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bushfire&natural HAZARDSCRC

BUSHFIRE AND NATURAL HAZARDS COOPERATIVE RESEARCH CENTRE

Submission to the Productivity Commission Inquiry on Natural Disaster Funding Arrangements

"An ounce of prevention is worth a pound of cure." - Benjamin Franklin

JUNE 2014

INTRODUCTION

The Bushfire and Natural Hazards CRC (Cooperative Research Centre) welcomes the current Productivity Commission Inquiry into 'the effectiveness and sustainability of Australia's natural disaster funding arrangements' and is pleased to have the opportunity to provide input and comment.

Given that the national arrangements for natural disaster funding have not been reviewed since 2002, and the recent trends in the costs of natural disasters in Australia, the review clearly has the potential to make a valuable and timely contribution to this important area of public policy.

The Bushfire and Natural Hazards CRC was established in July 2013. Its creation was a joint initiative of the Commonwealth Government and jurisdictional fire, emergency service, land-management agencies and non-government organisations across Australia and New Zealand. It builds on ten years of successful research and utilisation of the Bushfire CRC.

This submission has the following attachments:

1) An overview of the Bushfire and Natural Hazards CRC
2) An overview of the research conducted by the Bushfire and Natural Hazards CRC
3) An overview of the needs of the Emergency Management sector assessed following an multi-jurisdictional workshop in March 2013

It should be stressed that this submission is made entirely by the Bushfire and Natural Hazards CRC and does not reflect the views of its members or individual Board Directors. Most of the Bushfire and Natural Hazards CRC's members will be submitting separate submissions through their own jurisdictions.

The Bushfire and Natural Hazards CRC works closely with the Australasian Fire and Emergency Service Authorities Council (AFAC) and supports the initiatives proposed in its separate submission the Productivity Commission's Inquiry.

The Bushfire and Natural Hazards CRC is ready to provide appropriate assistance to your Inquiry in its important task. Please do not hesitate to contact me should you require more information regarding the material below or in relation to other matters.

SUMMARY OF RECOMMENDATIONS

Recommendation
It is recommended that a national data management infrastructure be established, to enable access to consistently interpreted, long-term data that will support research, policy and analysis.

The development of this infrastructure will require exploration and development of data models and information management systems, development of meta-data, definition of supporting practices, capture, storage, processing and delivery mechanisms, as well as a need to build capacity across the sector.

Recommendation
It is recommended that the emergency management system be viewed as a complete interconnected system and that the Commission does not neglect the role that response can play in mitigating future events.

In support of this recommendation the Bushfire and Natural Hazards CRC notes the need for research that identifies the role that incident response can play in long-term mitigation efforts and the potential for decreased future recovery expense.

Recommendation
It is recommended that, consistent with the call by AFAC, the use of the term 'risk reduction' rather than 'prevention' be adopted.

The Bushfire and Natural Hazards CRC notes the critical need to continue the research work on adaptation to the impacts of locked-in climate change and demographic changes. This will ensure that Australia is mitigating, not only against today's threat, but also those of the future.

Recommendation
It is recommended that detailed consideration be given to a more focused research effort in the area of relative costs and benefits of mitigation versus recovery, over and above the vital research work already under way.

Recommendation
It is recommended that a national strategy be developed for research investment in the natural hazards space, covering the various requirements of the different levels of government, the non-government organisations and the private sector.

THE BUSHFIRE AND NATURAL HAZARDS CRC

The Bushfire and Natural Hazards CRC is funded for eight years with $47 million from the Australian Government's Cooperative Research Centres Program. The remaining funds – approximately $80m cash and in-kind – come from partner agencies, non-government organisations, government organisations and research institutions from all States and Territories and New Zealand. The Bushfire and Natural Hazards CRC has an annual cash research spend of approximately $7 million per year; this is augmented by in-kind resources from the partners.

The work of the Bushfire and Natural Hazards CRC is intrinsically linked to a number of national policies and strategies, including:

- the National Disasters Resilience Strategy (NSDR) (COAG endorsed);
- the Strategic Research Priorities (Australian Research Committee endorsed); and
- the National Bushfire Policy Statement (COAG endorsed);

The Bushfire and Natural Hazards CRC is an incorporated, not-for-profit public company limited by guarantee. It is managed through a small central office in East Melbourne. It has a skills-based Board of Directors elected by its Members. The Board is chaired by an independent Director, Dr Laurie Hammond.

The Bushfire and Natural Hazards CRC has the following strategic goals:

- Create a sustainable emergency management research capability
- Generate knowledge through high-quality research
- Build enduring partnerships for effective conduct and use of research
- Translate the research to adoption and use
- Contribute to the delivery of a disaster-resilient Australasia

A more complete overview of the Bushfire and Natural Hazards CRC can be found in **Attachment 1**.

TARGETED RESEARCH

A full list of the research being conducted by the Bushfire and Natural Hazards CRC can be found in **Attachment 2**.

The Bushfire and Natural Hazards CRC's research program is just beginning and has been informed by the broader sector and the jurisdictions. In developing the research program, the CRC held a multi-jurisdictional workshop to scope out the issues and problem statements

that need to be addressed. This broad set of statements and discussion is appended in **Attachment 3**. This was used as the background document for a public call for research projects. Owing to the level of funding available, the final research agendum addresses only a portion of these issues.

The Bushfire and Natural Hazards CRC research programs that have commenced in the last few months, and that have relevance to the Inquiry's Terms of Reference, include the following.

Theme: Economics, Policy and Decision-Making

This research theme deals with the economics and the interface between risk-based priorities and the practice of decisions to allocate resources where the potential for some of the greatest tangible benefits can be realised. Projects in this research theme are:

Economics and Strategic Decisions

Better understanding of the economic costs of disasters and their risks, and the risk-reducing benefits of treatments, can build a more compelling case that improves the likelihood of risk treatments being resourced and implemented.

Furthermore, a better understanding of the economic and policy environment within which decisions are made, and an improved understanding of how risk information is perceived and understood by decision-making bodies, can allow risk-reduction proposals to be presented in a more effective way that increases the likelihood of resourcing and implementation.

This cluster of research projects focuses on developing the tools required to undertake sound economic analysis of the costs and benefits of different emergency management decisions. Projects in this cluster are:

- The development of a decision-support system for assessment of policy and planning investment options for optimal natural hazard mitigation;
- Economics of natural hazards;
- Mapping and understanding bushfire and natural hazard vulnerability and risks at the institutional scale; and
- Pre-disaster multi-hazard damage and economic loss estimation modelling.

Governance and Institutional Knowledge

Learning from past disasters is difficult. At a national level, the relatively long periods between major disasters result in few decision-makers having prior disaster management experience. At an international level, the frequent turnover of relief workers means that many of the actors are

relatively inexperienced and susceptible to adopting myths and clichés that are rarely challenged by the media and the academic world. It is time for an international initiative to identify the best practices, and it is time for affected countries and scientists to point out the inadequacies of responses. Projects in this cluster are:

- Policies, institutions and governance of natural hazards; and
- Scientific diversity, scientific uncertainty and risk-mitigation policy and planning.

Scenarios and Loss Analysis

This cluster of research projects focuses on understanding the historical costs and losses to Australia from natural disasters and how to 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 us to understand the possible implications of these events and thereby support the emergency management sector to better prepare for or mitigate impacts of events beyond their experience. Projects in this cluster are:

- An analysis of building losses and human fatalities from natural disasters; and
- Using realistic disaster scenario analysis to understand natural hazard impacts and emergency management requirements.

Theme: Resilient People, Infrastructure and Institutions

The focus of this research theme is to improve the conceptualisation of resilience and the factors that both promote and inhibit its development. Improved understanding of these factors will contribute to and optimise the development of a capability to identify vulnerability, manage the risk and enable resilience. Projects that are part of this research theme include:

Hardening Buildings and Infrastructure

The research objectives here are the establishment of an understanding of the vulnerability of buildings and key infrastructure that is consistent and comparable across a range of natural hazards (earthquake, flood and wind, initially). The projects will focus on existing high-risk components of the built environment but will include information on how new construction can be more appropriately undertaken for some hazards (flood and bushfire) as a risk-reduction strategy.

The research is designed not only to quantify the contributions of existing assets to community risk but also to provide information on how this risk can be mitigated through cost-effective interventions that will reduce damage, injury, community disruption and the future cost of natural disasters, from the present baseline of minimal intervention. It is an objective that these quantitative measures will be in a form that the insurance industry can also use in assessing potential reductions to portfolio risk and possible premium reduction incentives to the policy owner.

Significantly, the research cluster will consider more broadly the cost of disruption to economic activity by considering business activity at an interdependent district level, where disruption directly caused by damage to some businesses has a broader impact on other businesses in the locality (e.g. the Christchurch earthquake). Projects in this cluster are:

- Cost-effective mitigation strategy development for building-related earthquake risk;
- Cost-effective mitigation strategy development for flood-prone buildings;
- Enhancing resilience of critical road infrastructure: bridges, culverts and flood-ways;
- Improving the resilience of existing housing to severe wind events; and
- Natural hazard exposure information modelling framework.

Understanding and Measuring Social Resilience

The relationship between natural hazards and communities has traditionally been viewed from a vulnerability perspective, where communities are at varying levels of vulnerability and helplessness. Australia's recently adopted National Strategy for Disaster Resilience takes an internationally leading approach in the application of a disaster resilience paradigm.

This method gives communities greater options and diversity in managing natural hazards, and places the preparation, prevention, response and recovery in the context of societies learning from and adapting to change. The NSDR recognises four characteristics of disaster resilient communities: 1) they function well while under stress; 2) they adapt successfully; 3) they are self-reliant, and 4) they have strong social capacity. However, important questions are raised. How would progress towards the development of these characteristics be assessed and how should investments to develop disaster resilience be prioritised, evaluated and reported?

This cluster of research projects are:

- The development of an Australian Natural Disaster Resilience Index for assessing, evaluating, reporting and planning for resilience to natural hazards under the NSDR; and

- Development of a framework for understanding the ownership of risks from bushfires and natural hazards at the institutional level in order to improve risk governance through a range of measures, including investment strategies, resilience and risk mitigation.

Additional work

In addition to the work currently getting under way, research previously undertaken by the Bushfire CRC now underpins a number of the new research directions outlined above. This earlier work included projects undertaken as part of the *Economics and Future Scenarios* theme that was designed to improve the understanding of bushfire impact on human communities, the environment and the economy.

The Bushfire CRC also undertook significant studies into the effectiveness of mitigation approaches to bushfire, in particular the role played by prescribed burning. Further details of the Bushfire CRC work can be found at www.bushfirecrc.com

Insurance coverage

In the Productivity Commission's *Issues Paper,* a question is asked around the level of household insurance. The Bushfire and Natural Hazards CRC and Bushfire CRC have conducted post-incident interviews and surveys following major fire events in Victoria, New South Wales, and Western Australia. These surveys involved residents from houses that were destroyed and those which were threatened by the fires and survived.

A summary of these surveys is that 87% households indicated that they were insured (2758 of the 3392 responses). It is not known the degree to which they were fully covered or underinsured. Across the data sets the lowest level of insurance was 73% and the highest 92%.

The Bushfire and Natural Hazards CRC is willing to work with the Productivity Commission to examine these data in more detail.

GAPS AND OPPORTUNITIES

The extensive consultation undertaken late last year across the emergency management sector and across academia by the Bushfire and Natural Hazards CRC in developing its research program revealed a range of future challenges for public policy and institutional design, workforce capability and capacity, risk communication, land-use policy and planning, settlement and asset development. There is general agreement among responders and researchers that the current arrangements may become unsustainable and lose their efficacy in terms of building resilience.

Data

The research consultation frequently confronted data-related issues. While there are many existing and potential sources of data that are relevant to the emergency management sector and other stakeholders, there are critical gaps.

Data often were not accessible, or not in a format or on a platform that facilitated data exchange, use and analysis in a policy and practice context. For many cases, data did not exist at all.

Mechanisms and capabilities are needed to assist policy-makers and practitioners to collect and make use of complex data to produce the information and evidence to underpin strategic and operational decisions.

> ***Recommendation***
> *It is recommended that a national data management infrastructure be established, to enable access to consistently interpreted, long-term data that will support research, policy and analysis.*
>
> *The development of this infrastructure will require exploration and development of data models and information management systems, development of meta-data, definition of supporting practices, capture, storage, processing and delivery mechanisms, as well as a need to build capacity across the sector.*

Incident Response

The scope of the present Inquiry does not include *incident response*. The focus is on 'mitigation, resilience and recovery'. The experience of the Bushfire CRC in relation to wildfire, and indeed the experience internationally, is that a failure by governments to adequately fund and resource year-round management of natural areas in fire-prone jurisdictions is contributing considerably to escalating fire response costs (the reference in the Inquiry's *Issues Paper* to the work of Healy and Malhorta (2009) is noted). It is critical that the total end-to-end costs be understood otherwise there is a risk of unintended consequences of isolated changes, particularly when there are different levels of government responsible for different aspects of the system.

It is important to recognise that the response aspect can also act as a mitigating factor for future events. For example, a wildfire allowed to burn longer (when safe to do so) may reduce fuels more effectively and more cheaply than a prescribed burn later.

Recommendation
It is recommended that the emergency management system be viewed as a complete interconnected system and that the Commission does not neglect the role that response can play in mitigating future events.

In support of this recommendation the Bushfire and Natural Hazards CRC notes the need for research that identifies the role that incident response can play in long-term mitigation efforts and the potential for decreased future recovery expense.

The Inevitability of Future Events

Australia's natural hazard researchers and its emergency management agencies clearly have much work to do if they are to sufficiently understand the influence of climate change on the nation's level of bushfire, flood and other hazard risks. The scientific issues associated with climate change are obviously complex. Indeed, the Deloitte Access Economics 2013 report concluded:

> *'In 2012 alone, the total economic cost of natural disasters in Australia is estimated to have exceeded $6 billion. Further, these costs are expected to double by 2030 and to rise to an average of $23 billion per year by 2050, even without any consideration of the potential impact of climate change…'*

In this context, the findings of the Productivity Commission's report *Barriers to Effective Climate Change Adaptation*, suggesting that features of the current Natural Disaster Relief and Recovery Arrangements (NDRRA) may be inconsistent with effective risk management, made sobering reading (Productivity Commission 2013). The role that betterment options following a disaster play in mitigating future impacts needs further consideration, and making such initiatives more easily achievable will have significant benefits.

In August 2010, a national Inquiry by the Australian Senate described itself in its final report as the nineteenth major bushfire-related inquiry to be conducted in Australia since 1939 and the third to be conducted federally since 2003. In evidence to that Inquiry, Professor Peter Kanowski (an author of a 2004 COAG Inquiry report, the first such national Inquiry in the nation's history) said that his Inquiry had identified:

> *'….a repeated cycle of response by governments and the community to major fire events: first, suppression and recovery processes are always accompanied by assertions, accusations and allocations of blame, even while the fires are still burning; second, inquiries are established and report; third, recommendations are acted upon, to varying degrees; fourth, the passage of time sees*

growing complacency and reduced levels of preparedness... and the cycle begins again with the next major bushfire event…' (COAG, 2004)

The critical aspect of the above discussion is that such events cannot be prevented entirely; what can be done is to reduce the consequence of the events and hence reduce the impact and cost to the community. The impacts of climate change may change the nature or frequency of events, and demographic change will change the exposure and vulnerability. It is these factors that are driving the increasing cost of recovery; only mitigation stands between an event and a disaster.

Recommendation

It is recommended that, consistent with the call by AFAC, the use of the term 'risk reduction' rather than 'prevention' be adopted.

The Bushfire and Natural Hazards CRC notes the critical need to continue the research work on adaptation to the impacts of locked-in climate change[1] and demographic changes. This will ensure that Australia is mitigating, not only against today's threat, but also those of the future.

The Balance between Mitigation and Recovery

The Bushfire and Natural Hazards CRC strongly supports the notion that mitigation is by far the preferred option over post-disaster clean-up, for many reasons. However, as has been noted in the *issues paper* and the paper by Healy and Malhotra, the incentives for doing so are stacked against its achievement.

Although the arguments for doing so intuitively appear correct, it appears that there is little hard evidence to support the validity of switching money from recovery to mitigation. There are isolated case studies, and generalised statements, but little rigorous research. The work to be undertaken by the Bushfire and Natural Hazards CRC in its Economics, Policy and Decision-Making Theme will help to fill some of these gaps in the longer term.

It would be a mistake to assume that transferring all the funds to mitigation will prevent the impacts of events like Black Saturday, Cyclone Yasi or the Newcastle Earthquake for example. There is, therefore, a need to understand the scale of the transfer from one to the other, as some funds will need to be kept as contingent liabilities to cover the extreme events, by some level of government. However, what is the right

[1] Locked-in climate change means changes resulting from past greenhouse gas emissions and the inertia in the climate system (Productivity Commission, 2012)

mix is the outstanding question. It clearly is dependent on the nature of the event, its location, and the relative payoff of the mitigation, or leverage factor (Healy and Malhotra estimate a 1:15 payoff and Deloitte Access Economics demonstrate Benefit/Cost Ratios of between 1 and 9 depending on the case study and assumptions made). A further challenge is to understand how the choice is made to prioritise which mitigation action, against which hazard(s) will result in the highest likely payoff.

> ***Recommendation***
> *It is recommended that detailed consideration be given to a more focused research effort in the area of relative costs and benefits of mitigation versus recovery, over and above the vital research work already under way.*

Research Funding and Capability

Box 3 of the Inquiry's *Issues Paper* provides a timely reminder of one element of the costs of natural disasters, namely the insured value of damage to property. While the material presented shows that the costs of natural disasters are highly variable from year to year, it also shows that in recent years, Australia has experienced several natural disaster events that have imposed significant costs on the Australian community This illustration does not include the real economic costs of the disasters, merely those born by the insurers. Further research is needed to fully understand the full costs of disasters on Australia in order to better understand where mitigation can have the biggest impact.

Viewed in such contexts, the funds invested nationally in related research are arguably nominal. Indeed, in negotiations with the jurisdictions associated with the formation of the Bushfire and Natural Hazards CRC, the natural hazard problems raised were many, had complex interdependencies and were considered by some to be seemingly impossible to solve. Clearly the establishment of the Bushfire and Natural Hazards CRC presents an exceptional opportunity to make a difference. But the size of the task should not be underestimated.

As Mr Jim Gould, a Principal Research Scientist at CSIRO, told the Royal Commission that followed Victoria's Black Saturday fires:

> '*Because bushfire cuts across many management and scientific disciplines, because fire affects so much of the country, and because the risks to life and property are public and political issues, the breadth of opportunities for relevant, needed research is nearly unlimited. The great challenge is perhaps not so much what to do next as it is what to leave out in a limited budget climate…*' (Victorian Bushfires Royal Commission 2010 p. 394).

A relatively small proportion of the research work of the Bushfire and Natural Hazards CRC, and across other bodies in Australia, is focused on the issues central to the Commission's focus, that is, on the balance between mitigation and recovery. This is an issue that is not simply a matter of reprioritising existing research resources, but one requiring increased resources to address the issue effectively.

There are significant benefits to be gained from an ongoing commitment of funding to natural hazards research, combined with a strong engagement of policy, strategy and operational personnel from the jurisdictions, not-for-profit and private sectors to ensure there is swift uptake of the findings. In some ways, an ongoing commitment is more important than the quantum of funding, as it enables longer-term investment, and less time spent sourcing funding and retraining experts, which reduces efficiencies.

> ***Recommendation***
> *It is recommended that a national strategy be developed for research investment in the natural hazards space, covering the various requirements of the different levels of government, the non-government organisations and the private sector.*
>
> *The Bushfire and Natural Hazards CRC considers that such a strategy must embrace the multi-disciplinary nature of the problems and the many factors impacting on the emergency management sector, and must drive the commitment of new resources. It must recognise that shifting of resources from currently vital research to address the gaps will not result in an adequate national capability to address the balance between mitigation and recovery.*

CONCLUSION

Faced with climate and demographic change, Australia has reached a critical stage in the evolution of its approach to the management of the natural hazards it must continue to confront.

In an award-winning essay, written within days of Victoria's Black Saturday fires, the Australian National University historian Professor Tom Griffiths sought to remind his readers of how Judge Leonard Stretton's seminal Inquiry in Victoria in 1939 had sought to find words adequately to describe how: '*…rampant flame had scourged a country that considered itself civilised*', and how Stretton went on to define '*an active, half-conscious denial of the danger of fire, and a kind of community complicity in the deferral of responsibility*….'

Griffiths observed that:

> *'In the seventy years since 1939, we have lived through a revolution in scientific research and environmental understanding and we have come to a clearer understanding of the peculiar history and fire ecology of these forests. We have fewer excuses for innocence. We knew this terrible day would come. Why, then, was there such an appalling loss of life?'*

The comments above relate to major fire events but have equal validity for other natural hazards, be they cyclone, flood or earthquake. The need to continually reassess and monitor Australia's approach to managing its natural hazards has never been more pressing. Effective, cooperative, national and international initiatives that seek a greater understanding of the natural, social and political impacts of natural hazards have a critical role to play in this process.

There is poor coordination of international research collaboration and exploitation in Australia. It is critical that Australia draws on international research and lessons to support Australian needs. The Bushfire and Natural Hazards CRC is willing take a lead role in this through its links to national and international research groups and organizations.

SOURCES

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Victorian Bushfires Royal Commission. 2010. *Report of the 2009 Victorian Bushfires Royal Commission*. Volumes 1–3. Parliament of Victoria. 1141 pp.

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ATTACHMENT 1

THE BUSHFIRE AND NATURAL HAZARDS CRC (bnhcrc.com.au)

Launched at Parliament House, Canberra, by the Minister for Justice, the Hon Michael Keenan, on 10 December 2013, the $130 million Bushfire and Natural Hazards CRC draws together all of Australia and New Zealand's fire and emergency service authorities with the leading experts across a range of scientific fields to explore the causes, consequences and mitigation of natural disasters.

At the launch, the Minister said the establishment of the Bushfire and Natural Hazards CRC acknowledged the ongoing impacts of natural hazards upon communities, emergency service providers, governments, agriculture and other industries.

The Bushfire and Natural Hazards CRC's establishment followed several years of discussion regarding a successor to the Bushfire CRC, which, under the CRC program, is due to largely complete its work in June 2014. In announcing the Australian Government's commitment to the Bushfire and Natural Hazards CRC in February 2013, then Prime Minister Julia Gillard said the new centre would build on the work of the Bushfire CRC and expand the research into other natural hazards.

The Bushfire and Natural Hazards CRC is funded for eight years with $47 million from the Australian Government's Cooperative Research Centres Program. The remaining funds – cash and in-kind – come from partner agencies, government organisations and research institutions from all States and Territories and from New Zealand.

The work of the Bushfire and Natural Hazards CRC is intrinsically linked to a number of national policies and strategies, including:

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As the Inquiry's *Issues Paper* makes clear, over the last decade natural disasters have caused more damage and destruction across Australasia than ever before. Disasters such as flood, fire, cyclone, earthquake and tsunami expose human, infrastructure and institutional vulnerabilities and

subject the Australian community to considerable impact and loss. Such events make headlines when they cause injury, death and widespread damage. However, their full impacts often remain poorly quantified, while being felt through long-term consequences for individuals, communities, infrastructure, the landscape, and the economy.

The purpose of the Bushfire and Natural Hazards CRC is to conduct end-user-inspired applied research to:

- Create a sustainable emergency management research capability
- Generate knowledge through high-quality research
- Build enduring partnerships for effective conduct and use of research
- Translate the research to adoption and use
- Contribute to the delivery of a disaster-resilient Australasia

A NATIONAL APPROACH TO NATURAL HAZARD-RELATED RESEARCH

Both the Bushfire CRC and the Bushfire and Natural Hazards CRC are part of the national Cooperative Research Centre program that has operated since 1991, under successive federal governments. The CRC program was designed to facilitate '*end user-driven research collaborations* [that would] *address major challenges facing Australia. CRCs pursue solutions to these challenges that are innovative, of high impact and capable of being effectively deployed by the end users*.'

The Bushfire CRC was established in July 2003, with the strong support of the industry's peak body, the Australasian Fire and Emergency Service Authorities Council (AFAC). The Bushfire CRC's formation followed devastating fires around Sydney in December–January 2001–02. It became one of the larger CRCs, with over 40 partners – including 18 research institutions spread across Australia and New Zealand.

All the fire and land-management agencies of Australia and New Zealand are members of both the Bushfire CRC and the Bushfire and Natural Hazards CRCs as are many universities and research organisations. In addition, several international organisations are involved either through a formal Memorandum of Understanding (MOU) or through less formal arrangements or research links.

Relevant Inquiries by COAG (2004), the Senate (2010) and the Victorian Bushfires Royal Commission (2010) have all recommended the continuation of a nationally focused bushfire and natural hazard research program.

MEMBERSHIP OF BUSHFIRE AND NATURAL HAZARDS CRC

The following are the formal participants in the Bushfire and Natural Hazards CRC:

ACT Emergency Services Agency

ACT Territory and Municipal Services

Attorney General's Department

Australasian Fire and Emergency Service Authorities Council

Australian National University

Australian Red Cross

Bureau of Meteorology

Central Queensland University

Charles Darwin University

Country Fire Authority, Victoria

Deakin University

Department of Environment and Primary Industries, Victoria

Department of Fire and Emergency Services, WA

Department of Parks and Wildlife, WA

Fire & Rescue NSW

Fire Protection Association Australia

Fire Services Commissioner, Victoria

Flinders University

Geoscience Australia

James Cook University

Macquarie University

Metropolitan Fire & Emergency Services Board, Victoria

Monash University

Northern Territory Government

NSW Rural Fire Service

NSW State Emergency Service

NZ Fire Service Commission

Office of Environment and Heritage, NSW

Queensland Fire and Emergency Services

Queensland University of Technology

Royal Melbourne Institute of Technology

RSPCA Qld

South Australian Fire and Emergency Service Commission on behalf of the Government of South Australia

Tasmanian Fire Service on behalf of the Tasmanian Government

The University of Adelaide

University of Canberra

The University of Melbourne

The University of New England

University of Southern Queensland

The University of Sydney

University of Tasmania

The University of Western Australia

The University of Western Sydney

The University of Wollongong

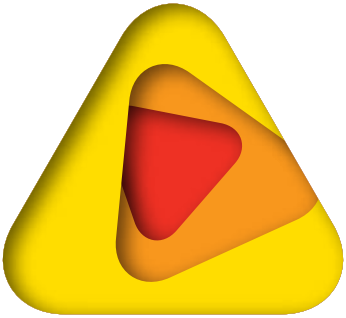
Victoria State Emergency Service

Victoria University

Volunteering Queensland

Attachment 2

THE BUSHFIRE AND NATURAL HAZARDS RESEARCH PROGRAM



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RESEARCH PROJECTS

THE RESEARCH CHALLENGE

In the last decade, we have seen natural disasters cause more damage and destruction across Australasia and our neighbouring region than ever before.

Cyclones, flood, fire, earthquake, tsunami and heatwave cause injury, death and widespread damage. The full impacts of these disasters often remain poorly quantified, but continue to be felt through their long-term consequences for individuals, communities, infrastructure, the landscape, and the economy.

Population growth and changing demographics feature highly among the factors that have increased exposure and vulnerability to natural disasters. A growing, ageing and more multi-cultural population places significant pressure on government policy, particularly around risk communication, land-use planning and infrastructure development.

The policies and settlement patterns of the past are proving inadequate for the challenges of the future and in many instances are intensifying the exposure to risk.

These issues are a challenge for the Bushfire and Natural Hazards CRC.

The new national research capacity is driving our ability to think differently about how to deal with natural disasters into the future.

– Dr Richard Thornton,
Chief Executive Officer,
Bushfire and Natural Hazards CRC

A NEW RESEARCH PROGRAM FOR BUSHFIRE AND NATURAL HAZARDS

The Bushfire and Natural Hazards CRC is conducting research to build a disaster-resilient Australia.

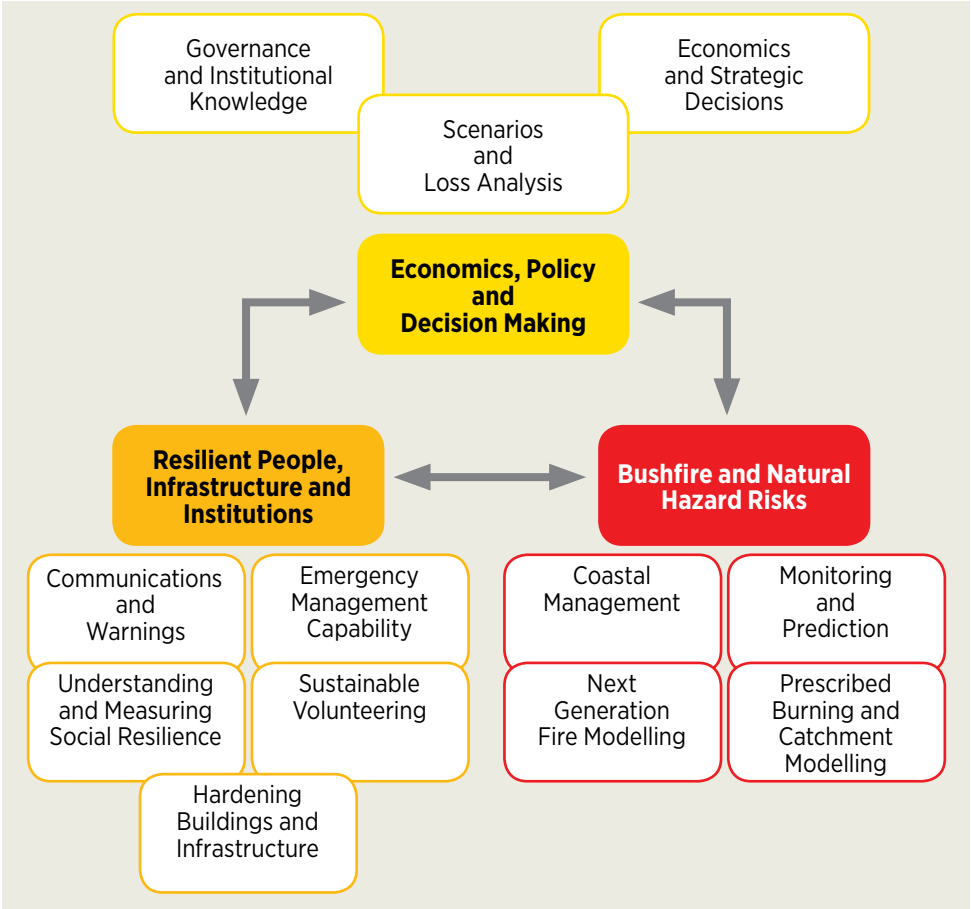
The new CRC expands the national research effort in hazards, including bushfires, flood, storm, earthquake, cyclone and tsunami.

From July 2013, $47 million in Australian Government funds under the Cooperative Research Centres Program have been matched by support from state and territory government organisations, research institutions and NGOs.

INDEX

The research program is taking shape under the direction of researchers and end user agencies.

The research has three major themes covering 12 clusters of projects, most of which span the priorities for those working in a multi-hazard environment.



ECONOMICS, POLICY AND DECISION MAKING

This theme deals with economics and the interface between risk-based priorities and the practice of resource allocation, where greatest tangible benefits can be made.

Governance and institutional knowledge

Lead End User: John Schauble, Fire Services Commissioner Victoria

Policies, institutions and governance of natural hazards

Lead Research Organisation: The Australian National University

Project Leader: Associate Professor Michael Eburn

This research project will shed light on current policy, institutional and governance arrangements with a view to developing new approaches to shared responsibility to increase community resilience to all natural hazards.

The research will build on important issues exposed in recent work in Bushfire CRC and NCCARF projects by the researchers. Across three related topics it will consider issues of policies, institutions and governance across the entire "Prevent, Prepare, Respond and Recover" spectrum.

Topic 1: Mitigating the risk. This topic will identify how current emergency management policies, institutions and governance arrangements help or hinder the ability of communities to play an active role in preparing for and responding to natural hazard events.

Topic 2: Financing recovery and future resilience. The topic will expose the perverse incentives that are hidden in current policies, institutions and governance arrangements, for avoiding steps to reduce exposure to future hazards.

Topic 3: Post event review. Current post-event reviews such as Royal Commissions and coronial inquests and inquiries do not adequately identify and respond to future threats, challenges and vulnerabilities. This topic will look at how best to review the impact of natural hazard events to help communities prepare for the next impact, rather than focus on the last one.

Scientific diversity, scientific uncertainty and risk mitigation policy and planning

Lead Research Organisation: University of Western Sydney

Project Leader: Dr Jessica Weir

A better understanding of the role of science in decision-making will help industry articulate

and defend decisions to the community, media, inquiries and elsewhere, and, better frame information and advice on how scientists and professionals communicate.

The project has four components:

1. Exploring how people have different understandings of the science of flood and bushfire risk.
2. A focus on flood and bushfire mitigation activities in urban, peri-urban and rural locales in southeast Australia. This will include sites where flood and fire risk are combined, such as catchment and riparian vegetation management upstream and downstream of large metropolitan water storages.
3. Considering bushfire and flood risk across the spectrum of Prevent, Prepare, Respond and Recover, with an emphasis on mitigation activities.
4. Informing bushfire and flood mitigation practice, policy and planning, and engaging with the experiences of practitioners.

Economics and strategic decisions

Lead End User: Ed Pikusa, SAFECOM

Economics of natural hazards

Lead Research Organisation: University of Western Australia

Project Leader: Professor David Pannell

Decision makers require information about: risks of fire occurrence, risks of fire spread, frequencies of fires of different severities, impacts of weather conditions on these things, losses associated with bushfires of different severities, reductions in those losses under different prescribed burning regimes, and costs of different prescribed burning regimes. This information must be combined in an appropriate way to illuminate the merits of different decision options.

For hazards such as earthquakes, floods, cyclones and tsunamis, similar observations apply. This project aims to fill key knowledge gaps in these areas. It spans issues related to values, risks, and decision making to deliver value for money from public investments in natural hazard management.

The main objectives of this project are to:

1. Estimate in dollar terms the non-financial benefits (particularly the environmental and social benefits) of management and policy for natural hazards.

2. Undertake an integrated economic analysis of management and policy for natural hazards.
3. Conduct risk analysis for different levels of overall budget for natural hazard policy and management, exploring the high variance of budget requirements from year to year.
4. Develop guidelines for the conduct of sound economic analysis of natural hazard policy and management.

Pre-disaster multi-hazard damage and economic loss estimation modelling

Lead Research Organisation: The University of Melbourne

Project Leader: Professor Abbas Rajabifard

The scope of this project is twofold. At the national level it will investigate the economic impact of natural disasters on sectoral growth of the Australian economy. At the state level, it will assess the multi-hazard risks, and estimate the potential damages and economic losses. This will be followed by identifying the optimum economic policy option to recover or minimise such adverse effects. This project will focus on Victoria, with emphasis on three types of natural disasters – bushfires, flood and earthquakes.

The specific sectors for which economic growth impact of natural disasters will be considered include 19 sectors in the National Accounting System of Australia – agriculture, forestry and fishing; mining; manufacturing; food, beverage and tobacco products; electricity, gas, water and waste services; construction; wholesale trade; retail trade; accommodation and food services; transport, postal and warehousing; information media and telecommunications; financial and insurance services; rental, hiring and real estate services; professional, scientific and technical services; administrative and support services; public administration and safety; education and training; health care and social assistance; arts and recreation services; and other services.

Decision support system for assessment of policy and planning investment options for optimal natural hazard mitigation

Lead Research Organisation: The University of Adelaide

Project Leader: Professor Holger Maier

The project will develop decision support tools that enable the impact of different policy and planning options on various economic, environmental and/or social objectives to be assessed. This will enable the best possible disaster mitigation options to be identified, thereby increasing disaster preparedness, as well as reducing disaster impact and the cost of disaster response and rehabilitation.

Mapping and understanding bushfire and natural hazard vulnerability and risks at the institutional scale

Lead Research Organisation: Victoria University

Project leader: Professor Roger Jones

There is a large imbalance nationally between disaster relief and recovery payments on the one hand, and investments in resilience and risk mitigation on the other. At the same time, increasing climate-related hazards and exposure to those hazards will result in greater damage and loss.

Current institutional arrangements would see future insured losses increase, along with uncompensated losses and demands on government compensation. Uncompensated losses have a disproportionate effect on small businesses, communities and the natural environment. Many of these are un-owned risks, and many such risks are systemic, not being well identified at the institutional scale.

Recent events show not only do the immediate and direct economic impacts of bushfires and natural hazards need to be better understood, but also the medium and long term direct and indirect costs to the economy (tangibles) and associated damages to non-monetary values (intangibles).

This project will develop a 'broad brush-stroke' national picture of vulnerability and values at risk to bushfire and natural hazards at the institutional scale. A comprehensive selection of social and economic measures will be combined with hazard data to ascertain hot spots of institutional vulnerability where multiple values are at risk. These measures will then be mapped at the Local Government Area (LGA) scale to communicate current and potential future risks and where key areas of vulnerability lie.

This map will then be used as a basis for developing, in collaboration with key stakeholders, a process-based framework that enables decision makers to work through the task of risk allocation in these areas.

The aim is to build a picture of the factors needed to enable institutional resilience to changing bushfires and natural hazards.

Scenarios and loss analysis

Lead End User: Belinda Davies, NSW State Emergency Service

An analysis of building losses and human fatalities from natural disasters

Lead Research Organisation: Risk Frontiers (Macquarie University)

Project Leaders: Dr Rob van den Honert and Dr Katharine Haynes

This project will analyse building losses and human fatalities from natural disasters in Australia. The detailed examination is a

fundamental first step to enabling efficient and strategic risk reduction.

The foundation for this work is the Risk Frontiers data base *PerilAUS.* This is the most authoritative database of Australian natural hazard events that have resulted in either loss of life or damage to property. The database contains historical data dating back to European settlement on the incidence and consequences of such events.

This project will provide an analysis of building damage by hazard and by state and territory due to natural hazards since 1900, and a longitudinal analysis of the social and environmental circumstances in respect to fatalities, injuries and near misses. These trends will be interpreted in the context of emerging issues such as an ageing population, population shifts and climate change, and how these issues might influence vulnerability and exposure trends in the future.

Using realistic disaster scenario analysis to understand natural hazard impacts and emergency management requirements

Lead Research Organisation: Risk Frontiers (Macquarie University)

Project Leader: Dr Matthew Mason (QUT), Dr Felipe Dimer de Oliviera

This project will generate a series of natural disaster scenarios for major cities across Australia to quantify their impacts on society, critical infrastructure, lifelines and buildings, and where possible the natural environment.

This information will allow end-users to understand the implications of these events for their agencies and their industries so they can better prepare for, or mitigate the impacts of events that are beyond their experience.

The hazards to be considered are earthquake, cyclone, flood, tsunami and bushfire.

The project will develop a modelling framework so the impacts of hazard events can be quantified.

Resilient People, Infrastructure and Institutions

This theme aims to improve the conceptualisation of resilience and the factors that both promote and inhibit its development. Improved understanding of these factors is intended to contribute to and optimise the development of a capability to identify vulnerability, manage the risk and enable resilience.

Communications and warnings

Lead End User: Andrew Richards, NSW State Emergency Service

Child-Centred Disaster Risk Reduction

Lead Research Organisation: Central Queensland University

Project Leader: Professor Kevin Ronan

The role of children's disaster education in managing disaster risk has been recognised as a major priority in the National Strategy for Disaster Resilience. Yet, despite a recent surge in child-centred disaster research, the social, psychological, economic and political mechanisms that enable children to both understand and take action to reduce disaster risk remain largely unexplored and the evidence base for best practice remains limited.

A promising approach to supporting children's active engagement in disaster risk reduction is an approach most commonly referred to as Child-Centred Disaster Risk Reduction. Its primary objective is to strengthen children's skills so that they understand the disaster risk in their communities and are able to take a lead role in reducing that risk. While it is becoming increasingly popular among government and non-government agencies and organisations around the world, rigorous empirical research on the efficacy of the approach is scarce.

This project will conduct a nationwide evaluation of programs and strategies based on a Child Centred-Disaster Risk Reduction framework.

Managing animals in disasters: Improving preparedness, response, and resilience through individual and organisational collaboration

Lead Research Organisation: University of Western Sydney

Project Leader: Dr Melanie Taylor

The aim of this project is to identify the best practice approaches to the management of animals in disasters that result in optimal outcomes for public safety, and longer term mental and physical health of emergency

services responders, those with animal-related businesses, community members and their communities.

Research in this area is urgently required as there is a paucity of evidence to guide policy development and training needs.

In this project 'animals' include domestic pets, commercial animals, livestock and wildlife. Animal owners may include pet owners, small-scale animal related business owners, livestock producers and those concerned with and interested in wildlife (for example, wildlife carers, rural dwellers). Similarly, responders may be drawn from a broad range of groups, such as emergency services, Local Government, RSPCA officers, Parks and Wildlife rangers, NGOs (Red Cross, Salvation Army), general practitioners, veterinarians and volunteer organisations.

Improving the role of hazard communications in increasing residents' preparedness and response planning

Lead Research Organisation: The University of Melbourne

Project Leader: Associate Professor Jennifer Boldero

The increasing frequency and complexity of natural hazards poses a challenge for community resilience. Communication of risks and warnings plays an essential role in building, maintaining and restoring resilience. Recent natural hazard events demonstrate that current risk and warning communications do not always have the desired effect on community preparedness and planning, response, and recovery.

More specifically, little is known about the extent to which existing hazard communication strategies influence the levels and quality of preparedness and planning for natural hazards, comprehension of the requested actions, and the actual behaviour of individuals (for example, the timing and type of response during hazards) in affected communities during and after hazards.

This project will identify barriers and enablers in residents' decision making, preparing, and planning with regard to natural hazards. It will examine residents' intended use of different types of triggers for action during hazards; for example when to start evacuating and what information source to use. It will investigate why some residents form a better quality household plan with safer intended triggers than other residents. This will provide recommendations for end-users regarding the communication of action triggers to residents during actual hazards. This project will both focus on aspects that will lead to safer responses during disasters, and on aspects that will facilitate recovery post-disaster. The focus will be on recurring hazards such as bushfires, floods, and cyclones and storms.

Connecting communities and resilience: A multi–hazard study of preparedness, response and recovery communications

Lead Research Organisation: Queensland University of Technology

Project Leader: Professor Vivienne Tippett

Risk and warning communication plays an essential role in building, maintaining and restoring resilience in individuals, communities and businesses. Recent natural hazard events demonstrate that current risk and warning communications do not always lead to the desired effect on community response and recovery. This project combines expertise in communication, consumer psychology and marketing, disaster and emergency management and law. The project aims to develop evidence-based strategies that motivate appropriate action and increase informed decision-making during the response and recovery phases of disasters.

The project adopts a multi-hazards approach to examine the effectiveness of response and recovery communication in communities (comprising individuals, groups, and businesses) affected by floods, cyclones, fires and earthquakes. Reflecting the research techniques specific to the disciplines of communication, marketing and law, this project adopts a multi-method research design to:

- Examine the content and delivery strategies of official emergency messages.
- Develop evidence-based advice to guide trigger communications during hazards.
- Analyse the effectiveness and efficiency of official emergency messages in the response and recovery phases.
- Promote both community and end user understanding of the psychological and legal motivators for maximising engagement with emergency instructions.
- Examine opportunities for application of new technology and communication systems (e.g. emerging digital and social media platforms) to maximise the comprehension and compliance of communities at risk.

Community understanding of the tsunami risk and warnings systems in Australian communities

Lead Research Organisation: Massey University

Project Leader: Professor David Johnston

This project aims to better understand the factors that shape community resilience to tsunami in Australia, and effective tsunami warning risk communication.

Public understanding of the limitations of Australia's official tsunami warning systems has been found to be limited in many communities. Reliance on actual and perceived siren systems for public notification during tsunami events has been found to increase the risk to citizens and may increase the risk of fatalities and injuries. Public inability to interpret natural warnings for tsunami, and make decisions about appropriate actions, also places increased

responsibility upon Emergency Management practitioners and other hazard education and public safety agencies to educate the public.

This research will evaluate the gaps in public understanding of risk and intended response to official and natural warnings for tsunami and to explore why the push for siren-based systems continues throughout many Australian communities. The outputs of the research will enable us to recommend more effective use of resources and methods to engage with and educate the public about tsunami, natural warnings, and the limitations of technology-based systems such as sirens.

Emergency management capability

Lead End User: Keith Fitzgerald, NSW State Emergency Service

Capability needs for emergency and disaster management organisations

Lead Research Organisation: Queensland University of Technology

Project Leader: Dr Paul Barnes

This study will examine in-depth lessons from historical emergencies and disasters by engaging with state and federal response agencies, as well as those supporting response and recovery, and local government. From this it will examine options for defining agile and sustained skills sets across the full cycle of disaster management.

This study will also enhance planning mechanisms for the delivery of effective disaster response and efficient recovery strategies for future emergencies. The combination of capability gap analysis and scenario-based futures-based thinking will allow the formation of scaled descriptions of capability along a continuum of increasing effectiveness, adaptability and sophistication to contribute to strengthening community resilience.

This knowledge is critical because within the context of modern disaster situations, institutions would be unlikely to face single incidents but rather a series of systemic failures, often appearing concurrently. Emergent complexities in linked systems make crises difficult to anticipate and consequences difficult to plan for. Furthermore, under emergency conditions the pressure on senior decision-makers to 'make-sense' of multiple lines of information (for both crisis and consequence modes) is significant.

Practical decision tools for improved decision making in complex time-constrained and multi-team environments

Lead Research Organisation: Central Queensland University

Project Leader: Dr Chris Bearman

This project will develop practical cognitive decision tools and heuristics that can be used in different emergency contexts to enhance strategic level decision making in complex, time-critical, multi-team situations.

This will include constructing straightforward

ways for strategic level managers to track the performance of teams they are responsible for to ensure the team is not operating at the edges of safety.

The outcomes of the project are therefore:

- Cognitive decision-making tools: Practical cognitive decision tools that can help people at strategic levels of emergency management to better deal with complex, time-pressured and multi-team situations.
- Monitoring and tracking tools and strategies: Tools to provide a way for strategic level supervisors to monitor the performance of individuals and teams.
- Metrics for evaluation: Process-based performance metrics that allow independent evaluators to assess real-time performance.
- Methods for evaluating existing and newly developed decision heuristics and monitoring tools.

Hardening buildings and infrastructure

Lead End User: Matt Hayne, Geoscience Australia

Cost-Effective mitigation strategy development for flood prone buildings

Lead Research Organisation: Geoscience Australia

Project Leader: Dr Tariq Maqsood

The project will inform decision making on the mitigation of community risk posed by Australian buildings in flood plain environments, either through poor planning, or placed there by design as part of planned developments. It complements parallel CRC projects for earthquake and severe wind.

Floods impact many Australian communities, while some communities are inundated repeatedly due to inappropriate urban development in flood plain areas. This results in significant logistical issues for emergency management, disruption to communities and considerable cost to all levels of government to repair damages and to enable communities to recovery. There is also a need for supporting information on the cost effectiveness of mitigating the risk posed by existing buildings either through retrofit, reconstruction on the site or relocation.

This project is aligned to two other related CRC projects that will collectively address vulnerability and mitigation information requirements associated with the built environment consistently across the hazards of severe wind, earthquake and riverine flooding.

The research in this project will provide the evidence base for decisions concerning the buildings having the greatest vulnerability in Australian communities and contribute the most significant part of severe flood related risk.

Natural hazard exposure information modelling framework

Lead Research Organisation: Geoscience Australia

Project Leader: Dr Krishna Nadimpalli

A nationally consistent exposure information framework for natural hazard risk reduction forms the basis of an essential element for decision making. Decision making at various levels of the disaster governance process is highly complex and depends on multiple attributes, objectives, criteria and functions.

This project will develop a modelling framework based upon a decentralised and open approach to access, merge and transform fundamental data (spatial, attribute and metadata) to create location based exposure information relevant for use at national, state and local government levels. The modelling framework forms the basis of exposure information capabilities describing key characteristics of the population, buildings assets and essential infrastructure exposed to natural hazards and enables vulnerability assessments.

This project will identify the fundamental data requirements and modelling framework to derive exposure information to enable a better understanding of the vulnerability of people, buildings and infrastructure.

The key research outcome of this project will be the development of consistent, standardised exposure information that supports scalability in vulnerability assessments for disaster risk reduction and socio-economic impact analysis to support policy making.

The project provides a framework to assess the reliability of exposure information for both tactical and strategic disaster management from multiple hazards. This will assist government (national, state and local) and industry end users to better understand the reliability of exposure data for decision making.

Once the project is complete, the outputs will be used to improve existing exposure database capabilities at Geoscience Australia (NEXIS), various State Emergency Services and various stages of disaster management and risk assessment models.

Improving the resilience of existing housing to severe wind events

Lead Research Organisation: James Cook University

Project Leader: Associate Professor John Ginger

Typically older Australian houses built prior to the mid-1980s do not offer the same level of performance and protection during windstorms as houses constructed to contemporary building standards. Given that existing houses will represent the bulk of the housing stock for many decades, practical structural upgrading solutions based on the latest research will make a significant improvement to housing performance and to the economic and social wellbeing of the community.

This project will develop the evidence base for risk mitigation by devising simple practical and economic upgrading options for existing houses. The outcomes will promote retrofit investment by home owners and provide a basis for incentives to encourage this action through insurance and government initiatives.

The primary objective of this project is to develop cost-effective strategies for mitigating damage to housing from severe windstorms across Australia. Outputs from this project will target a range of users from policy development through to homeowners and builders on recommended actions to improve resilience of existing housing. The uptake of the research will reduce the cost of natural disasters in Australia.

Enhancing resilience of critical road infrastructure: bridges, culverts and floodways

Lead Research Organisation: RMIT University

Project Leader: Associate Professor Sujeeva Setunge

Road networks and critical road structures such as bridges, culverts and floodways have a vital role before, during and after extreme events to reduce the vulnerability of the community being served.

A major gap in the current research is the lack of assessment techniques and tools to reduce the vulnerability of road structures to enhance both community and structural resilience. This project will develop innovative tools and techniques for implementing strategies to enhance resilience of road infrastructure to multi-hazards of floods, fire and climate change and earthquakes.

The research will commence with close assessment of two case study regions: one in Victoria and one in Queensland. It will then be expanded and validated.

The outcomes of this project will include

1. Quantitative evaluation of vulnerability of road structures under multi hazards of fire, flood, earthquake and climate change; a web based tool for design and maintenance optimisation of bridges, culverts, floodways to flood, bushfire, climate change and earthquake.
2. Quantifying social, environmental and economic consequences of failure; community, emergency services staff and road/local government authorities; community adaptation options to enhance resilience as an alternative to hardening of structures when critical road structures are damaged.
3. Input for decision support at local government and state road authorities; a new design guide for floodways, plus recommended changes to other standards.
4. A generic research methodology that can be applied to other infrastructure, such as transmission towers and water infrastructure.

Cost-effective mitigation strategy development for building related earthquake risk

Lead Research Organisation: The University of Adelaide

Project Leader: Professor Michael Griffith

Earthquake hazard has only been recognised in the design of Australian buildings since 1995. This failure has resulted in the presence of many buildings that represent a high risk to property, life and economic activity. These buildings also contribute to most of the post-disaster emergency management logistics and community recovery needs following major earthquakes. This vulnerability was in evidence in the Newcastle Earthquake of 1989, the Kalgoorlie Earthquake of 2010 and with similar building types in the Christchurch earthquake. With an overall building replacement rate of two percent nationally, the legacy of vulnerable building persists in all cities and predominates in most business districts of lower growth regional centres.

This research project will draw upon and extend existing research and capability within both academia and government to develop information that will inform policy, business and private individuals on their decisions concerning reducing vulnerability. It will also draw upon New Zealand initiatives that make use of local planning as an instrument for effecting mitigation.

The project's scope includes all typical building construction types in Australia as specified in Australian Standard for Earthquake Loading AS 1170.4. It excludes special construction such as power plants, offshore structures, and other industrial/manufacturing structures.

The project will address the need for an evidence base to inform decision making on the mitigation of the risk posed by the most vulnerable Australian buildings subject to earthquakes. While the focus of this project is on buildings, many of the project outputs will also be relevant for other Australian infrastructure such as bridges, roads and ports, while at the same time complementing other CRC project proposals for severe wind and flood.

Understanding and measuring social resilience

Lead End User: Suellen Flint, Department of Fire and Emergency Services, Western Australia

Scoping remote north Australian community resilience and developing governance models through action research

Lead Organisation: Charles Darwin University

Project Leader: Professor Jeremy Russell-Smith

Almost half of the north Australian community are Indigenous and the majority live in remote communities ill-served by existing emergency services.

While these communities have significant

Indigenous and local knowledge allowing them to understand and interact with their traditional estate, poor health, under-investment in infrastructure, restricted communication services and flawed governance models heighten vulnerability to the increasing array of natural hazards across the region.

This project will address the complexities inherent in this problem by identifying and building on the existing knowledge of bushfire and natural hazards. It will develop a fine-grained understanding of how local knowledge and other capacity underpins existing risk management and post-event responses and what changes would be most effective and valued. It will also document how community proposed changes could best be implemented.

A second part of the project aims to critically examine, communicate, and advocate for the contribution that 'new economy' opportunities and associated institutional and policy settings can make towards enhancing community resilience especially in relatively intact north Australian landscapes, and also in adjacent regions.

Northern Australian Bushfire and Natural Hazard Training

Lead Organisation: Charles Darwin University

Project Leaders: Steve Sutton and Jeremy Russell-Smith

The project focusses on the development and implementation of training for the communities and habitats of all the jurisdictions of northern Australia. It will use existing or emerging community organisations as a scaffold for growing leadership and resilience.

There are few examples of advancing capacity in remote north Australia, but two are the indigenous land, fire and sea management rangers and NORFORCE. These two groups identify, encourage and employ talented and motivated community members to achieve specific land management and defence/intelligence duties. The organisations are also accumulating technical resources that may be adapted to manage natural hazards. These resources, both the human capital and infrastructure provide a foundation to significantly enhance remote community resilience in the face of bushfire and natural hazards.

The Australian Natural Disaster Resilience Index: A system for assessing the resilience of Australian communities to natural hazards

Lead Research Organisation: University of New England

Project Leaders: Dr Phil Morley and Dr Melissa Parsons

The relationship between natural hazards and communities has traditionally been viewed from a vulnerability perspective. Australia's recently adopted National Strategy for Disaster Resilience (NSDR) takes an internationally progressive approach in the application of a disaster resilience paradigm. This strategy gives communities

greater options and diversity in managing natural hazards, and places natural hazard preparation, prevention, response and recovery in the context of societies learning from and adapting to change.

The NSDR recognises four characteristics of disaster resilient communities: 1) they function well while under stress 2) they adapt successfully 3) they are self-reliant and 4) they have strong social capacity. Building these characteristics of disaster resilient communities is seen as a shared responsibility among individuals, households, businesses, governments and communities. Yet how could progress towards the development of these characteristics be assessed? Where are the areas of high and low disaster resilience in Australia? How could investments to develop disaster resilience be prioritized, evaluated and reported?

This project will develop an index of the current state of disaster resilience in Australian communities – the Australian Natural Disaster Resilience Index. The index will facilitate assessment, evaluation, reporting and planning for natural hazard resilience under the NSDR. Deliverables will include development of disaster resilience indicators, maps of disaster resilience at multiples scales, a state of disaster resilience report, and examples that use the index in a natural hazard resilience planning context.

Sustainable volunteering

Lead End User: David Rae, NSW State Emergency Service

Out of uniform: building community resilience through non-traditional emergency volunteering

Lead Research Organisation: RMIT University

Project Leader: Professor John Handmer

There is a significant and largely untapped opportunity for state emergency management agencies to contribute to building community resilience to natural hazards by supporting and engaging with non-traditional emergency volunteers – and volunteering organisations – in new ways. The role of volunteers in increasing community resilience to disasters is recognised in both the priority actions of the UN Office of Disaster Risk Reduction's Hyogo Framework for Action and the priority outcomes of the Australian National Strategy for Disaster Resilience.

The traditional model of emergency volunteering employed in Australia and New Zealand is based on formal, accredited volunteers who are affiliated with state emergency management (EM) agencies and are largely involved in response and recovery roles. While this form of volunteering is crucial and has many strengths, it excludes the potentially large number of people who are motivated to volunteer before, during and after emergencies in a less ongoing and formal way.

Given dwindling numbers of traditional volunteers within the EM sector workforce over recent years, it is likely that non-traditional volunteers will provide the bulk of the additional surge capacity needed to deal with the more frequent natural hazard events occurring under climate change. At the same time, there are more and more 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 for the EM sector. The development of new, coordinated models is needed to provide a framework for engaging further with this potential additional workforce.

This project has three key objectives:

- To identify how non-traditional emergency volunteering contributes to building community resilience to disasters throughout different phases of emergency management.
- To identify ways the emergency management sector in Australia and New Zealand can promote community resilience through support of non-traditional emergency volunteering.
- To develop and evaluate alternative models for emergency volunteering in Australia and New Zealand that are inclusive of non-traditional volunteering and volunteering organisations.

Improving the retention and engagement of volunteers in Emergency Service agencies

Lead Research Organisation: University of Wollongong

Project Leader: Dr Michael Jones

The NSW SES estimates that the attrition rate of active volunteers is around 20 percent per year. High attrition rates create high operating costs (recruiting, training and equipping volunteers) and reduced organisational effectiveness (a small, overworked core of experienced and trained volunteers). This phenomenon of high turnover in the volunteer sector is not restricted to the SES, it is a common problem in most volunteer organisations.

This research will address an area of organisational strategy that has been largely overlooked in both practice and in research, that is, hosting organisations (e.g. the SES) are not effectively managing endogenous elements of their organisational practice, the impact of this is sub-optimal volunteer retention.

This project will help volunteer-based organisations to better utilise and manage both their resources and their volunteer workforce.

Findings from the project can then be used by comparable organisations across Australia to similarly optimise their workforce and financial strategies and thereby also better serve their communities.

BUSHFIRE AND NATURAL HAZARDS RISKS

This theme seeks better forecasts of likely events and precursor conditions; greater accuracy of forecast tools and more timely forecasts. This leads to increased preparedness for the impacts of natural hazards, improved communications and warnings and enhanced ability to predict and mitigate the risk.

Coastal management

Lead End User: Dr Martine Woolf, Geoscience Australia

Develop better predictions for extreme water levels

Lead Research Organisation: The University of Western Australia

Project Leader: Professor Charitha Pattiaratchi

Potential impacts and hazards of extreme water level events along our coasts are significantly increasing as populations grow and mean sea levels rise. To better prepare, coastal engineers, managers and planners need accurate estimates of average exceedance probabilities for extreme water levels. The occurrence of extreme water levels along low-lying, highly populated or developed coastlines can lead to considerable loss of life and billions of dollars of damage to coastal infrastructure, as the events in New Jersey with Hurricane Sandy recently demonstrated.

It is vitally important that the exceedance probabilities of extreme water levels are accurately evaluated to inform risk-based flood management, engineering and future land-use planning. This ensures the risk of catastrophic structural failures due to under-design or expense due to over-design are minimised.

This project will develop better predictions and forecasts for extreme water levels arising from storm surges, surface waves, continental shelf waves, tsunamis and mean sea level rise.

Resilience to clustered disaster events on the coast – storm surge

Lead Research Organisation: Geoscience Australia

Project Leader: Dr Scott Nichol

Coastal communities in Australia are particularly exposed to clustered disasters, due to the impact of cyclones and tropical storms when there can be coincidence of severe wind damage, storm surge, coastal flooding and shoreline erosion. Because the climatic drivers of cyclones and severe storms are stronger during specific times, these events often repeatedly impact the coast over periods of weeks, months or up to

a few years. The consequences of individual events are therefore exacerbated with little or no opportunity for recovery of natural systems or communities.

The processes that drive the coincidence or clustering of natural disasters are reasonably well understood. However there is as yet no clear methodology in use to quantify the elevated risk to communities from clustered or coincident events. Typically, risk assessments are based on individual hazards against a long-term frequency baseline. This is misleading as it underestimates the true impacts of coincident or clustered events on the resources and resilience of communities.

While clustering of events can add significant impact to all natural hazards, coastal communities are particularly sensitive to clustering because of the dynamic nature of the coast. Coastal landforms are not static, and themselves are vulnerable to the impact of the hazards. Coastal landforms provide the physical foundation of coastal communities, as well as potentially forming natural protection to those communities. Inadequate techniques that do not take a holistic approach to the dynamic response of coastal landforms and communities to clustered events can lead to inappropriate decision making or funding allocation.

This study will demonstrate how a methodology developed for storm surge events can be applied to better inform decisions around resource investment in terms of disaster mitigation, planning and response and thereby optimise the resilience of the communities involved.

Geoscience Australia recently developed a national classification of coastal compartments for the entire Australian coast, and this study will build and extend that work to integrate with the risk assessment framework, supporting outcomes with applications at a national, regional and local level.

The aim of this project is to develop a new methodology to quantify the impact and risk of coincident and clustered disasters on the coast, with an initial focus on storm surge, associated erosion and reshaping of the coastline and the resulting inundation and damage to buildings and infrastructure.

Monitoring and predictions

Lead End User: John Bally, Bureau of Meteorology

Mapping bushfire hazard and impacts

Lead Research Organisation: Australian National University

Project Leader: Professor Albert Van Dijk

Government agencies, individuals and businesses need accurate spatial information on fire hazard to prevent, avoid and manage

impacts. Bushfire hazard depends not only on weather but also on landscape conditions.

In Australia, fire hazard monitoring involves fire danger indices that consider mainly meteorological conditions, although a simple algorithm is used in the MacArthur Forest Fire Danger Index to calculate the 'Drought Factor Value' from antecedent weather data, intended as a rough estimate of litter moisture content.

To date, there has not been much emphasis on routinely providing and using spatial information on landscape-related hazard factors in determining fire risk. Partly, this is because of a lack of reliable, consistent, accurate and long-term information. This situation is changing, however. Several relevant satellite, airborne and mapping derived products and prediction models are now readily available to estimate important landscape variables that determine fire hazard.

This project will develop methods to produce the spatial information on fire hazard needed by planners, land managers and emergency services. The relevance and added value represented by these new information sources will be compared to the practical feasibility and costs of their use.

Disaster landscape attribution: fire surveillance and hazard mapping, data scaling and validation

Lead Research Organisation: RMIT University

Project Leader: Professor Simon Jones and Dr Karin Reinke

This project will systematically address the provision of rapid, timely and high quality information from multi-scale remote sensing systems. It will develop enhanced metrics on active fire extent, intensity and configuration as well as bushfire landscape attributes.

The project aims to bridge significant information and knowledge gaps that currently prevent optimal use of earth observing technology. These include accuracy and reliability issues in active fire surveillance, quantitative estimates of post-fire severity, a lack of product validation, and out-of-date approaches to collecting information on landscape condition.

The project will lead Australian contributions to GEO / GEOSS / CEOS in this area and integrate and enhance Australian led existing disaster monitoring (e.g. the CSIRO/GA Sentinel Asia / Sentinel hotspots) and reporting systems with next generation earth observation technology and systems from the DLR and other agencies.

Improved predictions of severe weather to reduce community impact

Lead Research Organisation: Bureau of Meteorology

Project Leader: Dr Jeff Kepert

This project will use high-resolution modelling, together with the full range of meteorological data, to better understand and predict several important meteorological natural hazards, including fire weather, tropical cyclones, severe thunderstorms, and heavy rainfall. The outcomes from the project will contribute to reducing the impact and cost of these hazards on people, infrastructure, the economy and the environment.

Improvements in understanding of the interaction between bushfires and the atmosphere are also necessary. For example, bushfires modify the atmospheric flow nearby, with the changed winds then affecting fire spread and intensity. The development of strong updrafts, leading to ember transport, spot-fire generation and the formation of pyrocumulus clouds likewise involve interaction between the atmosphere and the fire.

This project will to extend our successful high-resolution fire weather modelling work with the Bushfire CRC in the following directions:

1. Extend into additional weather phenomena, particularly tropical cyclones, severe thunderstorms and intense extratropical cyclones.
2. Begin to move from "deterministic" prediction of the most likely outcome, to a pilot demonstration of probabilistic prediction of the range of plausible scenarios, together with the estimation of their relative likelihood.
3. Contribute to the development, and eventual operational implementation, of a run-on-demand severe weather version of the Bureau's ACCESS NWP system.

Improving flood forecast skill using remote sensing data

Lead Research Organisation: Monash University

Project Leader: Dr Valentijn Pauwels

Remote sensing can be a helpful tool for operational water management, and particularly for flood forecasting. In this project, remote sensing data will be used in two ways. First, estimated soil moisture profiles from hydrologic models will be improved through the merging of these model predictions with remotely sensed surface soil moisture values. This is expected to have a beneficial impact on modelled hydrographs.

Second, estimated flood inundations and water levels from hydraulic models will be improved through merging these model results with remotely sensed observations of flood inundations or water levels. This is expected to improve the predictive capability of the hydraulic model. Overall, using remote sensing data in flood forecasting is expected

to lead to better early warning systems, management of floods, and post-processing of flood damages.

The objective of the project is to demonstrate the utility of coupled hydrologic/hydraulic model forecasting and data assimilation using remotely sensed data for potential operational use. This is expected to have a strong future beneficial impact on flood management practices in Australia.

Mitigating the effects of severe fires, floods and heatwaves through the improvements of land dryness measures and forecasts

Lead Research Organisation: Bureau of Meteorology

Project Leader: Dr Imtiaz Dharssi

Fire intensity, spread rate and ignition are sensitive to the fuel dryness which is strongly linked to soil moisture content. Estimates and forecasts of fuel and soil moisture are the foundation of the fire danger calculations used to rate and manage wildfires and to warn of developing fire danger. Similarly, estimates and forecasts of soil moisture are essential ingredients to be able to forecast with accuracy river flows on a seasonal scales (one to three months), which is much in demand by water managers and reservoir operators.

Currently landscape dryness is estimated using crude models developed in the 1960s. The most prominent of these used in Australia are the Keetch-Byram Drought Index (KBDI) developed in the US Forest Service, and the related Mount Soil Dryness Index developed by Forestry Tasmania. These simple empirical soil moisture models are designed to be easily hand calculated once per day for a small number of points across the landscape. Flood prediction, runoff potential and water catchment/dam management also are not using the best available technology and use simplified soil moisture accounting systems.

Modern Numerical Weather Prediction (NWP) systems calculate landscape dryness, but with much greater sophistication. They can account for soil characteristics, solar insolation, root depth, vegetation type and biological factors such as stomatal resistance, to better estimate the evaporation and other landscape moisture processes. Satellites can remotely sense soil moisture in the top few centimetres below the surface, with data available from dedicated soil moisture satellites since 2009. Satellite soil moisture data can be used directly, or assimilated by an NWP system to improve consistency with other environmental observations.

The current fire systems only use landscape dryness that uses one layer, soil type and vegetation, at one point in the day. It is imperative to the Australian community that best science and technology that is available to Emergency Management is used effectively and incorporated into warnings systems.

Next generation fire modelling

Lead End User: Simon Heemstra, NSW Rural Fire Service, Andrew Stark, ACT Rural Fire Service

Fire spread prediction across fuel types

Lead Research Organisation: Victoria University

Project Leader: Professor Graham Thorpe

It is essential that emergency and disaster management organisations are able to predict the rate of spread and intensity of bushfires. This is achieved by implementing simplified fire propagation models that generate results on time scales that are useful to emergency managers. However, it is essential that these non-physics-based applications tools be refined so that they can predict fire behaviour under a wide range of localised topographic and weather conditions; they also need to be able to account for a range of vegetation types and their moisture status.

To help ensure that non-physics-based application modelling tools are accurate and flexible, the principal objective of this project is to develop an accurate and well-documented computer model that is based on firm physical principles. The model will be used to generate input data for non-physics-based models by simulating a large number of case studies. The new physics-based three-dimensional (3-D) model will form a key component of this project's strategy to develop "next generation" fire modelling capability and capacity.

The underlying physical and chemical mechanisms of fire spread are interdependent and extremely complex, and this renders their modelling intellectually challenging. However, inexorable advances in the physical and computing sciences are transforming the accuracy and detail with which the simulations can be made. The "physics-based model" will include all modes of heat transfer (conduction, convection, radiation) in which both fire-fuel and fire-atmosphere interactions are modelled. The model will account for the transportation of firebrands, pyrolysis (gasification of fuel from the solid state before taking part in combustion), combustion, and soot production submodels.

Bushfires can modify local weather conditions, hence modelling the interaction of fires and the atmosphere is a key component of the project. This requires a deep understanding of the factors that determine air flows and temperature distributions. For example, the height of flames generated by combustion may be tens of metres but it is an inescapable fact that small length scale phenomena on the order of a fraction of a millimetre are important in determining the behaviour of bushfires.

In this project these length scales will be spanned by making use of a computational technique known as large eddy simulation, which accurately resolves phenomena that occur on the length scales of tens of centimetres, and which relies on approximations of the small scale phenomena.

Prescribed burning and catchment management

Lead End User: Naomi Stephens, Office of Environment and Heritage

Savanna fire management

Lead Research Organisation: Charles Darwin University

Project Leader: Professor Andrew Campbell

This project has three major components:

- Savanna burning.
- Management of high biomass weeds.
- Spinifex and mulga landscapes.

Savanna Burning:

The Savanna Burning project builds on the substantial work previously undertaken within the Bushfire CRC's North Australian Fire Mapping project.

The project developed a comprehensive algorithm for mapping fire effects on tropical savanna vegetation. These data and the annual fire history mapping data were then applied in preliminary analyses to assess the risk to biodiversity, greenhouse gas emissions and ecosystem services in general under various climate scenarios.

The Savanna Burning project will build on this work by gathering finer scaled data and undertaking more detailed assessments of these and other criteria in regions defined as being at greatest risk.

The preliminary analyses suggested that the most deleterious effects to ecosystem services occur predominantly on Indigenous owned and/or managed lands. Therefore, the project will involve consultation with lead Indigenous groups such as the North Australia Indigenous Land and Sea Management Alliance and the Land Councils to determine those areas where it would be most feasible to undertake the detailed analyses through the collation of fine scale spatial data leading to research determining community resilience to those risks.

This project will expand upon broad-scale bushfire risk assessments in previously determined high risk regions using higher resolution spatial analyses. Current risk assessments include impacts on greenhouse gas emissions abatement, biosequestration, soil erosion, biodiversity, communities, and enterprises – under different management and climate scenarios.

Managing flammable high biomass grassy weeds:

A range of invasive grasses have spread rapidly in tropical Australia over the past two decades, substantially altering the savanna, riparian and wetland ecosystems.

The ecological, economic and social consequences of these grasses are so significant that many are now declared at the Territory and State level, have been listed as Weeds of National Significance, and listed as a Key Threatening Process under the EPBC Act. The impacts are primarily due to the substantial change in fire regime, with more frequent fires occurring at intensities higher than ever recorded previously in north Australian tropical ecosystems.

In the NT, special fire zones have already been declared based on the increased fuel loads and fire risk resulting from high-biomass grasses. There is a lack of decision support tools or models to effectively inform the longer-term consequences of grass invasion or the optimal decisions regarding the allocation of resources to manage this fire risk. The lack of these tools directly affects determinations about where to invest scarce resources to have the greatest impact on reducing risk and improving community resilience.

This project will assess the likelihood and magnitude of risk of high biomass invasive grasses to fire regimes in the tropical savanna region and provide critical information for Government policy and planning, particularly prioritisation of weed risk for fire-regime changing species, and for fire management planning.

Central Australian spinifex and mulga landscapes:

Substantial R&D has been undertaken over the past 15 years into the development of savanna burning greenhouse gas emissions abatement and sequestration methodologies, and associated project applications.

There may also be considerable potential for the development of complementary methodologies focusing on improved fire management of extensive central Australian mulga- and spinifex-dominated rangelands. Most prospective is a biosequestration methodology focusing both on mulga (*Acacia aneura*) and spinifex (*Triodia spp*). Unlike tussock grasses, Triodia continues to accumulate biomass at decadal scales similar to woody shrubs.

Available national mapping sources indicate that such landscapes cover at least a quarter of the continental landmass. These landscapes are very sparsely settled (mostly by Aboriginal people in small isolated communities), and support no economically significant agricultural or pastoral enterprises.

Despite the extreme aridity (with highly annually variable mean annual rainfall conditions <250 mm/yr) of mulga-spinifex landscapes, very extensive fires occur in the contemporary era particularly after intermittent rainfall events.

These contemporary 'boom and bust' patterns contrast strongly with the well-documented patchwork fire mosaics maintained under Aboriginal fire management until as recently as the late 1950s in some regions.

This project will contribute to the development of an approved Carbon Faring Initiative (or related) biosequestration methodology addressing improved fire management under central Australian conditions.In the longer term, to provide an economic and employment foundation for remote central Australian communities to develop land management enterprises/ undertakings so as to provide a sustainable basis for developing stronger and more resilient communities.

Optimisation of fuel reduction burning regimes for fuel reduction, carbon, water and vegetation outcomes

Lead Research Organisation: University of Sydney

Project Leader: Dr Tina Bell

Application of fuel reduction burning (FRB) to eucalypt forests has been guided for many years by knowledge of the fire-response traits of key species. Managers have been able to prioritise FRB in a spatial context on this basis.

Similarly, landscape features are now moderately well understood in relation to FRB – some landscape positions and aspects are more manageable than others, and, again, managers have been able to prioritise FRB on this basis.

What has been lacking, but which has become increasingly important, is knowledge and projecting capacity of the effects of FRB on fuel loads, broad vegetation types (in biomass terms) and carbon and water potential (e.g. capacity for carbon sequestration, water yield) of the forests at a manageable spatial scale.

This knowledge is required in a format that is readily useable by managers. Most commonly, this lies in the form of predictive models or tools.

This project will move research and management capabilities to its next logical focus – building a predictive model and framework for planning of FRB.

Two underlying issues need immediate attention:

1. Limited knowledge of the water storage capacity and dynamics of soil profiles (e.g. to a depth of at least 1 m) – this hinders both our ability to model water fluxes, especially the yield of water to streams and dams, and our ability to model whole stand and forest water use, before and after fires.
2. Limited knowledge of the effects of differing fire intensities on soil carbon. This requires, *a priori*, development of techniques to reliably and routinely assess the fire-related temperatures within soils at different depths.

These key issues can be tackled within an overall framework of developing models to facilitate optimised FRB regimes. Such spatially explicit models will take into account changes in fuel loads and predict the likely effects of individual fuel reduction fires (FRF) and collectively as FRB regimes on carbon and water potentials and vegetation composition.

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ATTACHMENT 3

SECTOR NEEDS

The outcome of a multi-jurisdictional workshop in March 2013 held to define the possible scope of works for the Bushfire and Natural Hazards CRC was used as the basis of a public call for expression of interest from research providers.

Attachment 1

PROBLEM STATEMENTS AND CHALLENGES

The Bushfire and Natural Hazards CRC (BNHCRC) implementation team have begun the process of defining the program of work required to address problems as identified by the end-users and other stakeholders. The BNHCRC has drawn upon the work of the Bushfire CRC and the work undertaken as part of the Disaster Resilience CRC bid process to start the discussions among the various jurisdictions.

A two-day workshop was held in Melbourne on 25-26 March with key participants from the states and territories, the Commonwealth, a number of NGOs and selected hazard experts to scope out the problems needing particular attention.

A set of high-level problem statements have been developed covering strategic issues aligned with the Council Of Australian Governments (COAG) National Strategy for Disaster Resilience (NSDR) and the National Bushfire Policy Statement.

The problem statements were considered in the context of natural hazards. The scope of the BNHCRC is non hazard-specific, as it aims to address issues that cut across all natural hazards, including bushfire, cyclone, flood, storm, earthquake and tsunami. The problem statements are organised in five main research themes:

- Data and Knowledge;
- Disaster Resilience;
- Decision Support and Resource Investment;
- Risk Mitigation Policy and Planning, and
- Emergency Management Practice.

Some of these themes are further defined to include different scoping elements.

It should be noted that the order in which the research themes are discussed in this document does not reflect a prioritisation of particular components of the scope. In fact, as is typical for a ‘wicked’ problem, the elements and themes in the proposed scope of the BNHCRC are highly interconnected. Recognising these relationships and dependencies is fundamental to addressing the issues raised by the end-users and stakeholders.

An overall view of the proposed areas of work is illustrated in the following diagram.

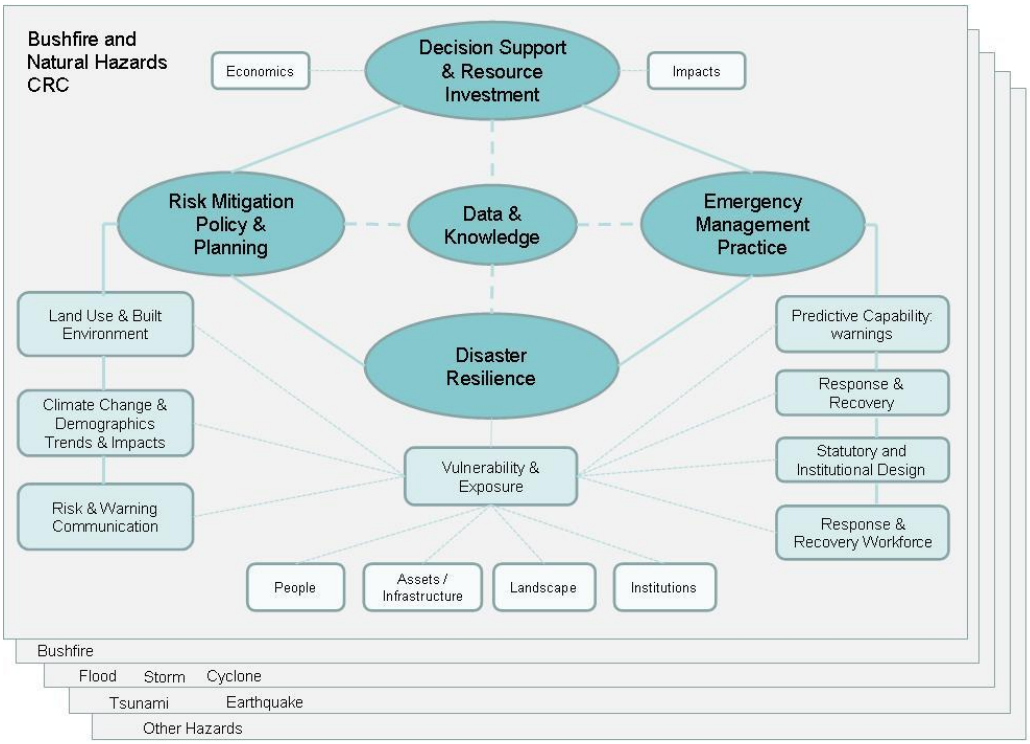

Illustration of the Areas of Work

THEME: DATA AND KNOWLEDGE

Central to all issues that drive the BNHCRC agenda is the pressing need for data and knowledge to support effective research, analysis and decision-making. The lack of reliable and accessible data on hazard, exposure[1], vulnerability[2], risk and resilience leads to inconsistencies in the development and execution of policy and practice across the spectrum of Prevention, Preparation, Response and Recovery (PPRR).

Government, agencies, communities, industry and stakeholders, (eg critical infrastructure or land managers) need reliable, timely and accurate information to manage the risks posed by bushfire and natural hazards. Data and information supports activities ranging from monitoring, reporting, and research, to policy making and evaluation. This includes information needed to make critical, strategic decisions for purposes such as:

- Meeting and measuring statutory obligations (service delivery);
- Identifying and monitoring what and who is 'at risk';
- Assessing whether land use and the built environment provide appropriate levels of safety;
- Prioritising allocation of resources across the Prevention Preparedness, Response and Recovery (PPRR) spectrum;
- Assessing whether policy, legislation and regulation is effective;
- Evaluating the sustainability of statutory and institutional arrangements;

[1] Exposure: community assets of value that can be exposed to natural hazard events. These include people, the built and natural environment, supporting infrastructure and economic activity.
[2] Vulnerability: The degree of susceptibility of community assets of value to natural hazards.

- Developing strategies for maximising learning and continuous improvement

Broadly speaking data needs include the information to support the following elements:

- Quantifying risk and community resilience;
- Forecasting;
- Situational awareness;
- Post-disaster impact and recovery information;
- Model validation, verification and improvement.

Whilst there are many existing and potential sources of data that are relevant to the emergency management sector and other stakeholders, there are critical gaps. Moreover, often data are not accessible, or not in a format or on a platform that facilitate its exchange, use and analysis in a policy and practice context.

Alternative and more sophisticated mechanisms and capability is needed to assist policy-makers and practitioners to make use of complex data to produce the information and evidence to underpin strategic and operational decisions.

Furthermore, there is a strong requirement to explore and develop data models and information management systems, define supporting practices, capture, storage, processing and delivery mechanisms, as well as a need to build capacity within the sector.

Problem:

Governments, jurisdictions and organisations often do not have the data and information they need to make critical, strategic and operational decisions.

There is a clear expectation that policy and practice will be based on evidence supported by knowledge including data and information. Currently, this expectation is not consistently met.

There is a lack of reliable data and information that can result in ambiguity and inconsistencies in the development and execution of PPRR strategies.

A great deal of current and potential data can be sourced within the emergency management sector, however it is unclear how to achieve this. In addition, there is no clear purpose and scope defining what needs to be collected and by whom. Moreover, there is no agreed mechanism to achieve this.

The data collected is not in a clear, coherent and accessible platform that supports governments, agencies, stakeholders and partners in decision-making, monitoring, evaluation, reporting, research and improvement.

THEME: DISASTER RESILIENCE

The concept of resilience in the Australian emergency management sector is relatively new and is not broadly understood. As the use of the concept matures and definitions are introduced and agreed this will assist in the implementation of targeted, strategic initiatives.

There is no single commonly accepted definition of the concept of resilience as it relates to the potential impacts of natural disasters across the complexities of individuals, communities, the built environment, critical infrastructure and ecosystems. Without some agreed understanding of the concept and how it is measured, will limit the ability to develop effective strategies to improve national resilience, as it is not possible to evaluate if and when desired outcomes have been achieved.

The Australian Government invests widely in strategies to increase disaster resilience and requires a way of determining the level of return on investment, be it in human life, economic, environmental and social terms. Governments, through their various agencies, need common measures and evaluation frameworks and techniques to inform future policy and action.

The work under this research theme is directly linked with both the *'Data and Knowledge'* and the *'Decision Support and Resource Investment'* themes.

Problem:

We have limited data and information to indicate how resilient Australia and its communities are, nor where the vulnerabilities and exposures lie. As a result it is difficult to make strategic policy and resource allocation decisions. It is also unclear what resource mix should be applied to risk reduction, response and recovery, to maximise community resilience

There is no agreed and consistent definition or measurement methodology.

Vulnerability and Exposure

Disaster resilience is to a large extent driven by the vulnerabilities of elements of the community, its institutions, its built assets and (critical) infrastructure, and its ecosystems. For many elements, there is limited understanding of these vulnerabilities across the full range of potential natural disasters. This includes identification of the vulnerable groups in a community at risk from natural hazards, understanding the impact of a disaster on an ecosystem, or predicting the full range of socio-economic consequences of critical infrastructure failure during a disaster. A better understanding of all components of vulnerability to natural disasters and their interdependence would allow better management of the risks, and thereby improve community resilience.

In order to make use of an understanding of vulnerability, it is essential to have good knowledge on the exposure at risk. This means there is an urgent requirement for datasets that describe the population, buildings and infrastructure and elements of the natural environments exposed to natural hazards. These datasets need to specify the relevant exposure characteristics that allow linking this information to the vulnerability (and hazard) models. This always includes location; and

for example might record age, health and disability indicators and other pertinent drivers of vulnerability for individuals, or construction type and material for buildings.

Potential research areas include:

- Further developing the ability to identify vulnerable/resilient individuals, communities, assets and infrastructure, institutions and ecosystems;

- Developing methodologies that qualify and quantify vulnerabilities in Australian communities, institutions, infrastructure and ecosystems relating to disaster resilience across the hazard spectrum.
- A better understanding of the interdependencies between vulnerabilities. In particular there is a critical need to develop better models for the vulnerabilities of critical infrastructure and the impact this has on the vulnerability and resilience of communities.

Problem:

There are still large gaps in the knowledge of the vulnerabilities to the impacts of natural disasters of elements of the Australian community and its natural and built environment. This includes identification of the vulnerable groups in a community at risk from natural hazards, understanding the impact of a disaster on an ecosystem and the built environment, or predicting the full range of socio-economic consequences of the failure of critical infrastructure during a disaster.

A better understanding of all components of vulnerability to natural disasters, and availability of the associated exposure information would allow better management of the risks, and thereby improve community resilience.

THEME: DECISION SUPPORT AND RESOURCE INVESTMENT

The emergency management sector, responsible across the PPRR spectrum, is faced with an increasingly complex environment. Risks and vulnerabilities are dynamic, driven by changes in geography of the population, demographics, population health, and climate. While operating with scarce resources, the sector has to meet growing expectations and scrutiny. It is likely that the demand for transparency and the ability to justify and defend decisions will only continue to increase.

There is a lack of decision support tools, processes and models to allow the assessment of benefits and costs of mitigation and risk reduction measures, as well as supporting optimal recovery and response policies. Such tools will help determine where to invest scarce resources, to derive the greatest impact on reducing risk and improving resilience to natural disasters, and support informed robust and justifiable allocation of resources.

These tools are based on the fundamental capability to model and predict disaster impacts and consequences across all hazards. This capability needs to account for the full range of economic, social and environmental aspects, including loss of assets, loss of production, societal impacts, and environmental harms.

By quantifying a comprehensive assessment of impacts, consequences, risk and resilience, tools can be used by the emergency management sector or a community to pre-emptively mitigate a risk through management of assets and the built and natural environment, as well as optimising warnings.

The interdependencies of systems, particularly critical infrastructure, can also be assessed using these tools to better understand and prepare for the cascading consequences of disruption. For example, power outages can affect information and communications technology, financial systems, water supplies and hospital systems. Similar tools can also be used post-event to determine how best to rebuild assets by assessing the efficacy of betterment options.

The outcome of creating and using these tools are informed trade-offs that maximise benefits of investment to the community. The tools will inform how best to reduce risk, and minimise the residual risks to the community.

Potential research areas include:

- Where these do not yet exist, developing medium resolution risk models across the hazard spectrum that model the full range of their impacts for different annual return intervals;
- Developing the information processes and tools that are required to qualify and quantify the resilience of individuals, communities, assets and infrastructure, landscapes and the environment, the economy and institutions. This is directly linked to the work in the '*Disaster Resilience*' theme;
- Developing and applying tools, methods and frameworks to undertake integrated assessments to inform trade-offs and investment decisions that are cost-effective and usable by operators and policy makers across the PPRR spectrum in an all-hazards context;
- Recommending the policy, legislative and decision-making settings in which the results from the above can be utilised.

Problem:

There are limited decision support tools, processes and models across hazards, jurisdictions and tiers of government to effectively inform decisions regarding the allocation of resources. The lack of these tools directly affects determinations about where to invest scarce resources to have the greatest impact on reducing risk and improving resilience.

THEME: RISK MITIGATION POLICY AND PLANNING

The traditional approach to major disasters and emergencies has focussed on investments in response and recovery. Recent experience, inquiries and the NSDR recognise that this approach is no longer adequate or sustainable. The frequency, impacts and consequences of significant events are likely to continue increasing into the future along with community exposure and vulnerability. This will result in greater impacts and higher demands on the emergency management sector.

A key component of increasing Australia's resilience to natural disasters is identifying options for mitigation. This research theme addresses three broad research areas:

- The planning of land use and the built environment, which includes building standards;
- The need to understand future risk and resilience posed by trends in demographics, population and climate change, and
- Planning risk communication and warnings.

Clearly, the work in this theme requires thorough understanding of the vulnerabilities that define potential impact, developed under the '*Disaster Resilience'* research theme. In parallel, the tools and processes developed under the '*Decision Support and Resource Investment'* research theme can be directly applied to support the outputs developed.

Problem:

The frequency, impacts and consequences of significant natural disaster events are likely to continue increasing into the future along with community exposure and vulnerability. This will result in greater impacts and higher demands on the emergency management sector.

In response to this, there is increased emphasis on identifying options for mitigation of disasters.

Planning of Land Use and the Built Environment

There are benefits to be gained from giving more consideration to the risk from natural hazards in the decisions around land use planning for residential and infrastructure construction. This issue will gain increasing urgency at a time where predicted demographic changes will mean growing pressure to increase the availability of land.

While it is widely recognised that disaster resilience of communities and landscapes can be improved through better linkages between the emergency management sector and planning of land use and the built environment, this potential is not yet fully realised. Apparent barriers include the inability to determine and articulate the cost of the transfer of risk for the protection of life and property on an all-hazards basis. This applies to new development, extensions to existing development including brown field, in-fill and retro-fitting existing development, and critical infrastructure.

Potential research areas include:

- Assessment of the appropriateness of current standards and building codes, e.g. flood floor level, cyclone wind loadings, roof types, bushfire building codes etc;
- Assessment of whether there is adequate knowledge transfer between professionals within and between disciplines involved in land use planning;
- Determining the level of knowledge represented within the emergency management sector around the options available for the protection of life and property, so that these can be

assessed and articulated (e.g. community education, warning, evacuation, property protection, mitigation);

- Assessment whether there is good integration across all hazards in terms of emergency management input to land use planning, so as to avoid conflicting or contradictory requirements;
- Assessment whether the public safety requirements being expressed by emergency management agencies are defensible in the legalistic environment of land use and building planning;
- Assessment of the evidence base to support the public safety standards being proposed by the emergency management sector e.g. loss of life, risk from isolation, access to and functioning of public infrastructure, risk exposure of high risk groups (aged care).

Problem:

There is a growing need to incorporate consideration of the risk from natural hazards to a larger extent into decisions around land use planning for residential and infrastructure construction.

Greater understanding as to the most effective mechanisms to achieve this is required, at a time where predicted demographic change will mean growing pressure to increase the availability of land for settlement purposes.

Climate Change and Demographics, Trends and Impacts

There is a growing body of research looking at the impact of climate change on the frequency and severity of climate extremes, including natural hazards. However, there is a lack of work being undertaken to translate this into changing requirements around preventing, preparing, responding to and recovering from severe natural disasters through changes in the hazard profile. This should consider changes in land use planning, building codes, and resource allocation, but also assess whether the current preparedness and response paradigm is suited to the likely natural hazard future. As much of our current planning and investment in infrastructure is based on historical risk profiles, we need assurance that these long-terms decisions won't become a liability into the future.

Australia is a country with an evolving community that lives longer, is increasingly concentrated in high-risk areas, and suffers from first world issues. These socio-economic trends alone make the nation increasingly vulnerable to disasters. Moreover, they interact with the changing natural disaster risk profile from climate change.

Potential research areas include:

- Investigating the (national) future risk profile in terms of impacts on communities and their infrastructure for a range of natural hazards. This should include scenarios for future events and their impacts and consequences;
- Assessing how climate change affects bushfire fuels across the nation, and how this affects frequency and severity of bushfires and their potential impact on communities;

- Investigating how climate change affects the correlation of natural disasters. For example, whether there will be an increasing/decreasing frequency of coincident events with compound impacts, such as cyclone, storm surge and flooding, or heatwaves and bushfires;
- Determine of the interaction of socio-economic trends with the likely impacts of climate change on disaster risk;
- Assess whether Australian building codes and planning practices are appropriate for our future risk profile, and investigate options for adaptation to a future risk profile;
- Understand whether the current response paradigm is adequate for an increasingly uncertain climate future, including different types and duration of impact and different scale of impacts.

Problem:

There is a lack of understanding of the impacts of climate change on the frequency and severity of severe natural hazard events, as it applies to their potential impact and consequences on urban and rural communities, ecosystems, institutions assets and infrastructure.

There is a need for the research to deliver outcomes in terms of likely future impacts of disasters on the community in such a way that this becomes directly useful for current practitioners across the PPRR spectrum.

Communication of Risk and Warnings

Many Australians are not well aware of the risks from natural hazards that they are exposed to. As a consequence, some individuals and communities do not take an active role in disaster prevention and management. Communication of risk and how to prepare and respond to natural hazards is usually seen as (part of) the solution. However, the effectiveness of communication often does not meet expectations, for example due to a lack of understanding of the effectiveness of various tools and methods.

Available communication models have become dated in a rapidly changing technological and demographic environment. Some communities have by-passed governments, and agencies that have sought their own solutions to risk communication. Research is needed to adapt the current understanding of effective communication to the new environment. This includes a better grasp of how communication around risk and natural hazards can be tailored to the needs of different communities.

The provision of adequate warnings is a particular aspect of broader risk communication. The warning communication paradigm is much more complex than it was a decade ago. The community has higher expectations of warnings. At the same time, technological advances mean that there is scope for any individual to report on emerging events, to spread information and even to issue warnings. As the warning paradigm evolves, research is needed that involves the users and practitioners of new technologies.

Potential research areas include:

- Further understanding of psychological and social aspects of risk awareness and behaviour in response to communication and warnings in the current (technological and social) environment;
- The potential impact of, and opportunities offered by, new technologies on the effectiveness and timeliness on risk communication and warnings;
- Methodologies and models for multi-dimensional engagement;
- Costs and benefits of delivering targeted warnings;
- Evaluation of the effectiveness of current warning mechanisms;
- Best practice approaches to creating and disseminating warnings
- Understanding expectations and shared responsibility around risk and response to natural disasters;
- Understanding the impact of changing demographics on the efficacy of risk communication and warnings.

Problem:

Some individuals and communities do not assume an active role in disaster prevention and management. There is insufficient awareness of the impacts of natural hazards and the need and methods with which to reduce risk. This is compounded by mismatched expectations of individuals, communities and government and its agencies in a rapidly changing technological, demographic and risk environment.

While communication is usually seen as (part of) the solution, there is a lack of understanding of the effectiveness of various communication tools.

THEME: EMERGENCY MANAGEMENT PRACTICE

The historical practice of the emergency management sector looks to be inadequate in its current form to meet the challenges of the future environment. Expectations of the emergency management sector appear to be rising, while disasters have increasingly severe consequences placing increasing pressures on government, industry and personal budgets.

In order to create the sustainable emergency management practices that are essential for a resilient nation, there is a need to address a range of research areas to develop the practice to meet future needs.

The research areas in this theme include the predictive capability that is required to issue warnings, response and recovery practice and statutory and institutional design.

Finally, there is a growing need to address issues around workforce planning for the emergency management agencies engaged in response and recovery, with increasing pressures on traditional volunteer models and productivity being an ongoing workforce issue.

Problem:

The traditional practice of the emergency management sector may become unsustainable and inadequate in the future environment. Expectations of the emergency management sector appear to be rising, while disasters have increasingly severe consequences. In order to create the sustainable emergency management practices that are essential for a resilient nation, there is a need to address a range of research areas to develop the practice to meet future needs.

Predictive Capability: Warnings

The ability to forecast and predict natural hazards underpins response and recovery efforts. There is considerable variability between the current predictive capability for different natural hazards, for example in accuracy and geographic or temporal coverage. There is a continued need to improve the quality, accuracy and coverage of the predictive capability. There is a need to quantify the accuracy of predictions so that 'error bars' can be integrated into decision making processes at all stages of disaster management.

Forecasts are required for hours to days, but also on seasonal timescales and, where possible, longer. Extending the lead time for forecasts enables earlier and more effective response and disaster management, although longer lead times impose a trade-off with forecast accuracy.

Finally, there is a need to extend the traditional 'hazard' forecasts to include predictions of likely impact and consequence to support response and recovery efforts. This links directly to research and outputs described in the '*Decision Support and Resource Investment*' themes.

Potential research areas include:

- Further develop and improve tools to enable better forecasting and prediction of tropical cyclone formation and intensity change;
- Better prediction of the occurrence and duration of heat waves;
- Further develop, validate and verify tools for fire spread prediction across a broader range of fuel types;
- Develop better seasonal outlook predictions for storm, cyclones, flood and fire;
- Develop better storm surge forecasts and predictions;
- Drawing on international best practice, propose strategies and systems to deliver effective flash flood early warning to vulnerable communities across Australia.
- Develop national medium-resolution cyclone and storm wind hazard modelling for a range of annual return intervals;
- Determine the relative utility and cost-effectiveness of flood frequency analysis versus full hydrodynamic / hydraulic flood modelling based upon risk, population, built form, vulnerability etc.
- Develop national impact models to humans, buildings and other infrastructure (e.g. roads) for flooding and other hazards.

Problem:

Reducing the consequence of natural hazards requires predictions that are more accurate, cover all hazards and are available with longer lead times. Research is required in three areas: improving and extending prediction accuracy, (better) quantifying the uncertainty of predictions, and addressing gaps in predictive capability.

Response and Recovery

As disasters continue to become more frequent, more intense and of longer duration, the interoperability, capacity and capability of emergency management organisations to respond is being significantly tested. Recent natural disasters have revealed emerging issues at the regional, state, national and international levels.

Fatigue, insufficient surge capacity and lack of appropriately skilled personnel to perform critical roles are becoming common-place issues. Of significant concern are the increasing instances of long-duration natural disasters occurring simultaneously and across multiple jurisdictions.

There is a growing need to match response and recovery strategies not only to immediate post-disaster needs, but also to ultimately help shape community resilience.

Recovery from disasters is an inherently complex process that takes place over differing timeframes and across social/health, economic, natural environment and built environment dimensions. Recovery strategies are not always well tailored to address the priority and long-term needs of Australian disaster-impacted communities.

Potential research areas include:

- Developing tailored management approaches involving partnering strategies, strategic policies, scalable governance and early identification of exit/transition plans;
- Determining the factors that influence the effectiveness of response and recovery and how those factors change: across hazards, over time, when communities have been impacted by multiple events, by the scale of the disaster, in relation to community expectations;
- How get a cohesive view of the legacy needs of communities based on assessment of the impacts and consequences following a disaster. Identification of effective frameworks and practical tools to assess these needs;
- Methods for qualifying and quantifying the effectiveness of the recovery phase by measuring community resilience before and after the disaster, taking into account the factors identified in the first bullet point above;
- An evidence base on which to identify effective (resilience enhancing) response and recovery interventions, with a better understanding of what interventions impede or delay ultimate recovery. An understanding how effectiveness of interventions might change over time and in relation to the scale of the disaster. Evidence of how post disaster recovery interventions might encourage adaptive outcomes.

Problem:

Undertaking response and recovery actions in a manner that maximises a community's ongoing resilience, rather than building reliance is a challenge, particularly immediately following a disaster.

There is a need to understand what capabilities and surge capacity is available to support multi-jurisdictional disaster response and recovery in Australia. At this point there is room for improved understanding of jurisdictional roles and responsibilities.

Further knowledge is needed what factors influence the effectiveness of response and recovery and how those factors change over time in accordance with community expectations. Moreover, this requires measures by which to judge effective recovery strategies.

There is a challenge to examine federal and state emergency management arrangements that are appropriate and meet contemporary and future response and recovery needs.

Statutory and Institutional design

Increasing expectations and traditional institutional and statutory design are creating tensions between established institutional business models and the requirements of contemporary disaster resilience and emergency management policy and practice.

Of particular concern is planning for land use and the built environment, where emergency management considerations are not always optimally integrated into decision-making. Roles and responsibilities, relationships and priorities are sometimes in conflict or are unclear. The traditional role of emergency service organisations is becoming blurred as expectations increase and expand.

A number of successful attempts have been made to integrate new approaches with the old. However, it is evident that an incremental approach is unsustainable given the current challenge posed to contemporary emergency management. This emphasises the need to re-think and consider international best policy and practice into the future.

Solutions and thinking around emergency management statutory and institutional design could be compromised in the future by only considering solutions that fit within current structures and policies**.**

Problem:

It is not clear whether the current statutory and institutional design is appropriate to meet the emergency management challenges of the future.

Response and Recovery Workforce

Anecdotal evidence indicates there is a current decline in structured volunteering. To maximise community resilience we need to best utilise all available elements of the workforce including structured and spontaneous volunteers in government and non-government organisations, as well

as retained, part-time, and full-time personnel. Existing response limitations between urban and rural agencies need to be reviewed to promote more flexible approaches particularly during disasters.

As society cultures, values and demographics evolve, emergency management organisations need to be flexible in their engagement with the current and potential workforce. Identifying issues and barriers can contribute to reducing limitations on the existing workforce. For example, research is needed in an all-hazard context to identify the most significant OHS risks, ranging from slips, trips and falls to post-traumatic stress disorder or cancer in emergency service workers, together with options to mitigate these risks.

Existing workforce strategies are very structured around emergency service organisations and do not accommodate spontaneous volunteering or maximum engagement with non-government organisations. Future models should be flexible to allow for the integration between elements of the emergency management workforce. This would promote greater leveraging of the existing workforce, and the workforce model would allow people to contribute in a variety of ways. Development of such models requires an understanding of the organisational culture of the emergency management organisations and its impact on the ability to adapt to different models.

The challenge for the emergency management sector in promoting resilient communities is to draw on all potential elements of the workforce and maximise social capital. Research is needed to help identify opportunities to engage with segments of the community that are currently under-represented in emergency management. Changes to workforce models need to be supported by evidence and data. Research is needed to identify the existing workforce models, potential alternative approaches and strategies to close the gap.

Potential research areas include:

- Investigation of the impact of changing demographics on the (volunteer) workforce;
- Analysis of the framework(s) of engagement that are used identifying weaknesses and opportunities, including barriers to collaboration and coordination across agencies and organisations;
- Cost-benefit analysis of a paid vs. volunteer workforce;
- An assessment of the contribution of volunteers to the resilience of the community they live in, and the potential decline in resilience as volunteer numbers drop;
- Investigation of the capacity and capability to provide surge response for increasingly regular and longer-duration events;
- Develop a better understanding of the interaction between volunteers and employers, and its impact on and opportunities for volunteer availability.
- The impact of legislation outside emergency management (eg OHS, licensing) that has an impact of the emergency management workforce;
- The opportunities and limitations of the existing and potential volunteer workforce posed by the interaction between volunteers and employers;
- The true health and safety impact/cost of the emergency management workforce;
- Options and a framework to support the emerging trend for spontaneous volunteers, particularly with respect to responsibility and integration.

Problem:

In times of natural disaster, the current emergency management workforce is limited, either in number, demographic and geographic spread, capability or availability. Greater access and engagement with a broader emergency management workforce will have a significant impact on our ability to prepare for, respond to, or recover from natural disasters.

There is a need for options and strategies to reduce the limitations in the current workforce and identify, engage and deploy the potential additionally available workforce.