel hazards and generated many benefits. Its findings are informing our continued hazard reduction burning in the cyclone-affected areas. They are also helping us to promote a shared responsibility approach to community risk reduction. QFES staff and volunteers have gained valuable knowledge from working on the project and community information sessions have disseminated findings of this pressing issue.

– Andrew Sturgess, Predictive Services, Queensland Fire and Emergency Services.

HAZARD **NOTE**

VISUAL ASSESSMENT FIELD GUIDE TO CYCLONE-DAMAGED FUELS

This field guide is for assessing bushfire fuel hazard in tropical cyclone-damaged forested vegetation.

PHOTOGRAPH EXAMPLES	CYCLONE DAMAGE SCORE	CYCLONE DAMAGE RATING	DESCRIPTION *LARGE TREES*: DBH >5 CM *SMALL TREES* (SAPLINGS): DBH <5 CM	INPUT VALUES FOR FIRE MODELS
	0	Nil	Intact – no obvious damage	
	1	Low	*Large trees:* minor branch damage of <25% branch lost; *Small trees:* few trees (<10%) bend and unbroken	Surface fuel hazard rating: High (3) Near-surface fuel hazard rating: High (2.5) Overall fuel hazard rating: Moderate Near-surface fuel height (cm): 25 Elevated fuel height (cm): 100 Total fine fuel load (< 6mm) t/ha: 15 Down woody material (> 25 mm) t/ha: 15
	2	Moderate	*Large trees*: 25–50% branches lost, few trees (<10%) bend <45°, <10% of trees trunk snapped off, no uprooted trees; *Small trees*: substantial part of the canopy stripped off part of the small trees beneath other debris, 10–30% bend and unbroken	Surface fuel hazard rating: High (3) Near-surface fuel hazard rating: High (3) Overall fuel hazard rating: High Near-surface fuel height (cm): 30 Elevated fuel height (cm): 100 Total fine fuel load (< 6mm) t/ha: 17.5 Down woody material (> 25 mm) t/ha: 25
	3	High	*Large trees:* 50–75% branches lost, >75% of the canopy leaves stripped off, 10–30% of trees trunk snapped off, <10% of trees uprooted; *Small trees:* >75% of branches lost, no fine twigs and small branches present, >30% bend and/or snapped	Surface fuel hazard rating: Very High (3.5) Near-surface fuel hazard rating: Very High (3.5) Overall fuel hazard rating: Very High Near-surface fuel height (cm): 30 Elevated fuel height (cm): 120 Total fine fuel load (< 6mm) t/ha: 20 Down woody material (> 25 mm) t/ha: 40
	4	Very High	*Large trees*: no visible signs of twigs and small branches <10 cm, scattered large branch material on the ground, 30–50% of trees trunk snapped off, 10–30% of trees uprooted; *Small trees*: trunk snapped off low to ground or 30-50% uprooted trees	Surface fuel hazard rating: Extreme (4) Near-surface fuel hazard rating: Extreme (4) Overall fuel hazard rating: Very High Near-surface fuel height (cm): 35 Elevated fuel height (cm): 120 Total fine fuel load (< 6mm) t/ha: 25 Down woody material (> 25 mm) t/ha: 50
	5	Extreme	*Large trees*: >30% of trees are uprooted and flattened to ground; *Small trees*: > 50% uprooted or snapped off	Surface fuel hazard rating: Extreme (4) Near-surface fuel hazard rating: Extreme (4) Overall fuel hazard rating: Very High Near-surface fuel height (cm): 35 Elevated fuel height (cm): 120 Total fine fuel load (< 6mm) t/ha: 25 Down woody material (> 25 mm) t/ha: 80

DBH: diameter at breast height (i.e., 1.5 m above ground). t/ha: tonnes per hectare

The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

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Policy, Political Engagement and Influence

HAZARD **NOTE**

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TOPICS IN THIS EDITION | DECISION MAKING | MULTI-HAZARD | POLICY

LEARNING LESSONS FROM THE PAST WITH THE INQUIRIES AND REVIEWS DATABASE

▲ **Above:** THE INQUIRIES AND REVIEWS DATABASE CATALOGUES 315 NATURAL HAZARD INQUIRIES AND REVIEWS ABOUT EMERGENCY MANAGEMENT FROM THE PAST 130 YEARS IN AUSTRALIA. SHOWN HERE IS THE NUMBER OF INQUIRIES, BY HAZARD TYPE, ACCESSIBLE IN THE DATABASE.

ABOUT THIS PROJECT

The Inquiries and Reviews Database catalogues the outcomes of more than 300 inquiries, reviews and Royal Commissions across all states and territories in Australia. Initially developed as part of research completed by Martijn Gough (Aither), Prof Stephen Dovers (Australian National University), A/Prof Michael Eburn (Australian National University) and Lawson Cole (Aither) for the *Major post-event inquiries and reviews: review of recommendations* Tactical Research Fund project, the Database has since been considerably expanded and now brings together more than 130 years' worth of data, capturing the outcomes from more than 300 inquiries and reviews into emergency management and natural hazards in Australia since 1886.

SUMMARY

The Inquiries and Reviews Database is web-based and builds on research that reviewed post-event inquiries in Australia. Using the outcomes of the research, the CRC developed the Inquiries and Reviews Database, which is now hosted on its website at https://tools.bnhcrc.com.au/inquiries.

The Database currently holds 4,194 recommendations from 315 reviews and inquiries dating back to 1886 – making it a highly valuable resource for gaining an oversight of, and insight into, the recommendations that are made across multiple Australia states and territories, hazards and inquiry types.

The Database captures and categorises the recommendations by state/territory, hazard type and inquiry type, allowing users to access all of this information in one place and making it easy to incorporate lessons learned during past natural hazards. Australia's emergency services sector can now use the Database to easily navigate through more than 130 years of data, facts and recommendations from 315 different inquiries, reviews and coronial inquests into natural hazards in Australia.

The Database is being used to support increased inter-jurisdictional lesson sharing, giving emergency services the upper hand in learning from the past to create a safer future.

You can access the Inquiries and Reviews Database at **https://tools.bnhcrc.com.au/inquiries**

▲ **Figure 1:** NUMBER OF INQUIRIES BY INQUIRY TYPE IN THE INQUIRIES AND REVIEWS DATABASE.

BACKGROUND

Natural hazards and emergencies in Australia are often followed by formal, complex, post-event inquiries, Royal Commissions and reviews, most recently the *2020 Royal Commission into National Natural Disaster Arrangements*. These inquiries vary in form and focus, however their common objective is to identify the causes and consequences of natural hazards, so as to inform better future practices that reduce damage and loss. Together, these inquiries have made thousands of recommendations and findings, varying across states and territories.

The outcomes and recommendations that arise from major inquiries in one state or territory sometimes have ramifications and can lead to reform in other states and territories. While this is especially the case with larger, higher profile events and inquiries, the extent to which cross-jurisdictional lessons have been applied from less high-profile post-event inquiries and reviews is unclear. To enable lessons to be learned between states and territories after a natural hazard inquiry or review, emergency services need to be able to access a synthesised and categorised set of outcomes. This would help states and territories identify the main recurrent themes and would assist agencies in the application of lessons in their own context.

This project and the subsequently developed Inquiries and Reviews Database addressed this need by developing a comprehensive and user-friendly database of thousands of recommendations from post-event reviews and inquiries, which can inform agencies' own identification of lessons now and into the future.

BUSHFIRE AND NATURAL HAZARDS CRC RESEARCH

The Inquiries and Reviews Database was initially developed through a partnership between researchers at Aither and ANU, before being further expanded and managed by the CRC. The research team's approach broadly consisted of three phases: development of the database, coding recommendations and thematic analysis, and interpretation of findings. The research aim was to examine the ongoing value for state and territory emergency services to consider lessons from major reviews and inquiries from other states and territories.

Database preparation

The preparation of a searchable, retainable and updateable database, that compiles the recommendations of inquiries and after-action reviews, was required first, before undertaking analysis. Through a desktop search of keywords and relevant websites, more than 140 reviews and inquiries were identified, initially just between 2009 and 2017. This was refined by applying exclusion and inclusion criteria to identify a subset of appropriate reports. Reviews that did not appear to yield any practicable recommendations were ignored. A final shortlist of 55 major post-event reviews and inquiries was selected for analysis.

Data coding and thematic analysis

Initially, researchers incorporated 1,336 recommendations into the Database. This has since been expanded. Each recommendation was then independently coded into one of 32 broad themes, which are now included in the current Database's 39 recommendation topics. The themes were analysed to separate the largest high-level themes into groupings of recommendations with similar subject matters. The same process was applied to several themes that contained an average number of recommendations. The themes containing the least recommendations were also identified for analysis.

END-USER STATEMENT

"Such a relatively simple system, but such an incredible amount of knowledge contained within. It really is such a potentially powerful tool, and brilliant that it enables practitioners from across the sector to assess such a wide range of knowledge."
Stephen Sennet, Volunteer National Incident Management Officer, Australian Red Cross

"The inquiries and reports following major natural disasters are produced in the context of powerful community sentiment and political considerations such that, despite their best intentions, investigators often struggle to produce reports that are fully objective and complete. The CRC's new Inquiries and Reviews Database enables researchers to more effectively distil the accumulated wisdom from across a large and growing body of inquiry reports."
Adrian Birch, private data analyst and developer

Interpretation

The last stage of the research was to examine the specific meaning of recommendations against others of the same subject matter, to understand whether they were generic in nature and recurred across multiple inquiries (and so could be valuable across multiple states and territories), or were specific to unique contexts.

RESEARCH FINDINGS

The analysis and interpretation showed that there were a significant number of parallel recommendations made amongst the reviews and inquiries, as well as a number of recommendations that could have broad significance for multiple states and territories. While there were several recommendations that were not matched across states and territories, this may be due to the fact that some states and territories have not yet experienced an event that reveals specific weaknesses or issues in a system.

The analysis revealed that recommendations can generally be understood as belonging to one of what is now 39 descriptive topics, grouped under six key themes: agency organisation, responsibility, response, preparedness, research and technology, and recovery. The number of recommendations within each of the themes is represented in Figure 2 (page 4).

Within those themes, the topics with the largest number of recommendations are:

- doctrine, standards and reform (760 recommendations)
- emergency management agency and authority (334 recommendations)
- government responsibility (253 recommendations)
- training and behaviour (209 recommendations)
- inquiry, audit, lessons management (206 recommendations).

Among the recommendations were several calls for national consistency and cooperation, which has been recently echoed in the *2020 Royal Commission into National Natural Disaster Arrangements*. These recommendations are important because they elevate the goal of accurate and consistent information and communications across Australia, not just isolated to one or several states and territories.

HOW IS THE RESEARCH BEING USED?

Since its release in 2019, the Inquiries and Reviews Database has been a valuable resource for gaining an overview of, and insight into, the recommendations that are made across multiple states and territories, hazards and inquiry types – helping government and emergency management agencies recognise past lessons and identify effective practices both now and into the future. The *2020 Royal Commission into National Natural Disaster Arrangements* referenced the Database and noted that it would not be seeking to duplicate efforts of past inquiries.

As of February 2021, the Database contains recommendations and findings from 315 inquiries and reviews relating to emergency management and natural hazards across all jurisdictions in Australia between 1886 and 2020, including agency, audit, coronial, government, independent parliamentary and Royal Commission inquiries (see Figure 1, page 2).

The data can be sorted by disaster and inquiry type, date and state/territory using a simple table display. For more in-depth analysis, CSV files can be downloaded allowing users to run local queries and reports.

The Database also contains the full recommendations from 186 inquiries and reviews between 2003 and 2020. A facetted exploration interface enables a filter-search of 4,194 recommendations, allowing effective search and comparison through keywords and themes (Figure 2, page 4).

The Inquiries and Reviews Database can be used for a variety of purposes including:

- to compare equivalent recommendations between inquiries, themes and jurisdictions
- to track inquiries across jurisdiction, year and types
- to download and work with all inquiries and listed recommendations for the particular needs of an organisation.

To give a specific example, a search for bushfire inquiries in the Database shows that, since 2003, there have been 82 inquiries, resulting in 1,748 recommendations. The 'doctrine, standards and reform' classification has the most recommendations (254). 'Emergency management agency and authority' and 'Incident Management Teams' have also had many related recommendations, with 110 and 88 respectively.

For floods since 2003, there have been 19 related inquiries with 478 resulting recommendations; 135 of which relate to 'land use and building regulations', 76 to 'government responsibility' and 72 to 'doctrine, standards and reform'.

On the other hand, there have been only two tsunami-related inquiries in Australia since 1886, with three resulting recommendations relating to 'research' and the 'role of Commonwealth Government' from the 2005 *Tsunamis – Does anyone have to die?* Federal inquiry.

FURTHER READING

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Royal Commission into National Natural Disaster Arrangements (2020) *Background paper: Australian inquiries and reports concerning natural disasters*, Commonwealth of Australia, https://naturaldisaster.royalcommission.gov.au/publications/background-paper-australian-inquiries-and-reports-concerning-natural-disasters

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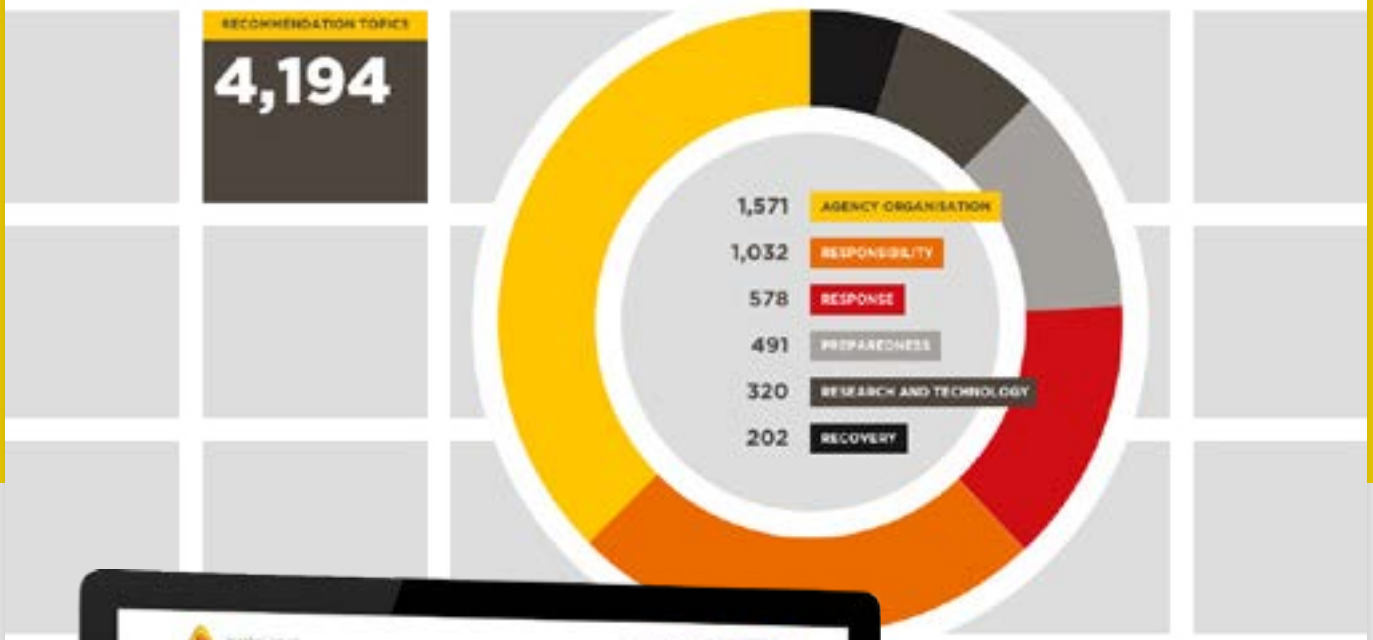

▲ **Figure 2:** NUMBER OF RECOMMENDATIONS BY CODED THEME IN THE INQUIRIES AND REVIEWS DATABASE.

INQUIRIES AND REVIEWS DATABASE

The Inquiries and Reviews Database webpage, accessible at **https://tools.bnhcrc.com.au/inquiries**

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Hazard Notes are prepared from available research at the time of publication to encourage discussion and debate. The contents of *Hazard Notes* do not necessarily represent the views, policies, practises or positions of any of the individual agencies or organisations who are stakeholders of the Bushfire and Natural Hazards CRC.

HAZARD **NOTE**

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TOPICS IN THIS EDITION | FLOOD | LAND MANAGEMENT | POLICY | MITIGATION | RESILIENCE

FLOOD MANAGEMENT IN A CHANGING CLIMATE

ABOUT THIS PROJECT

This research was conducted as a PhD study: *Flood management in a changing climate: integrating effective approaches*, under the broader Bushfire and Natural Hazards CRC project: *Policies, institutions and governance of natural hazards.*

AUTHORS

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SUMMARY

Flooding is Australia's most expensive natural hazard and climate change will magnify risks. However, recent floods suggest that Australia has limited capacity to manage even current risks. Australian flood policy relies heavily on the twin concepts of disaster resilience and shared responsibility. While increased self-reliance is desirable, resilience strategies have been criticised for failing to address underlying development issues, while shifting responsibility onto communities. This begs the question as to whether resilience strategies will lead to essential adaptive outcomes over the longer term (see breakout box on page 2).

This research investigated the adaptive potential of alternative management options. Results have implications for policy, land planning and management.

▲ **Above:** COMMUNITY RESISTANCE TO RELOCATION AT NORTH WAGGA: PLANNING FAILURE IS HARD TO REMEDY. PHOTO: CAROLINE WENGER.

CONTEXT

Australian natural hazard funding programs place little emphasis on flood prevention; where they do, the majority is spent on structural mitigation. However, some measures, such as levees, are inflexible in the face of climate change and, are arguably maladaptive when assessed against criteria (see breakout box on page two). Costly levee failures overseas have led to the development of innovative approaches in the Netherlands, the United Kingdom, China and the United States to address future climate threats. These approaches have potential for policy transfer to Australia.

BACKGROUND

Globally, levees have been important for flood mitigation. However, major levee failures (Yangtze River 1998; New Orleans 2005) have raised questions about whether such measures will be able to cope with future, unpredictable climate conditions.

Unlike overseas reviews, Australian post 2010-2011 flood reviews failed to consider the adequacy of existing policies to address climate change risks, a serious omission for future policy development. Despite this, Australian reviews identified flood mitigation deficiencies including development planning and highlighted inadequacies of levee use and management.

BUSHFIRE AND NATURAL HAZARDS CRC RESEARCH

Case studies were prepared for four flood-prone countries: Australia, the USA, the Netherlands and China. Interviews were held with Australian flood experts and case studies were verified by international experts.

Academic literature relating to policy transfer, institutional theory, adaptation and resilience provided an analytical framework and criteria to assess the adaptive potential of various management options.

Capacity to adopt adaptive options was then assessed in the Australian context to reveal institutional barriers and perverse incentives. Where adaptive options had been implemented, success factors were identified.

Finally, research was carried out into how disaster resilience is interpreted in different countries and whether resilience policies support adaptive approaches.

RESEARCH FINDINGS

Adaptive management options used overseas, such as flood compatible development planning, relocation and floodplain restoration, face significant barriers in Australia. Lack of development restraint in flood-prone areas generates ongoing demand for maladaptive remedies such as levees and dams. These will prove increasingly unreliable when confronted with climate change and 'unprecedented' flooding.

ADAPTATION CRITERIA

Adaptive: Long term planning over large areas; cross-sectoral synergies; 'soft' (i.e., management and planning); socially acceptable; equitable; flexible/reversible (can respond to climate uncertainty); economic efficiency (e.g. low cost safety margins).

Maladaptive: Negatively impacts other systems, sectors, social groups (especially the most vulnerable); reduces incentives to adapt; induces path dependency; increases greenhouse gas emissions; high opportunity costs.

END-USER STATEMENT

While those who ignore the past may be condemned to repeat it, those who slavishly look to the past for direction may equally be condemned to compound its failures. New challenges to the social and physical construction of reality mean that what used to work may in future make things worse when it comes to disaster management. The interdependencies of areas such as planning, public policy and emergency management should be obvious and yet across all tiers of government, it is not always so. Similarly, public policy promoting a resilience approach founders if it simply falls back on old thinking for solutions. In this significant research, Caroline Wenger has used flood management to illustrate this dilemma and to suggest new pathways that suggest the wisdom of adaptation rather than resistance.
– John Schauble, Director, Emergency Management Resilience, Emergency Management Victoria

FURTHER READING

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While institutional differences hamper policy transfer, overseas examples help to identify opportunity and under-the-radar examples operating within the recipient country's institutional context for scaling up. For example, agricultural productivity may be the primary reason a measure is adopted, with flood mitigation viewed as a co-benefit, revealing the importance of a cross-sectoral approach.

Because it can be used to justify almost any activity, the usefulness of resilience as a guiding concept is limited. Resilience policies need to be more discriminatory so they can more clearly support activities likely to be adaptive over the longer term. To this end, one research outcome was a preliminary revision of the Prevent-Prepare-Respond-Recover (PPRR) Framework to make it easier to distinguish activities most likely to lead to adaptive outcomes.

HOW THIS RESEARCH COULD BE USED?

Policy conflicts continue to encourage the development of floodable areas. Meanwhile, state funding programs favour the use of structures such as levees to remedy poorly-sited development, in a pattern of path dependency commonly known as the levee paradox. These same programs may explicitly render options such as raising houses and relocation ineligible, despite them being more adaptive.

The levee paradox is a 'resilient' feedback loop whereby levee building/augmentation, increased development and higher damages go hand in hand, meaning that ever higher levees are not the answer for both economic and technical reasons. Resistance strategies are not resilient over the longer term: they accumulate risks for the future, ultimately resulting in catastrophic failure.

The challenge for policy makers is to deliberately break out of this loop into a more desirable resilience regime – 'living with floods', instead of resisting them.

Cross-sectoral planning (to achieve co-benefits), suitable project funding length and foreplaned integration into disaster recovery are needed.

The issue of ongoing development of floodable lands also needs solving. It can partly be attributed to the division of government responsibilities: private individuals and the federal government are largely responsible for recovery, not the state and local governments that authorise development. Federal disaster recovery policies that reward states and local governments which have stronger development controls may go some way to rectifying incentives.

This research has the potential to be used by development planners and flood managers to aid selection of adaptive flood management options. It could also be used to inform policy at different government levels.

FUTURE DIRECTIONS

The theoretical groundwork has been laid. The next step is implementation, perhaps leading to Australia's own 'living with floods' program.

Flood-prone areas that could benefit from an ecosystems-based approach first need to be identified. Of these, some pilots could be selected. These would be designed to integrate and assess cross-sectoral costs and benefits.

This stage would require government/private sector buy-in to proceed.

The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

HAZARD **NOTE**

bushfire&natural HAZARDSCRC

ISSUE 44 JANUARY 2018

TOPICS IN THIS EDITION | DECISION MAKING | POLICY | PLANNING | RISK MANAGEMENT

RHETORIC OR REALITY: CRISIS COORDINATION

ABOUT THIS PROJECT

This research was conducted as a PhD study, *Whole of government and crisis management: understanding coordination in a time of crisis*, which was completed in 2017 at the University of Sydney.

AUTHOR

Dr George Carayannopoulos, University of Sydney. Dr Carayannopoulos was an associate PhD student at the CRC and completed his PhD in 2017.
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SUMMARY

This project explored the response to two natural disasters: the 2009 Victorian bushfires and the 2011 Queensland floods. As large-scale events, they epitomise the challenges of crisis management in Australia. The research examined how each state confronted the disasters from political and operational perspectives. It specifically framed the understanding of these events through a model that emphasised seven important factors. Foremost among them was a 'whole of government' response, which involves public service agencies working across portfolio boundaries to achieve shared goals. The other key mediators were: crisis management; leadership; coordination; organisational culture; social capital; and institutions. The individual and combined impacts of these mediators defined the outcomes of these crisis events.

▲ **Above:** THIS PHD RESEARCH EXAMINED HOW THE 2011 BRISBANE FLOODS WERE MANAGED FROM A WHOLE OF GOVERNMENT PERSPECTIVE. PHOTO: ANGUS VEITCH (CC BY-NC 2.0).

CONTEXT

Given the rise of whole of government approaches in managing crises, the research sought to understand whether commitments to working across agencies were rhetoric or reality. It explored how the political and bureaucratic challenges of managing crises can be overcome.

BACKGROUND

Large-scale natural disasters are a significant test of how effectively governments and the public sector respond to adversity. This occurs against a backdrop in Australia where citizens' trust in government continues to decline. The public retains high expectations of government's ability to plan, prepare and respond to disasters. Crises are also occurring in a context where changes in the public sector mean that whole of government approaches are seen as an imperative in the management of crises.

RESEARCH ACTIVITY

The governance of natural disasters is an emerging field that assesses how key actors in mitigation, preparation and response work together to achieve the best possible outcomes. This project addressed the whole of government management of crises by assessing the interaction between political, bureaucratic and response agencies in order to generate new insights into the management of multi-level disaster arrangements.

The research was based on a comprehensive analysis of official government documents, media reports and commissions of inquiry reports. The researcher also interviewed 28 key people across executive government, government departments and emergency agencies involved in the response to both events.

The research was novel in the Australian context because it was the first large-scale project that explicitly linked whole of government to crisis management in order to understand how events unfold.

RESEARCH FINDINGS

The research revealed an overall consensus from those in executive government, government departments and emergency agencies that there is a strong commitment to implementing whole of government management during times of crises. It has, however, highlighted that a mere commitment to whole of government working is not sufficient for its successful implementation. It must be supported across all levels of government through leadership, coordination strategies and a culture that values integration over fragmentation. All parties involved must be aligned in order to make whole of government a reality.

The research has highlighted the complexity of achieving this. A driver of this complexity is the differing views and emphasis on collaboration of its political, administrative and operational strands of government.

The key actors in a crisis, including operational agencies, government

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END-USER STATEMENT

The challenges facing government in emergency and disaster management are seemingly endless. This research frames the responses to two major crises by considering the influence of seven factors. Importantly it points to both barriers and enablers for government. Some of these are well known, such as the bureaucratic inertia encouraged by complex systems that work against collaboration. It also highlights the importance of executive leadership and the need for strong coordination built upon a framework of legislation, policy and good governance. Among the themes to emerge most strongly is the need to put community at the centre of activity, to encourage resilience in partnership with government and move away from the social dependence encouraged by models that focus on service delivery and response-focused solutions. This research should help inform new policy directions in that regard.

– John Schauble, Director, Emergency Management Resilience, Emergency Management Victoria

departments and political leaders need to collaborate more closely to improve integration when responding. This requires effective coordination mechanisms and responses, such as clearly defined legislative arrangements supported by implementation groups for disaster committees or councils.

The key actors strongly agree that coordination mechanisms need to be prepared during 'peace time', so that they can be leveraged during a crisis. They also advocate an emergency management doctrine that values equally both the overall system coordination, and the response of individual agencies.

Finally, direct responses from executive leadership are critical in a crisis to provide authority and mandate during the event, but also to meet public expectations around leadership on the ground.

HOW COULD THE RESEARCH BE USED?

This research has made a distinct contribution by linking whole of government response and crisis management in a way that has not explicitly been done before. Both these areas share common pillars around coordination, leadership and connected organisational cultures that are needed to face the adversity caused by crises. It has provided a conceptual model, based on seven key mediators, through which disaster events can be analysed to better understand the factors that shape the success or failure of whole of government arrangements.

▲ **Above:** LOOKING AT BLACK SATURDAY IN 2009, THIS RESEARCH WAS THE FIRST STUDY TO LINK WHOLE OF GOVERNMENT TO CRISIS MANAGEMENT IN ORDER TO UNDERSTAND HOW EVENTS UNFOLD. PHOTO: BUSHFIRE AND NATURAL HAZARDS CRC.

The intersection between the political, administrative and operational response agencies is an important focus for future development. Raising awareness of an emergency management approach that prioritises overall system integration as much as the performance of individual agencies could better connect political leaders, staff in government departments and emergency response agencies.

This research could be used in staff workshops across the broad spectrum of government. It could also ensure that the important lessons from these past crises become a valuable resource to draw upon in preparing for and responding to future crises.

FUTURE DIRECTIONS

Given the complexity of large-scale disaster responses, more in-depth research is needed into the governance arrangements that cover the recovery phase after a natural disaster. Long-term recovery and reconstruction from disasters requires the input and capacity of government, non-government and corporate sectors. A more detailed analysis could be undertaken to better understand the relationships between these three sectors, and to evaluate how successful their disaster responses have been. This would be valuable for informing future disaster management policy and service delivery.

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ISSUE 41 NOVEMBER 2017
TOPICS IN THIS EDITION | FRAMEWORK | GOVERNANCE | POLICY

REMOVING DISASTER BARRIERS THROUGH POLICY REFORM

ABOUT THIS PROJECT

This project, which is transitioning to utilisation, is part of the Bushfire and Natural Hazard CRC's *Governance and institutional knowledge* research cluster.

AUTHORS

Emeritus Prof Stephen Dovers, A/Prof Michael Eburn, A/ Prof James Pittock, Dr Anna Lukasiewicz, Dr Caroline Wenger, Sue Hunt, Australian National University; Prof Karen Hussey, University of Queensland.
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SUMMARY

Building community resilience to natural disasters is a complex challenge that spans many policy areas. This project tackled it by delivering policy options that could help governments and emergency services to strengthen resilience in communities. The analysis has identified barriers to community resilience and potential policy solutions that could be factored into the preparation, response and post-event phases of emergency management.

The study's three research themes revealed significant tensions in the shared responsibilities between governments exercising power and community empowerment; between the conflicting needs of insurers and their clients; and within traditional models of post-disaster inquiries. For the latter theme, it is proposed that restorative practices as a powerful alternative to adversarial post-event inquiries is trialled.

Having identified these inherent tensions across the three themes, policies are proposed that could resolve or ease them or, in the case of disaster insurance, highlight the need to develop better models. Ultimately, findings from this study could contribute to making community resilience a priority within all policy making, in the context of disaster management.

▲ **Above:** THE RESEARCH IDENTIFIED WHY PRICING BUSHFIRE RISK IS NOT AN ATTRACTIVE OPTION FOR THE INSURANCE INDUSTRY, EVEN THOUGH IT IS THE INSURERS THAT ARE EXPOSED TO RISK OF FINANCIAL LOSS THROUGH BUSHFIRES. PHOTO: DAVID BRUCE, BUSHFIRE AND NATURAL HAZARDS CRC

BACKGROUND

The National Strategy for Disaster Resilience was released by the Council of Australian Governments in February 2011. It called for shared responsibility and resilient communities, but the impact of government policy on achieving those goals was unclear and unknown. This project and associated PhD projects by Caroline Wenger and Sue Hunt sought to fill these knowledge gaps and point to policy reforms that would support community resilience in dealing with emergencies.

BUSHFIRE AND NATURAL HAZARDS CRC RESEARCH

There were three themes to this project.

- What is 'community' and how can governments share responsibility with both communities and individuals?
- How can insurers play a more active role in communicating risk and encouraging hazard mitigation?
- Is there a better process or institution for effective lesson sharing after natural hazard events?

RESEARCH FINDINGS

What is 'community' and how can governments share responsibility with both communities and individuals?

The National Strategy for Disaster Resilience was analysed, which had the stated aim of 'Building the resilience of our nation to disasters'. This high-level policy statement prescribes or implies shared emergency responsibilities to different sections of the 'community'. The 'community' is defined by the Strategy as 'communities of place' within which exist multiple and diverse

▲ **Above:** THE STUDY UNCOVERED POLICY DIFFICULTIES AROUND SHARING RESPONSIBILITY FOR DISASTER MANAGEMENT BETWEEN THE GOVERNMENT AND INDIVIDUALS. PHOTO: MICHAEL DAWES (CC BY-NC 2.0).

'communities of interest'. For the purposes of this theme, the researchers focused on the different actors within a community of place, such as households and individuals, private businesses, infrastructure operators, government agencies and community organisations.

The analysis clarified the types of societal actors and the responsibilities that they have. For example, the Strategy outlines four broad responsibilities for individuals on the preparation and response phases of a disaster.

These are:

1. Understanding their risks and adequately preparing for them
2. Becoming actively involved in their local community disaster preparedness
3. Acting on relevant advice received from government and other community sources; and
4. Assuming responsibility for vulnerable household members (including pets and livestock).

The analysis also outlined the range of potential policy options that could enforce these responsibilities, which includes education and training, financial incentives and disincentives, and legislation, among others. The analysis also revealed a significant tension in the existing policy between the role of government agencies as central coordinating authorities in disaster management and the vaguer emphasis on community and individual empowerment.

To achieve disaster resilience, community actors must be aware of and able to accept the various responsibilities that the Strategy assigns them. This is why community empowerment and capacity building are also emphasised. However, they are also more vaguely defined. By clearly articulating community actors' responsibilities, the analysis underlines tensions and contradictions that can arise.

One such tension is the capacity of community actors to fulfil their responsibility to prepare for disasters that may require substantial physical modifications to a property. This often leaves renters with relatively little direct power to act as they rely on their landlords to ensure disaster preparedness. Conflicts can also arise between the need of emergency services to be in control of disaster response, and businesses wanting to maintain or resume normal acitivities (one of their stated responsibilities). This is regularly illustrated in post-bushfires when affected areas are closed to ensure public safety, while local farmers wish to enter as soon as possible to take care of affected livestock. Solutions to these tensions exist and are

END-USER STATEMENT

Creating sound emergency management policy in government remains an iterative process in all Australian jurisdictions. This project has demonstrated that translating public policy into readily identifiable and measurable community resilience outcomes presents a range of challenges. Among the tools that contribute to resilience are those driven by the private sector, such as insurance, and the inquisitorial processes employed post-event. This research has underlined some misconceptions, such as the minor extent to which insurance loss from bushfire is significant in an actuarial sense, while pointing to the problems of implementing highly theoretical approaches on the ground in local communities. The findings in relation to the restorative justice approach is indicative of a need for further innovation and research in this context.

– John Schauble, Director EM Resilience, Emergency Management Victoria

▲ **Above:** THIS RESEARCH SUGGESTS THE TRIALLING OF RESTORATIVE PRACTICES INSTEAD OF POST-EVENT INQUIRIES, SUCH AS THE INQUIRY AFTER THE 2011 QUEENSLAND FLOODS. PHOTO: ANGUS VEITCH (CC BY-NC 2.0)

best implemented in the preparation phase of disaster management, which is why the Strategy focuses on collaboration and partnership between emergency services and community actors.

The general policy trend to promote community empowerment while maintaining government control over disaster management is consistent with many other countries, making the project's analysis of 'community responsibilities' and their policy implications internationally relevant.

How can insurers play a more active role in communicating risk and encouraging hazard mitigation?

Two key arguments were identified and analysed: that insurance price does and should reflect bushfire risk, and that insurance price signals might encourage those seeking insurance against bushfire losses to mitigate their bushfire risk. The research identified why pricing bushfire risk is not an attractive option for the insurance industry, even though it is the insurers that are exposed to risk of financial loss through bushfires. Individual risk assessment of properties would be prohibitively expensive for insurance companies to countenance given that house loss by bushfires, even after catastrophic events, does not represent a major cost to the industry. Other natural hazards – flood, cyclone and hail – are much more costly and are considered in finer detail by Australian insurers.

Alternative tools were identified that could be incorporated into insurance to encourage risk mitigation, such as the adoption of a 'no claim bonus', providing rebates for mitigation measures, asking relevant questions and relying on the homeowner's duty to reply with 'utmost good faith' to bind the owner to those answers, and external certification of homes and risk mitigation. However, these have their limitations and costs, for example a 'no claim bonus' scheme, such as that used in motor vehicle insurance, may reflect risk when there is a recurring activity, such as driving, but will be less accurate when the risk is damage from a rare but catastrophic event. A rebate scheme may reward property owners for investing in mitigation such as water tanks, pumps and sprinklers, but does not guarantee that they are actually installed and ready for use. Asking relevant questions may give risk information about a property, but actually calculating different premiums to reflect risk may cost more than the benefit to insurers. Finally, private certification would no doubt lead to an industry of certifiers. A 'qualified inspector' would see an incentive to provide the cheapest and fastest fire-risk assessment. There would also be pressure to certify that a home is more fire ready than it actually is. Insurers would find it difficult to verify the quality of fire-risk assessment and they may inadvertently undercharge policyholders. Such a process most closely equates to an individual risk assessment by the insurer, but does not avoid the costs and problems associated with calculating individual premiums.

This research demonstrates to policy makers and individuals in fire-prone areas that insurance price should not be relied upon as an effective tool for communicating risk, or for encouraging risk mitigation by individuals, in particular with regard to bushfire risk. While insurers may allow premiums to reflect risk on a landscape level, individual risk is too expensive and complex to quantify. Communicating the message for individual, property-level mitigation will require other policy responses.

Is there a better process or institution for effective lesson sharing after natural hazard events?

In earlier research, Eburn and Dovers have argued that alternatives to quasi-judicial inquiries after significant natural hazard events should be explored if the Australian community is to learn from catastrophic events without destroying the good will of the emergency services and, more importantly, their volunteers. Their ongoing research has critiqued the adversarial processes used in inquiries. Restorative practices have been identified as a better, alternative way of conducting reviews. A discussion paper on this theme, Learning for emergency services, looking for a new approach, will be finalised in late 2017.

This research recommends the adoption

▲ **Above:** THIS PROJECT HAS DEMONSTRATED THAT TRANSLATING PUBLIC POLICY INTO READILY IDENTIFIABLE AND MEASURABLE COMMUNITY RESILIENCE OUTCOMES PRESENTS A RANGE OF CHALLENGES. PHOTO: NSW STATE EMERGENCY SERVICE.

of restorative practices, which may assist inquiries. This would allow all the parties to resolve collectively how to deal with the aftermath of the disaster and its implications for the future. This could focus on both short and long-term community recovery.

Moving to a new, community-based model of post-event learning will take leadership and confidence from the emergency management community, but it may be a way to learn more, without sacrificing the goodwill of responders.

HOW COULD THE RESEARCH BE USED?

The research could be applied in various contexts, including the selection of appropriate policy choices to encourage communities to share responsibility for emergency management with government. It could also help agencies to be better informed about how policy options can be tailored to encourage or facilitate desired outcomes.

Australia could trial restorative practices for post-disaster events by starting locally, such as for internal inquiries into accidents and near misses. If the system is effective and fosters learning without harm, then the practice could be applied to larger inquiries involving the emergency agencies and broader community interests.

FUTURE DIRECTIONS

This project's significant further outputs are expected to include further work on disaster justice, promoting the concept of restorative practices in post-disaster inquiries.

It is proposed that a symposium take place in 2018 to discuss findings from theme three, looking at restorative practices for emergency management in Australia as a more effective way to sharing lessons after an event. This symposium would involve key people from emergency management agencies across Australia, those who have conducted emergency management inquiries in Australia, as well as international experts. The symposium would share findings from the project and consider if restorative practices could be used in Australian emergency management inquiries.

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HAZARD **NOTE**

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ISSUE 37 AUGUST 2017

TOPICS IN THIS EDITION | DECISION-MAKING | POLICY | RISK MANAGEMENT

UNDERSTANDING WHAT RISK IS YOURS – AND WHAT TO DO ABOUT IT

ABOUT THIS PROJECT

This research was conducted as part of the *Mapping and understanding vulnerability and risks* project. The framework described in this *Hazard Note* is designed to support better identification of risk ownership and understanding of strategic decision making in the emergency management sector.

AUTHORS

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SUMMARY

Australia is experiencing new risks from natural hazards, and with these increased risks comes greater financial costs. Ownership of these risks is at two levels - the ownership of values (assets) and the ownership of risk management activities related to natural hazards – and can be owned by individuals, groups or institutions. It can vary from a single owner, to shared ownership, to no owner at all.

This research has identified three decision making areas across where risk ownership can be assessed as part of strategic decision making. They cover the actual values at risk from natural hazards, the impacts, consequences and risks arising if those assets are affected, and strategic risk management actions.

Key findings show that there is currently an imbalance of risk ownership between public and private sectors. More coordination is required between different groups and institutions, with no long term policy, plans or strategies for environmental or social recovery from natural hazards identified. Significant gaps currently exist in knowledge for mapping and identifying risk and its consequences.

To assist the emergency management sector to best understand the risk they own, and what can be done to reduce it, a framework has been developed. This framework aims to enable risk practitioners and policy makers to act decisively and collaboratively in the present, whilst thinking and planning for the future.

▲ **Above:** THIS RESEARCH HAS IDENTIFIED THREE DECISION MAKING AREAS ACROSS WHERE RISK OWNERSHIP CAN BE ASSESSED. PHOTO: DAVID BRUCE, BUSHFIRE AND NATURAL HAZARDS CRC.

CONTEXT

Risk ownership is a critical aspect of managing risk, especially systemic risks like natural hazards. If a risk is not owned, it is unlikely to be well managed, and may result in avoidable loss and damage.

BACKGROUND

Australia's institutions – its three levels of government, the community and business and industry – are well-positioned to respond to natural hazard events when they occur. They are less well positioned for the strategic management of the activities such as prevention, preparedness, resilience and recovery that surround these events.

The frequency and intensity of natural hazards is increasing in response to social, environmental and economic drivers – in particular, climate change and changing demographics. As a result, Australia is experiencing new risks and greater costs associated with these events.

Natural hazards and the risks they trigger are a systemic issue, impacting on environmental, social and economic systems simultaneously. These systems are interconnected. Reactions in one part of the system can impact another and can continue into the longer term. These risks often cannot be mitigated fully and require the building of resilience to aid short to long-term recovery (Figure 1, page 2). Systemic risks are generally poorly understood and sit outside conventional risk assessment frameworks and processes.

BUSHFIRE AND NATURAL HAZARDS CRC RESEARCH

What is risk ownership?

Risk ownership can be understood from two perspectives – the ownership of

▲ **Figure 1:** TIMELINES FOR STRATEGIC PLANNING AND RESOURCE REQUIREMENTS FOR EFFECTIVE INTEGRATED NATURAL HAZARD RISK MANAGEMENT

▲ **Figure 2:** AREAS OF DECISION MAKING FOR RISK OWNERSHIP

values (assets) and the ownership of risk management activities related to natural hazards. Ownership can be identified through three tiers of owners: individuals, groups, and institutions. These tiers cover local, state and federal government, the community, and business and industry. The broad spectrum of social, environmental and economic values includes both tangible (monetary – e.g., buildings and income) and intangible values (non-monetary – e.g., amenity and community connectedness). Risk ownership can vary from a single owner, to shared ownership, to no owner at all.

The research team have identified three decision making areas across where risk ownership can be assessed as part of strategic decision making. They cover the actual values at risk from natural hazards, the impacts, consequences and risks arising if those assets are affected, and strategic risk management actions as in Figure 2 (above).

There exists a wide range of formal instruments through which risk ownership is currently allocated (Figure 3, page 3). Informal arrangements, such as social contracts, also play a key role in risk ownership, particularly in relation to resilience activities at a community level. This means risk ownership is often a negotiated process, which requires collaboration and meaningful engagement to achieve fruitful outcomes.

Ownership can also be allocated in relation to hazard, where specific authorities and agencies are charged with managing a specific area of risk – for example, bushfire or flood mitigation. This can be problematic for emerging hazards such as heatwaves, where understanding

END-USER STATEMENT

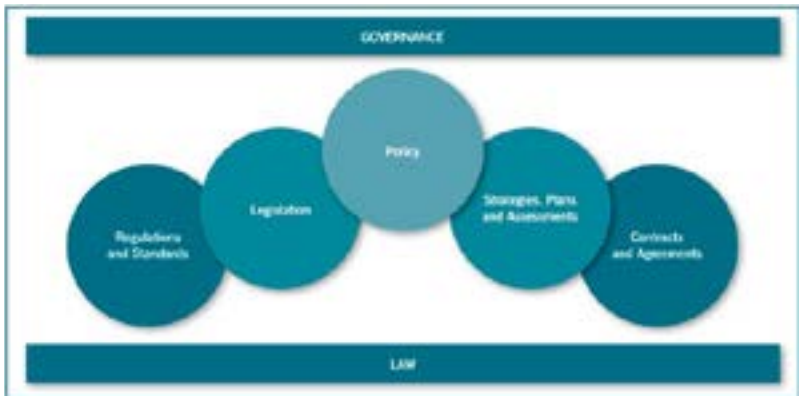
The risk ownership framework for emergency management policy and practice (the framework) has been developed through comprehensive research. It includes a companion process to identify risk owners and enhance emergency risk management activities, including treatments. The framework supports a collaborative approach for prioritising resource allocation (investment) for emergency mitigation, focusing on a broad range of stakeholders with responsibilities for managing emergency risks. It is also applicable to all types of emergencies and therefore consistent with the 'all communities/all emergencies' model.

Importantly, the framework provides clarity for shared responsibility, which is an important element of managing emergency risks. It not only makes sense of the dynamic nature of risk ownership for emergencies, it provides a method for identifying disparate risk owners at different stages. The companion process identifies risk owners beyond the agencies that have traditional emergency management roles. The outputs of this activity have the potential to guide priority projects and programs for mitigation and enhance community resilience.

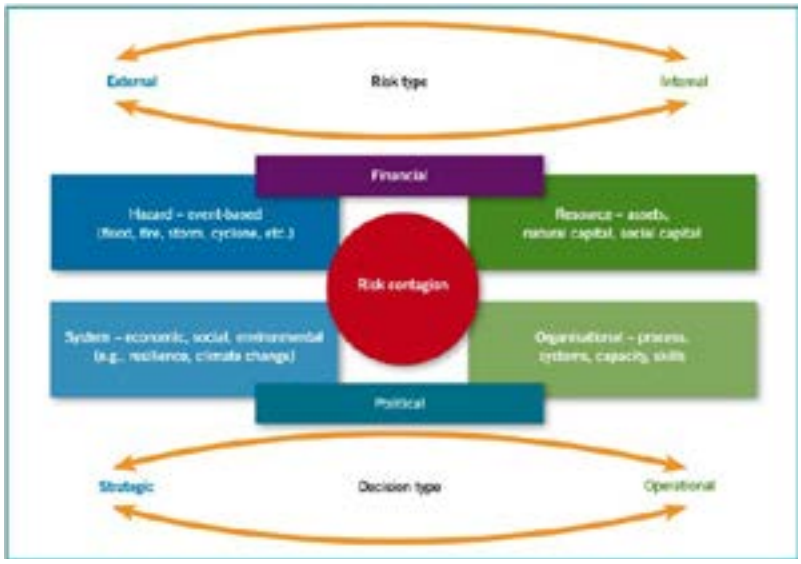
Key elements of the framework's risk ownership process have been mapped to the risk assessment process in the National Emergency Risk Assessment Guidelines. Even though this provides important linkages to the guidelines process, greater application of the risk ownership process is expected if the key concepts are integrated into guidelines. Accordingly, future revision of these guidelines should incorporate the risk ownership process.

I recommend the framework to anyone involved in emergency risk management. It makes sense of the complexity of risk ownership and has the potential to significantly improve the outcomes of emergency risk assessments, and enhance community resilience.

– Greg Christopher, Senior Officer Emergency Risk, Emergency Management Victoria



▲ **Figure 3:** INSTRUMENTS FOR ALLOCATING RISK OWNERSHIP



▲ **Figure 4:** RISK SYSTEMS WITH INTERNAL AND EXTERNAL COMPONENTS

and management strategies are still being developed.

Applying ownership to strategic decision making

Risk ownership of natural hazards is highly dynamic and can change abruptly as impacts and consequences cascade through a system. Two of the key ways this can happen are as a result of either risk contagion or exceedance of capacity thresholds. This broadens the focus of assessment from natural hazards themselves, to the internal and external risks that may be affected as a result. It is important to consider the 'system' of risks (Figure 4, above) to identify where interactions between different areas of risk may result. This can also help identify what type of decision making is most appropriate for specific contexts, and where actions are likely to be most effective.

The allocation of risk ownership is challenging, particularly in areas of shared ownership of complex values such as social cohesion and healthy environments that support a community. Such values are critical for future resilience. Ownership in these areas can often be unclear or unacknowledged, resulting in greater vulnerability to natural hazard impacts. As the ability to fulfil the obligations of ownership is critical to its effectiveness, it is also important to align expectations with current capacities and capabilities of risk owners.

RESEARCH FINDINGS

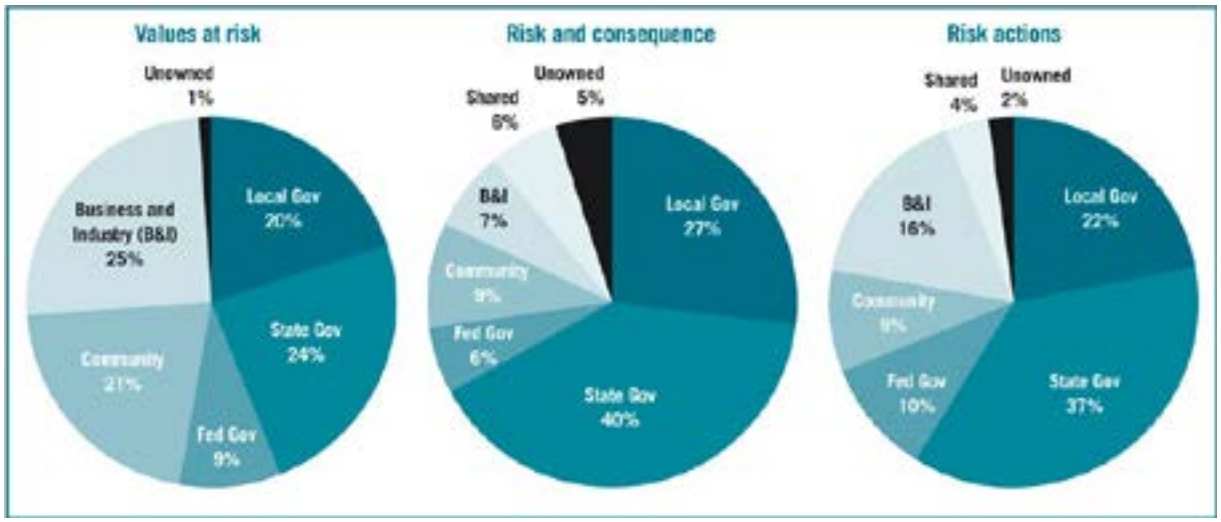
Through a series of studies, workshops and interviews, this project mapped the patterns of risk ownership at the institutional scale and decision making preferences at the organisational level. This research was then used as a basis for the development of the framework. Key findings included:

- **Risk ownership was found to show an imbalance between the public and private sectors, which is potentially unsustainable (Figure 5, page 4).** In particular, allocation for state and local government was considerably higher for risk and consequences and risk actions than was for the ownership of values at risk.
- **Coordination between contributing agencies and agendas is needed to clarify ownership and support more effective management of activities and use of resources.** Risk ownership in areas contributing to resilience and risk reduction were found across multiple agencies and agendas. This was particularly the case in agencies who work with regional and community development and climate change adaptation. Coordination between contributing agencies and agendas is needed to clarify ownership and support more effective allocation and use of resources.
- **Risk ownership relevant to strategic decision making is ill-defined, particularly for longer term activities focusing on recovery and resilience building.** No long-term (two or more years) policy, plans or strategies for environmental or social recovery to natural hazards were found.
- **Knowledge gaps were found across long-term strategic horizons (two or more years)** in relation to mapping and identifying ownership of risks and consequences, and resilience and recovery activities – particularly for flood and heatwave hazards, and for social and environmental values.

HOW IS THIS RESEARCH BEING USED?

An outcome of this research is the Risk Ownership Framework for Emergency Management Policy and Practice, which has been developed in collaboration with key project end-users to support better allocation of risk ownership as part of strategic planning and risk assessment activities.

The framework offers a companion process that differs from conventional processes as it uses a values-based approach, which includes negotiation



▲ **Figure 5:** ALLOCATION OF INSTITUTIONAL OWNERSHIP ACROSS KEY DECISION-MAKING AREAS.

and consensus. It is designed to be aligned with the National Emergency Risk Assessment Management Guidelines (Australian Institute of Disaster Resilience, 2015). The framework provides a starting point for understanding and clarifying risk ownership as part of strategic risk planning and assessment activities. It provides:

- Descriptions of what risk ownership is and how strategic risk works.
- The concepts that underpin the risk ownership process framework. These need to be understood to work in longer term strategic timeframes and to determine risk ownership across dynamic geographical and temporal landscapes.
- A companion process outlining the core components that can be integrated into current planning processes to develop emergency management plans by government agencies, communities and organisations.
- Key questions and tools to assist practitioners with the process.

Achieving effective risk ownership requires a common understanding of how risks are changing and consensus and acceptance around who owns these risks and how they own them. This moves beyond simple linear approaches, to a more adaptive and flexible approach focused on what values are identified as most important by risk owners. Strategic decision making based upon key values provides the bridge between the present and the future. Risk ownership is the one constant in a highly dynamic system where external risks such as natural hazards can affect that system in unpredictable ways. The risk ownership framework aims to enable risk practitioners and policy makers to act decisively and collaboratively in the present, whilst thinking and planning for the future.

FURTHER READING

Jones RN, Young CK and Symons J (2015), *Mapping values at risk from natural hazards at geographic and institutional scales: framework development,* Bushfire and Natural Hazards CRC.

Young CK, Jones RN, Kumnick M, Christopher G and Casey N (2017), *Risk ownership framework for emergency management policy and practice*, Bushfire and Natural Hazards CRC.

Young CK, Jones RN and Symons J (2016), *Understanding values at risk and risk ownership workshop synthesis report*, Bushfire and Natural Hazards CRC.

Young CK, Jones RN, Symons J (2016), *Institutional maps of risk ownership for strategic decision making*, Bushfire and Natural Hazards CRC.

Young CK, Symons J, Jones RN (2015), *Whose risk is it anyway? Desktop review of institutional ownership of risk associated with natural hazards and disaster*, Bushfire and Natural Hazards CRC.

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HAZARD **NOTE**

bushfire&natural HAZARDSCRC

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RAISING THE BAR ON RISK REDUCTION POLICY AND PLANNING

ABOUT THESE PROJECTS

This is an overview of the *Governance and institutional knowledge* cluster of Bushfire and Natural Hazards CRC research projects. This cluster has two linked studies:

1. **Scientific diversity, scientific uncertainty and risk mitigation policy and planning** – Dr Jessica Weir, Dr Timothy Neale, Western Sydney University, Dr Christine Hansen, University of Gothenburg, Associate Professor Michael Eburn, Professor Stephen Dovers, The Australian National University, Associate Professor Tara McGee, University of Alberta and Professor John Handmer, RMIT University. For more information contact j.weir@westernsydney.edu.au
2. **Policies, institutions and governance of natural hazards** – Associate Professor Michael Eburn, Associate Professor Karen Hussey, Dr James Pittock, Professor Stephen Dovers and Dr Anna Lukasiewicz, The Australian National University. For more information contact michael.eburn@anu.edu.au

CONTEXT

Learning from the past and predicting the future is difficult, especially when it comes to managing risk. Major disasters occur infrequently, with inherent uncertainty, while the science around them can be complex. These projects aim to provide a foundation for ensuring that responsibility for risk can be understood and shared transparently amongst all stakeholders.

SCIENTIFIC DIVERSITY, SCIENTIFIC UNCERTAINTY, AND RISK MITIGATION POLICY AND PLANNING

BACKGROUND

The increasing demand for evidence-based public policy places a premium on the need to translate scientific knowledge into policy, practice and common understanding. This translation is rendered even more challenging by the inherent uncertainty and diverse disciplines of the science behind the evidence. How should risk mitigation practitioners manage these scientific uncertainties and diversities in their strategic decision-making? This is a key question driving this project, which aims to help risk management practitioners to explain, justify and discuss mitigation practices to others, including mitigation professionals, the public, the media, and in court and inquiry processes.

The project uses qualitative social science methods, including scenario exercises, theoretical tools and case studies. It analyses how diverse knowledge is ordered and judged as salient, credible and authoritative, and its pragmatic meaning for emergency management across the prevention, preparedness, response and recovery spectrum.

RESEARCH ACTIVITY

The project has completed project development, literature reviews, fieldwork, publication development and end-user engagement. Three case studies have been scoped on bushfire and flood risk mitigation. Their various stages of development are outlined below.

1. Bushfire risk mitigation in the Barwon-Otway area, Victoria.

Over the past several years, the Barwon-Otway area in south west Victoria (including the Wye River and Separation Creek areas recently affected by bushfire) has been a pilot site for a new approach to bushfire risk calculation and mitigation led by Victoria's Department of Environment, Land, Water and Planning.

Above: GAMBA GRASS IS INCREASING THE FIRE RISK AROUND THE URBAN FRINGE OF DARWIN. A CASE STUDY IS INVESTIGATING THE CHANGING LEVELS OF RISK. PHOTO: NATHAN MADDOCK, BUSHFIRE AND NATURAL HAZARDS CRC.

This approach uses new scientific tools to plan mitigation activities, quantify mitigation effects and inform community stakeholders. For this case study the researchers have recruited a participant group, completed two rounds of in-depth interviews and convened a scenario exercise. The case study is now being developed for publication.

2. Bushfire risk mitigation in the Greater Darwin area, Northern Territory.

Though a significant portion of its grassland is burnt each year, the Greater Darwin area is not historically a high-risk bushfire area. However, the recent spread of highly flammable gamba grass (*Andropogon gayanus*) and the continuing subdivision of flood-prone and marginal lands in Darwin's urban/rural interface are both changing the level of risk and the need for mitigation solutions. A participant group has been recruited for this case study and the first round of in-depth interviews were held in mid-2015.

3. Flood risk mitigation in the Hawkesbury-Nepean Valley, NSW.

Historical and predictive evidence suggested that the Hawkesbury-Nepean Valley is at risk of low-probability flood events with very high consequences. The issue of mitigating this risk is the objective of the Hawkesbury-Nepean Valley Flood Management Taskforce. A participant

group is being recruited for fieldwork that is scheduled to start in early 2016.

RESEARCH OUTCOMES

The project team has completed two literature reviews, with the findings informing the development of the case studies. Specifically, 250 sources on scenario exercises, methodology, analysis and design were reviewed. There are two dominant approaches, and while they can bring together diverse expert knowledges to better understand complex systems, the focus is often on the product and not the process. Scenarios are also vulnerable to being influenced by the interests of dominant participants.

Key scientific uncertainties encountered, managed and utilised by practitioners and decision-makers involved in bushfire and flood risk mitigation have been surveyed. They can be categorised as historicist, instrumental and interventionist uncertainties.

- Historicist uncertainties are those uncertainties which emerge from the reliance of scientific knowledge on archives of historical data.
- Instrumental uncertainties are those uncertainties which emerge from the limitations of a given apparatus, heuristic or theory.
- Interventionist uncertainties are those uncertainties which emerge from a given mitigation intervention.

POLICIES, INSTITUTIONS AND GOVERNANCE OF NATURAL HAZARDS

BACKGROUND

Community resilience depends on more than just engineering and preparation. Government policies, institutions and governance arrangements also shape community resilience. These fundamentally influence how individuals and communities prepare for, respond to and recover from natural hazards. Both governments and communities need to understand the nature of this influence in order to fully comprehend and manage natural hazards.

This research project will shed invaluable light on current policy, institutional and governance arrangements with the aim of developing new approaches to shared responsibility that will increase community resilience to all natural hazards.

RESEARCH ACTIVITY

The project is working on three themes:

1. Delivering evidenced-based suggestions to help communities to share responsibility for emergency risk management.
2. Identifying perverse incentives and hidden barriers in disaster insurance.
3. Providing recommendations for a revised, post-event inquiry process to better identify lessons.

A research paper has been completed on disaster insurance policy, identifying some reasons why insurers are reluctant to more actively communicate and price risk, particularly with respect to bushfire. The paper also suggests some policy initiatives that might be adopted to encourage home-owners and insurers to identify and mitigate risk.

▲ **Above:** CURRENT POLICIES AND GOVERNANCE ARRANGEMENTS ARE BEING INVESTIGATED WITH THE AIM OF DEVELOPING NEW APPROACHES TO SHARING RESPONSIBILITY FOR EMERGENCY MANAGEMENT. PHOTO: DEPARTMENT OF ENVIRONMENT, LAND, WATER AND PLANNING, VICTORIA. PHOTO: DAVID BRUCE

Dr Eburn has travelled to the United States to gather information about improved post-event learning. He visited Sacramento, California to attend the Facilitate Learning course offered by the National Advanced Fire and Resource Institute and the US Forest Service. He later visited the US Wildland Fire Lessons Learned Centre in Tucson, Arizona.

Work on delivering evidence-based suggestions to help communities to share responsibility for risk management will be undertaken in 2016.

END USER STATEMENT

These projects are tackling some of the most challenging policy, governance and communication issues confronting emergency management. We all have a stake in resolving the public policy dilemmas of shared responsibility, resilience and accountability. Developing a common language between risk professionals, policy makers and the broader community, including politicians, lawyers and the media, is essential for managing differing opinions and uncertainties in relation to natural hazards. The combined efforts of this research cluster could lead to cultural change in how we approach and respond to a broad range of natural hazards – this is an exciting prospect.
– John Schauble, Strategic Advisor, Emergency Management Victoria

RESEARCH OUTCOMES

Two literature reviews have been completed. While Australia has a high level of capacity and experience in managing climate-related risks, our complex systems are vulnerable to shocks. Increased attention needs to be paid to the resilience of critical infrastructure. In reviewing bushfire inquiries in Australia between 1939 and 2013, there are many reoccurring themes that may show a lessons management problem. Inquiries may be identifying issues that cannot be solved, making recommendations that cannot be implemented or making sound recommendations that are ignored or not diligently applied. Many inquiries have made recommendations inconsistent with previous inquiries, which causes problems for emergency services implementing findings.

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