



THE VALUE OF THE BUSHFIRE AND NATURAL HAZARDS COOPERATIVE RESEARCH CENTRE

FINAL REPORT
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Prepared for
Bushfire and Natural Hazards CRC

Independent
insight.



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EXECUTIVE SUMMARY

The Bushfire and Natural Hazards Cooperative Research Centre (henceforth referred to as the CRC) coordinates a national research effort in natural hazards, including bushfire, flood, storm, cyclone, heatwave, earthquake and tsunami. The CRC is undertaking work to quantify the value it has delivered as part of its future scoping. SGS Economics and Planning (SGS) has been commissioned to undertake this study of the value of the Bushfire and Natural Hazards CRC.

This research project used four stages to assess the impacts of the CRC. The first is a program logic mapping, which took an overarching view of the purpose of CRC’s research and its expected benefits. The second phase was a survey of users of CRC research outputs to understand how the end users valued the research, how they had put it into practice and what they thought could be improved. The third was a series of case studies on specific research projects, and the fourth was a cost-benefit analysis, quantifying and valuing the benefits identified in other sections.

FIGURE 1: PROJECT METHODOLOGY

PHASE 1 PROGRAM LOGIC and BENEFITS OF THE CRC	PHASE 2 STAKEHOLDER ENGAGEMENT	PHASE 3 CASE STUDIES	PHASE 4 COST-BENEFIT ANALYSIS
Program logic mapping and description of benefits, with research examples	Targeted survey of users of CRC research, including governments, universities, industry associations and not for profits	Detailed case studies of five CRC research programs, high level summaries of other case studies as deemed important by stakeholders, and a summary of the CRC’s involvement in the media.	Quantification and valuation of benefits of CRC in a cost-benefit analysis (CBA)
Section 2	Appendix 2 and 3	Referenced throughout the report, provided in their entirety in Appendix 1	Section 3

Benefits of the CRC

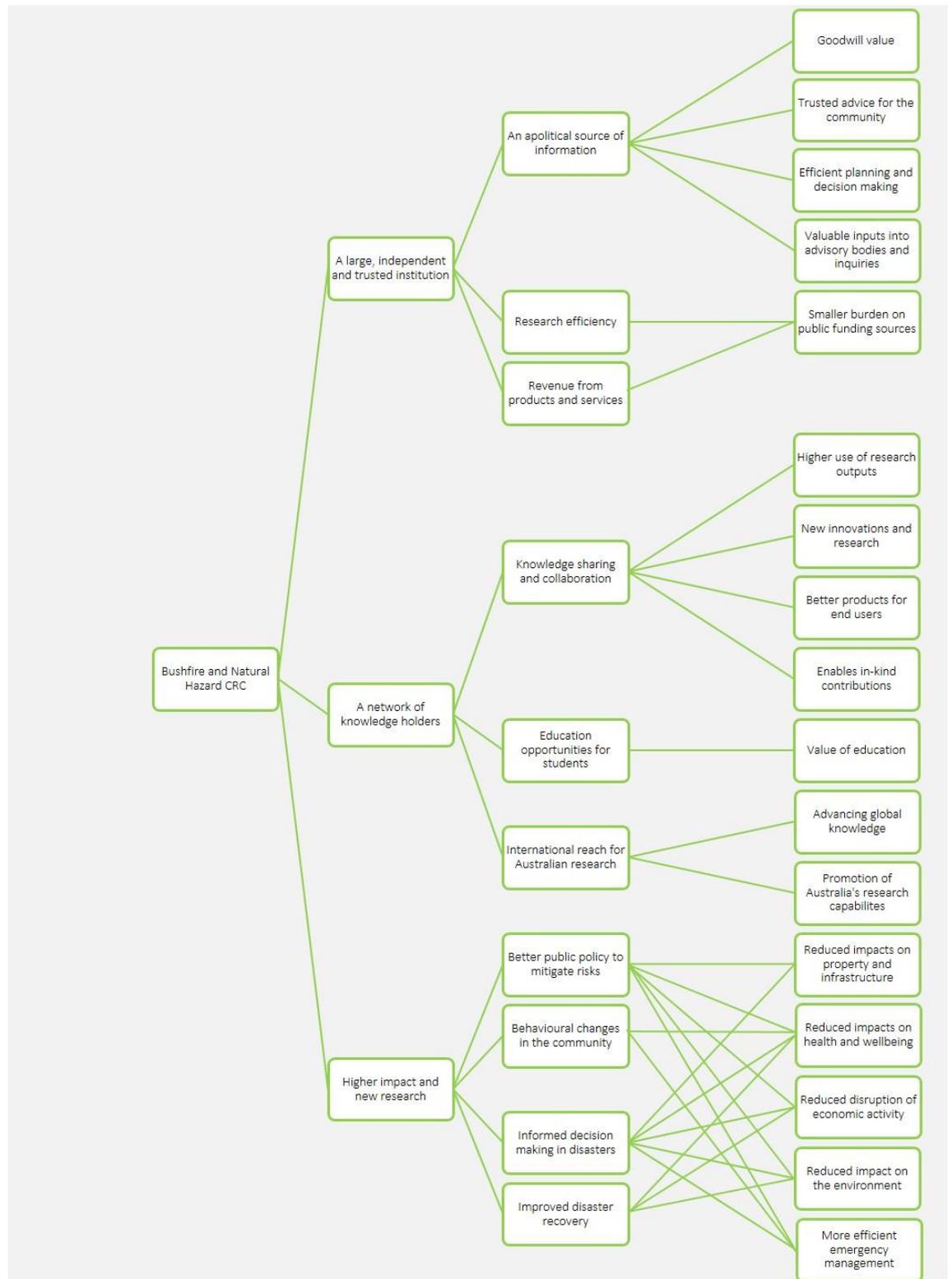
The benefits flowing to the Australian community from the CRC are many and varied. There are also strong links between benefits, and as such, it is useful to map them visually in a program logic framework, shown overleaf.

The three headline benefits of the CRC that generate benefits to end users and the wider public in Australia and overseas are:

- **A large, independent and trusted institution:** it delivers reliable information, information that is needed, in an efficient manner.
- **A network of knowledge holders for natural hazards:** it enables knowledge sharing, collaboration and education of experts at the national and international level.
- **Higher impact and new research:** it delivers information, products, services and tools that drive better decision-making, behavioural changes in the community and improved disaster recovery.

The following diagram outlines how the headline benefits connect with the benefits generated to end users and the wider public.

FIGURE 2: CRC BENEFITS PROGRAM LOGIC MAP



Source: SGS Economics and Planning

A large, independent and trusted authority

The CRC is a large, independent and trusted authority on natural hazards in Australia. This allows the CRC to be an apolitical source of information, to generate research efficiencies and bring in its own revenues from its high-quality products and services.

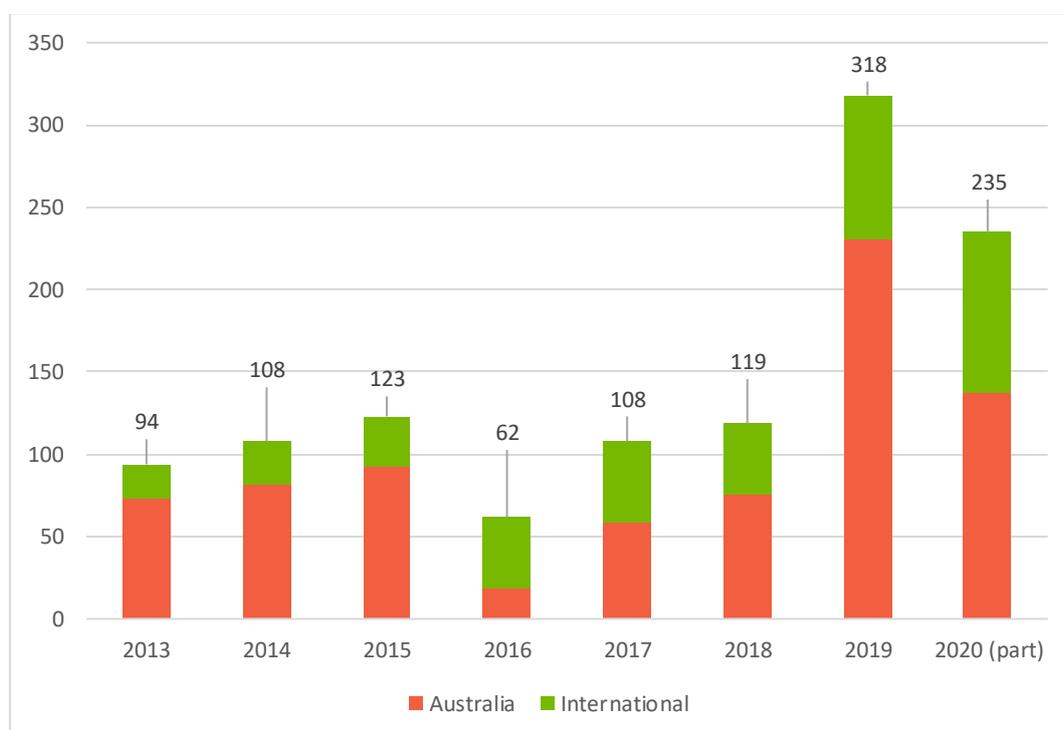
CRC's role enables a host of benefits for Australia including:

The goodwill value of the CRC. Goodwill is an intangible, but quantifiable, asset that contributes to the monetary value of an organisation. The success behind the CRC is exemplified by its recent three behaviour change projects (Research into Warning Systems, Managing Animals in Disaster, and Child-Centred Disaster Risk Reduction) and has been a result of CRC's reputation in the community. The backbone of the research relied on surveys completed by the community. The high levels of participation in these projects has been attributed to CRC's brand recognition in the communities they were working in.

"The CRC's reliability as a source of respected truth and knowledge enables it to be a pillar upon which decisions are made by agencies." (CRC End User Survey direct response, 2020)

Trusted advice for the community. The CRC provides trusted and reliable information for the broader community on natural hazards. The media has recognised the CRC as a trusted source to inform their reporting on natural hazards, and especially the recent bushfire. Since its inception in July 2013, the CRC has been quoted, referenced or discussed in 1,167 media sources. In particular, the number of Australia-based references has more than doubled in 2019, coinciding with the unprecedented 2019-20 bushfire season. The Ad Value Equivalency, or AVE, of the media references to the CRC during this same time period is estimated to be \$47.94 million AUD.

FIGURE 3: ANNUAL COUNT OF MEDIA SOURCES REFERENCING CRC: 1 JULY 2013 TO 21 APRIL 2020



Source: Meltwater, 2020. Search terms: Bushfire, Richard Thornton, Bushfire and Natural Hazards CRC

The value is further confirmed by the fact that many users of CRC information rely on this source, as there is often no satisfactory alternative. Survey respondents who regularly used CRC information were asked about the alternative options for sourcing similar information to that provided by the CRC. The results are highly informative. While a broad range of free local

and international sources such as academic journals and government agencies were pointed to, many responded that they did not know where they could find reliable alternatives.

Efficient planning and decision-making. Due to the CRC's reputation and high-quality research and data, government and emergency services can make decisions and plan more efficiently. This saves staff time within government agencies and other organisations.

The CRC have been the key organisation in coordinating and developing research into extreme weather and natural hazards that the Bureau of Meteorology (BoM) use to improve their services. This partnership allows the BoM to capture and operationalise new and emerging science. Over the past three bushfire seasons (2018- 2020) CRC researchers have been embedded into state control centres and agencies to provide a variety of essential services. In the 2019 bushfires, New South Wales, Queensland and South Australia state agencies requested the assistance of CRC researchers at their respective state operations centres (CRC 2019). Each researcher provided advice according to their expertise.

The Australian Exposure Information Platform (AEIP) demonstrates how research findings have been implemented to provide better and more rapid data for decision-making. During the 2019/20 bushfire season, the number of exposure reports produced from the AEIP was in excess of 14,500 by more than 200 individual users. Western Power, a WA-based energy provider, has recently utilised the platform to create 700,000 reports (CRC, 2020).

The Answering the Call, Recovery Capitals and PHOENIX RapidFire projects are also clear examples of this benefit. Additionally, PHOENIX RapidFire is an example of how investment made into research now will undoubtedly have impacts on the way natural hazards managed and disasters are planned for in the future.

Valuable inputs into advisory bodies and inquires. Staff from the CRC often present and provide crucial evidence and information to advisory bodies and inquiries. CRC staff sit on about a dozen advisory boards, and have provided expert advice to 1 Royal Commission, 5 Parliamentary Inquiries, 5 Independent Inquiries, and 3 general Government Inquiries.

A smaller burden on public funding sources. Being a large body with a high level of expertise on the one topic (natural hazards) allows for efficiencies to be gained in research (as opposed to the same research occurring across many separate organisations), and also for the CRC to generate its own revenue via its commissioned research program.

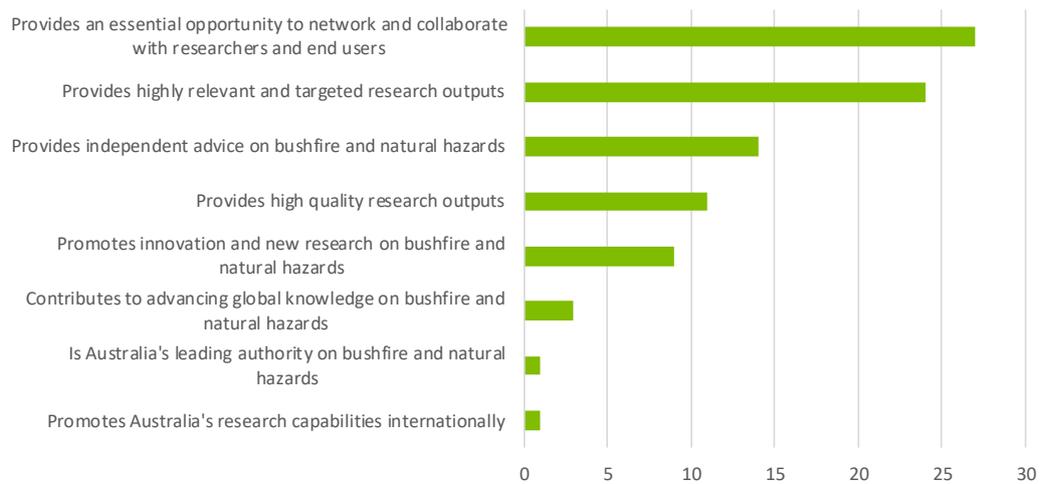
A network of knowledge holders for natural hazards

Since inception, the CRC has put effort into building a network of knowledge holders. This includes the promotion of knowledge sharing and collaboration, educational opportunities for PhD candidates and other students, and sharing Australian research globally.

Collaboration and embedding researchers in practitioner organisations generates more effective academic research that better meets the needs of practitioners, improved communication between practitioners to researchers and more influential research outcomes. The CRC maintains strong collaborative links with organisations on the ground to ensure that its research meets the needs of the organisations it is designed to serve. As an example, during the Queensland bushfires in November/December 2018, a meteorologist and CRC researcher was embedded in the Queensland Fire and Emergency Services (QFES) at short notice to map out bushfire spread scenarios.

The most valuable role the CRC provides consists of the opportunities for networking and collaboration with researchers and end users, according to the greatest share of respondents (27 per cent). This is closely followed by the CRC providing highly relevant and targeted research outputs (24 per cent).

FIGURE 4: THE MOST VALUABLE CRC ROLE



Source: SGS Economics & Planning, 2020

The benefits of the CRC as a network of knowledge holders encompass:

Higher use of research outputs. Having a wide network of both researchers and end users means that research outputs are used by a wider array of people and organisations. This makes the research more valuable as it reaches more people and is applied more often. As an example, the Answering the Call project brought together a collaboration of Beyond Blue, the University of Western Australia and Roy Morgan Research to increase the understanding around mental health issues in emergency services workers and volunteers. The CRC has recently extended this research in a project to develop an approach to maintaining good mental health in young volunteers, which will be undertaken by the University of Adelaide in collaboration with the University of Western Australia.

Innovations and research. The knowledge sharing and collaboration enabled by the CRC means that innovations and research ideas are generated that would not have otherwise occurred if the network of researchers and end users were not working together. An example of research that would not have occurred without the CRC is Influencing Behaviour Change, which helped close gaps in knowledge on how to influence behaviour during natural disasters.

Better products for end users. By working with a wider range of experts and directly with end users, the CRC generates bespoke and higher impact research outputs than could be achieved otherwise. The increased quality and applicability of the outputs are a benefit in comparison to the same research happening somewhere else without the same focus on the end user. PHOENIX RapidFire, built by the Bushfire CRC, was made specifically for the use of end users to aid in planning and bushfire management. It has been built upon by Bushfire and Natural Hazards CRC research which has aided in utilisation and accuracy in different landscapes across Australia.

Enables in-kind contributions. The collaboration focus of the CRC sees other organisations and researchers contributing in kind to research and other activities. The value of this is equivalent to the staff hours and monetary contributions made. The ReCap project benefitted from multiple in-kind contributions from stakeholders and end users providing in-kind contributions.

The value of education provided. The CRC has a large program of student research providing important educational opportunities for students in natural hazard management in Australia. At last count, sixty-one PhD and nine Master's degree students have graduated through CRC research programs. The CRC also provides a central role in building and maintaining the capacity and working knowledge of bushfire and natural hazard industry members across Australia. It is the combination of all of the CRC's activities that enable this, from the

dissemination of their research outputs, their calendar of events and conferences throughout the year, through to their media presence.

Advancing global knowledge. The knowledge sharing and collaboration enabled by the CRC also reaches internationally. This international reach means that the CRC is adding to the global pool of knowledge on natural hazards. For example, the Warning Systems research as part of CRC's Influencing Behaviour Change series study is being used and referred to in the international research scene.

Promotion of Australia's research capabilities. The international reach of the CRC's reputation and research provides benefits to Australia, as the nation's scientific and research capabilities are promoted to the world.

Higher impact and new research

The research undertaken and models created by the CRC have seen better public policy to mitigate hazard risks, behavioural changes in the community around disaster readiness and resilience, informed decision-making during natural hazards, and improved disaster recovery. This is critical and core work for the CRC and for Australia.

The benefits of this work include:

Reduced natural hazard impacts on property and infrastructure. Work by the CRC has led to a reduction in the direct damage to property and infrastructure during natural hazard events. By using PHOENIX RapidFire, state agencies can reduce damage to property and infrastructure both by ensuring appropriate measures are taken before the fire season begins, and making more informed decisions about areas that are at risk when a fire has taken hold. For example, the town of Gracemere in Queensland was saved from destruction when PHOENIX RapidFire predicted that a seemingly small bushfire near the town posed a real threat to turn into a blaze and threaten the town. As a result of this warning and an experienced weather forecaster being in the area, the threat was identified early and the town saved. It played a key role in the protection of the community of Gracemere in Queensland. The Australian Exposure Information Platform (AEIP) has provided an exposure report that highlights the value of elements that would have been destroyed had a bushfire destroyed the town of Gracemere township:

- residential dwellings reconstruction value: \$1,506,830,000
- contents value: \$281,230,000
- commercial reconstruction value: \$464,960,000
- industrial reconstruction value: \$307,430,000
- agricultural commodity estimated value: \$42,000.

Reduced impacts on health and wellbeing. CRC work, including on changing behaviours, increases community resilience, but also leads to less casualty and injury during events, and a reduction in mental ill-health and other community wellbeing issues. The Answering the Call initiative is a response at tackling mental health and wellbeing issues faced by police and emergency services.

Reduced disruption of economic activity. CRC's research, models and programs contribute to a reduced disruption of economic activity. Firstly, this is due to a reduction in direct impacts on assets and infrastructure from hazards. And secondly, this is also through better-planned emergency responses and evacuations.

Reduced impact on the environment. The CRC research has led to the better protection and management of the natural environment during and after natural hazard events.

More efficient emergency management. The modelling and research done by the CRC enable better decision-making and improved allocation of scarce emergency management resources.

Distribution of benefits to stakeholders

The stakeholders of the CRC include emergency services, the Australian Government, states and territories, local government, businesses, households, regional and rural communities, landowners, infrastructure providers, volunteers, the environment and academia.

These groups benefit in different ways. Whereas universities primarily benefit through the network of knowledge holders (headline benefit 2), regional communities and landowners benefit from better decision-making as a result of CRC's higher impact and new research (headline benefit 3). The Australian, state and territory and local governments benefit from the CRC as a large, independent and trusted institution (headline benefit 1), and from better decision-making as a result of CRC's quality and new research (headline benefit 3). Importantly, state governments benefit from higher impact and new research as it can be implemented during natural disaster response (which is primarily state coordinated).

Emergency services benefit in a variety of ways from the quality research, the network of knowledge holders and from the CRC being a large, independent and trusted institution. Emergency services also benefits from the aggregation of research funding generating leverage at the individual agency level.

Unsurprisingly, the major beneficiaries of a network of knowledge holders are universities, and to a lesser extent, emergency services and state government.

The detailed distributional analysis in the report provides further detail on stakeholders and their specific benefit profile. The benefit profiles can help in targeting engagement with stakeholder groups.

Quantifying and valuing the impacts of CRC

The benefits of the CRC were quantified and monetised and compared to the costs. This provides an understanding of the relative importance of the benefits. However, not all benefits could be quantified, for instance in the case of tacit values. In other cases, benefits were not quantified and included as they are deemed to overlap with other quantified benefits, to prevent benefits being double counted. Therefore, the valuation of benefits paints a conservative and incomplete picture of all the CRC's benefits.

The total costs of CRC's research programs from 2013-14 to 2020-21 amount to \$138 million. In addition to this, the costs of implementing research findings have been estimated at a total of \$6.3 million from 2014-15 to 2024-25.

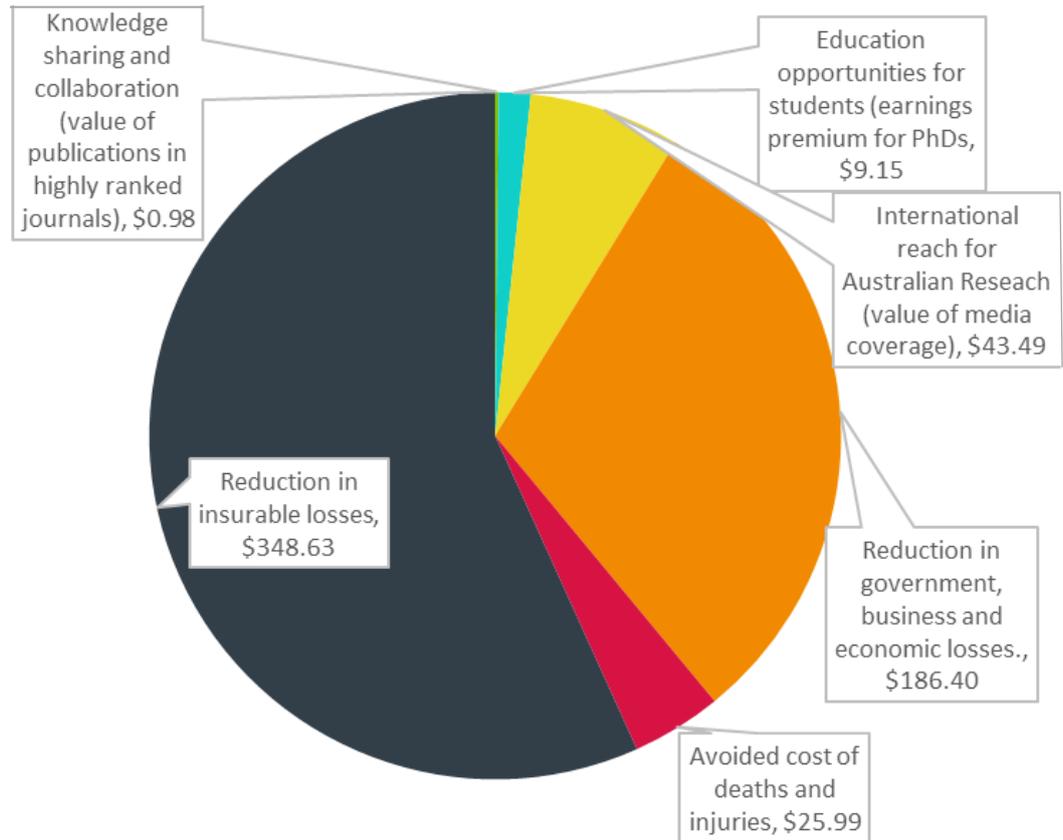
The benefits and costs of CRC's research were estimated over a 15-year period, from 2013-14 to 2027-28, although it is plausible that CRC will continue to provide benefits beyond this time.

The most significant benefits of the CRC are those associated with higher impact and new research to enable better decision-making: reduction in insurable losses (damage to buildings and infrastructure), avoided mortality and injury costs, and reduction in economic losses.

These benefits were based on a model developed by the CRC, which estimated the extent to which the CRC's research could be expected to result in a reduction in risk of loss of government and business activity, insurable losses and injury or loss of life. SGS reviewed these estimates in light of the impacts of research outputs in the 2019-2020 Black Summer fires, and concluded that the estimates were plausible to conservative.

At a more granular level, the figure below shows that the reduction in insurable losses (prevented damages to buildings and infrastructure) is the largest single benefit provided by the CRC, providing a 57 per cent share of all benefits.

FIGURE 5: SHARE OF BENEFITS



Source: SGS modelling, 2020

The benefits and costs were used in a discounted cash-flow analysis to establish the overall quantifiable benefits of the CRC. The table below shows the results of the cost-benefit analysis, at discount rates of 3 per cent, 7 per cent and 10 per cent. It shows that at a 7 per cent discount rate, each dollar invested in CRC provides \$6.07 worth of benefits. The total net benefit of CRC’s research program is \$513.57 million dollars, from a present value of investment of \$101 million. At a higher discount rate, 10 per cent, the benefits are still more than five times greater than the costs. Whenever the benefits outweigh the costs, society as a whole benefits. In the case of the CRC, the benefits outweigh the costs in an overwhelming fashion.

In addition, as the case studies outlined in this report illustrated, there are a number of specific occasions where CRC’s research outputs resulted in avoided losses of assets, infrastructure and life. Although these specific cases have not been included in the CBA to avoid double counting, these cases demonstrate that the likely benefit of the CRC is substantially higher again.

TABLE 1: COST-BENEFIT ANALYSIS RESULTS

	Discount rate 3%	Discount rate 7%	Discount rate 10%
Total present value of costs	\$123.29	\$101.07	\$87.89
<i>Benefits quantified</i>			
Knowledge sharing and collaboration (value of publications in highly ranked journals)	\$1.25	\$0.98	\$0.82
Education opportunities for students (earnings premium for PhDs)	\$12.36	\$9.15	\$7.38
International reach for Australian Research (value of media coverage)	\$55.19	\$43.49	\$36.84
Reduction in government, business and economic losses.	\$287.61	\$186.40	\$137.09
Avoided cost of deaths and injuries	\$40.10	\$25.99	\$19.11
Reduction in insurable losses	\$529.27	\$348.63	\$259.10
Total present value of benefits	\$925.78	\$614.64	\$460.35
NPV	\$802.49	\$513.57	\$372.46
BCR	7.51	6.08	5.24

Source: SGS modelling, 2020

Who benefits and in what way?

The many stakeholders of the CRC benefit in various ways and to various degrees. The academic world, the Australian Government, emergency services, regional communities and landowners are benefitting the most from the CRC, if treating all benefits as equal.

These groups benefit in different ways. Whereas universities primarily benefit through the network of knowledge holders (headline benefit 2), regional communities and landowners benefit from better decision-making as a result of CRC's quality and new research (headline benefit 3). The Australian, state and territory and local governments benefit from the CRC as a large, independent and trusted institution (headline benefit 1), and from better decision-making as a result of CRC's quality and new research (headline benefit 3).

Emergency services benefit in a varied way from the quality research, the network of knowledge holders and from the CRC being a large, independent and trusted institution.

The detailed distributional analysis in the report provides further detail on stakeholders and their specific benefit profile. The benefit profiles can help in targeting engagement with stakeholder groups.

Future opportunities and next steps

The case studies and survey identified a number of areas for CRC to focus its efforts on in the future.

The need to plan for natural disasters in advance to mitigate their impacts, in addition to responding and recovering from disasters as they occur, was identified as a priority by stakeholders. This includes the need to consider climate change impacts in natural disaster plans and in designing and constructing disaster-resistant infrastructure. Also identified was the need for real-time data during disasters and more detailed studies of the factors affecting bushfire spread. Natural hazards research must shift to looking at future scenarios and conditions: **planning for the 'unprecedented'**, to make us as equipped as possible for the future, which includes substantial climate change impacts the world is already locked in to.

The importance of human behaviour in response to natural disasters was also identified as an important area for research. In the Black Saturday fires in 2009, human behaviour was seen to be more critical than the fire itself to reduce injuries and losses of life. CRC's research on Planning for Animals in an Emergency also attests to the need to address human reactions during crises. The impact on volunteers of their contribution has also been identified, with weeks of volunteer work and psychological distress taking a toll on their wellbeing.

Local government plays a large role in community preparedness and future land-use planning. It is important for councils to be engaged with the CRC and its research on bushfire and natural hazards. Local government staff were noticeably absent in the group who responded to SGS's survey, indicating that the level of engagement is limited at present.

1. INTRODUCTION

1.1 The Bushfire and Natural Hazards Cooperative Research Centre

The Bushfire and Natural Hazards Cooperative Research Centre (CRC) coordinates a national research effort in natural hazards, including bushfire, flood, storm, cyclone, heatwave, earthquake and tsunami. Its mission is to provide high-quality research and advice on bushfire and natural hazards in order to:

- reduce risk
- enhance disaster resilience
- reduce negative social, economic and environmental impacts
- build an internationally renowned Australian and New Zealand research and utilisation capacity and capability.

The focus of the CRC is the impact of natural hazards on the Australian community and the need for emergency services, land managers, all levels of government and the private sector to understand and plan for hazards more thoroughly.

The CRC conducts coordinated and interdisciplinary research. This includes working with communities to improve disaster resilience and reduce the human, social, economic and environmental costs from bushfires and other natural hazards.

The CRC is end-user driven. This means that the various emergency service agencies, departments and non-government organisations around the country that become partners have a significant say in the development and execution of the research program.

The program is structured into three major themes:

- policy and economics of hazards
- resilience to hazards
- understanding and mitigating risks.

1.2 This project

The CRC aims to demonstrate the value it delivers to its many stakeholders as part of its future scoping. SGS Economics and Planning (SGS) has been commissioned to assess the value of the CRC. Other research bodies have also been commissioned for separate but related pieces of work.

It is known from past analysis that the CRC creates value by contributing to disaster management and resilience and associated prevented damages such as:

- government, business and economic losses
- loss of life and injury
- insurable losses.

In addition to these substantial benefits to the wider Australian community, the CRC creates value by fostering networks and communities of natural hazards researchers and practitioners, and for its role as an independent authority for natural hazards research and evidence-based advice. It is SGS's role to describe and value the gamut of the benefits the CRC provides, thereby building a solid evidence base for the CRC to pursue future opportunities for funding.

1.3 Methodology

The method chosen for this project is shown in the diagram below. SGS took a multi-disciplinary approach in assessing the benefits of the CRC, incorporating stakeholder surveying, document review, executive interviews, case study research and economic modelling within discrete project phases. Each project phase builds on the findings of the last, with all results incorporated in this report. Throughout the project, SGS has worked closely with the CRC which has provided a great deal of data, contact details and other background information. This has been invaluable and therefore should be acknowledged.

The first phase mapped the benefits of the CRC through a program logic map and the collection of examples of these benefits. The second stage involved stakeholder engagement through an online survey among CRC’s stakeholders. The survey was used to better understand the benefits the various stakeholders derive from the CRC and to identify case studies. Phase three was a case study review of activities or research programs that exemplify in more detail how the CRC adds value, and how these values can be quantified. The findings from the previous phases informed the final stage, the cost-benefit analysis (CBA). The CBA quantified the benefits of the CRC in monetary terms and compared them to the costs. It is noted that not all benefits of the CRC were monetised either due to the nature of the benefit (difficult to express in monetary terms) or to prevent any double counting in cases where benefits overlap. In all, the quantification of benefits is both conservative and partial.

FIGURE 6: PROJECT METHODOLOGY

PHASE 1 PROGRAM LOGIC and BENEFITS OF THE CRC	PHASE 2 STAKEHOLDER ENGAGEMENT	PHASE 3 CASE STUDIES	PHASE 4 COST-BENEFIT ANALYSIS
Program logic mapping and description of benefits, with research examples	Targeted survey of users of CRC research, including governments, universities, industry associations and not for profits	Detailed case studies of six CRC research programs and high level analysis of others	Quantification and valuation of benefits of CRC in a cost-benefit analysis (CBA)
Section 2	Appendix 2 and 3	Appendix 1	Section 3

1.4 Structure of this report

The structure of the remainder of the report is as follows:

- Chapter 2 maps the hierarchy of benefits of the CRC and describes in qualitative terms how the CRC is benefitting its multiple stakeholders.
- Chapter 3 provides a quantitative assessment of the benefits, measuring them against the costs of delivering the CRC and delivering a summative benefit cost ratio.
- Chapter 4 outlines the overall findings of the report and provides some additional insights arising from the consultation and survey.

The case study write-ups and stakeholder survey report are provided as appendices.

2. BENEFITS OF THE CRC

This section maps the benefits of the CRC and describes them in qualitative terms, reflecting the results of the stakeholder survey and case studies.

The survey among CRC stakeholders was conducted in March 2020 with a response of 92 stakeholders, or 22.7 per cent of all stakeholder contacts to which a survey was sent. The detailed results are contained in Appendix 3.

The five case studies that informed the qualitative benefits assessment are:

Australian Exposure Information Platform (AEIP), a collaboration between CRC and Geoscience Australia, provides nationally consistent exposure information for emergency management. It supplies key stakeholders with direct access at the onset of a crisis. The platform allows anyone to generate a report for any area of Australia at any time – before, during and after a hazard event has occurred.

Answering the Call, in partnership with Beyond Blue, was the first national survey that investigated the factors that affect the mental health of employees, volunteers and former employees in the police and emergency services. The research will inform strategies of agencies and the development of a framework to improve mental health and wellbeing in police and emergency sectors.

Influencing Behaviour Change comprises three research projects to improve community preparedness, responsiveness and resilience to bushfire events: Warning Systems Research, Managing Animals in Disaster and Child-Centred Disaster Risk Reduction.

PHOENIX RapidFire, which is a bushfire characterisation model that integrates fuel, terrain, weather conditions and suppression to simulate a fire's development and progression in the landscape. It is used by land and fire managers to support fire management and land-use planning and to support decision-making during bushfires. The tool was initially developed as a research tool for the Bushfire CRC and further developed and utilised with contributions and input from a number of organisations, including the Bushfire and Natural Hazards CRC.

Although the model was developed before the CRC was created, Phoenix RapidFire is an example of how investment and research made in the days of the Bushfire CRC are continuing to benefit the Australian community. Thus, it can be assumed that the research the CRC is investing in now may also continue to deliver benefits for years to come.

The CRC has also been involved in developing updates and conducting research for inputs into the model throughout the subsequent years, increasing its accuracy across different scenarios and landscapes (Esnouf, 2020). Current research projects that the CRC is undertaking that will inform the model include:

- fire coalescence research
- wind reduction in tree canopies
- research into soil moisture
- fire event spotting (Esnouf, 2020).

Recovery Capitals (ReCap), which was a research project in collaboration with Massey University (NZ) and the University of Melbourne. It focused on the long-term recovery of communities after disaster. It is based around rebuilding 'community capital'.

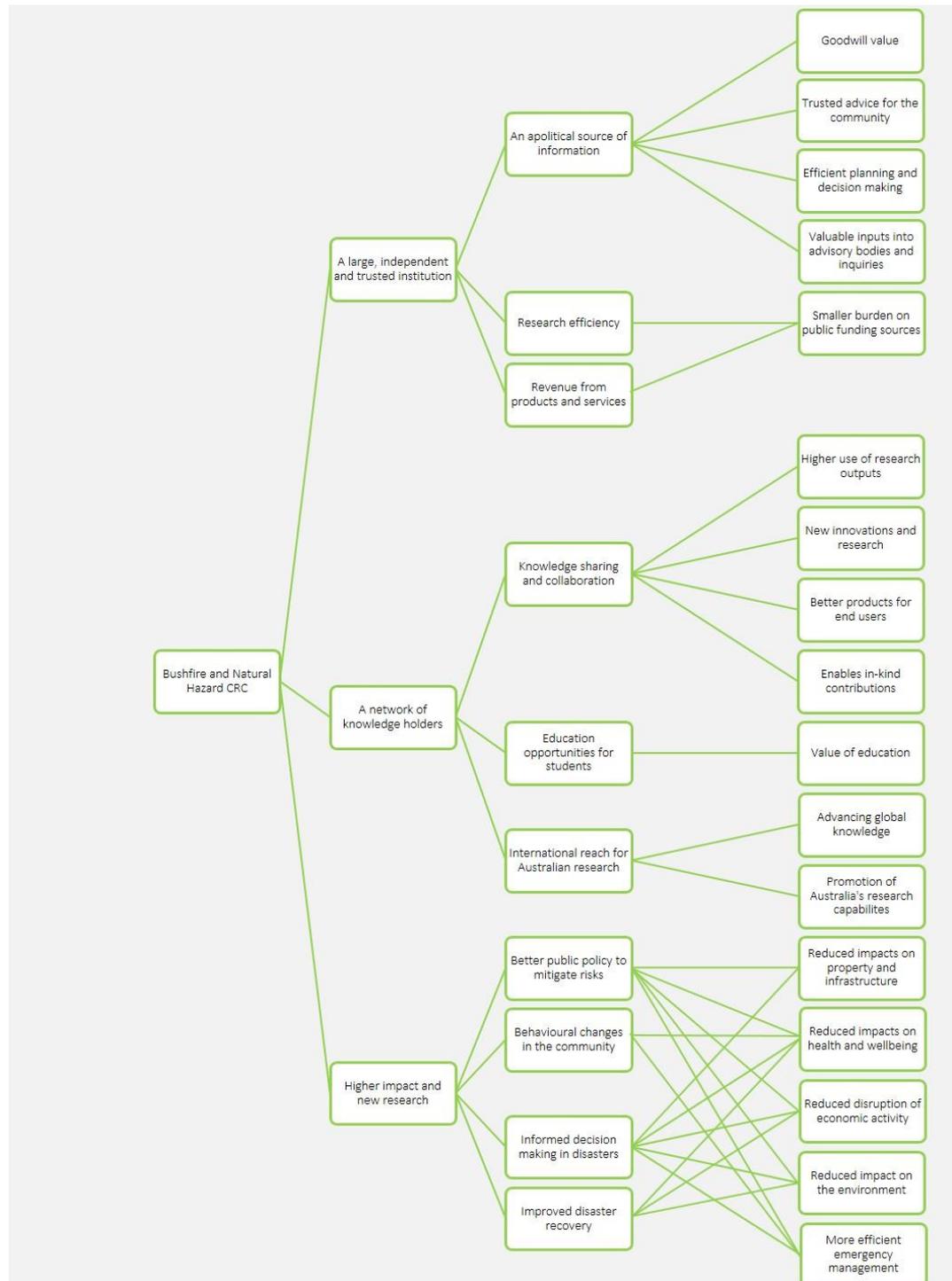
SGS has prepared an additional case study on the involvement of the CRC in the media from 1 July 2013 and mid-April 2020.

Detailed results of the case studies are contained in Appendix 1.

2.1 Program logic map

The benefits flowing to the Australian community from the CRC are many and varied. There are also strong links between benefits, and as such, it is useful to map them visually in a program logic framework. The program logic map below describes the full gamut of the benefits the CRC provides.

FIGURE 7: CRC BENEFITS PROGRAM LOGIC MAP



Source: SGS Economics and Planning

All benefits flow from the three primary roles the CRC performs:

- as a large, independent and trusted organisation
- in establishing a network of bushfire and natural hazard knowledge holders
- in producing higher impact and new research on bushfire and natural hazards.

The three headline benefits of the CRC that generate value to users and the wider public in Australia and overseas, are:

- **A large, independent and trusted institution:** it delivers reliable information, information that is needed, in an efficient manner.
- **A network of knowledge holders for natural hazards:** it enables knowledge sharing, collaboration and education of experts at the national and international level.
- **Higher impact and new research:** it delivers information, products, services and tools that drive better decision-making, behavioural changes in the community and improved disaster recovery.

The remainder of this section describes in more detail the hierarchy of benefits as illustrated in Figure 7.

The stakeholders of the CRC include emergency services, the Australian Government, states and territories, local government, businesses, households, regional and rural communities, landowners, infrastructure providers, volunteers, the environment and academia.

2.2 A large, independent and trusted authority

The CRC is a large, independent and trusted authority on natural hazard management in Australia. It is an apolitical source of information, generates research efficiencies and brings in its own revenues from its high-quality products and services.

This role is particularly valued by the various emergency service agencies, departments and non-government organisations around Australia that have become partners with the CRC and have a significant say in the development and execution of its research program.

- End users consistently describe the CRC as a source of trusted advice. As one survey responder commented¹: “CRC’s reliability as a source of respected truth and knowledge enables it to be a pillar upon which decisions are made by agencies.” Another stated: “The CRC’s research is used to inform business cases and set priorities as well as conferences and forums promoting evidence-based decision-making. The CRC has improved the voice for fire research in the national context by being a focal point where governments can come to.”

Its role as a large, independent and trusted authority drives a range of benefits for Australia including:

- the goodwill value of the CRC
- trusted advice for the community
- efficient planning and decision-making
- valuable inputs into advisory bodies and inquiries
- a smaller burden on public funding sources.

The goodwill value of the CRC

Goodwill is an intangible, but quantifiable, asset that contributes to the monetary value of an organisation. Goodwill includes customer/user loyalty and relationships, brand recognition, demonstrated staff performance and the CRC's reputation.

An important case study illustrating the value of this is the Influencing Behaviour Change program. The success behind the CRC’s three recent behaviour change projects (Research

¹ As part of this project, SGS Economics and Planning surveyed end users to understand the values they place on the the CRC (the full findings of which can be found in the appendix to this report).

into Warning Systems, Managing Animals in Disaster, and Child-Centred Disaster Risk Reduction) was largely the result of CRC’s reputation in the community. The backbone of the research relied on surveys completed by the community. The high levels of participation in these projects has been attributed to CRC’s brand recognition in the communities they were working in.

Trusted advice for the community

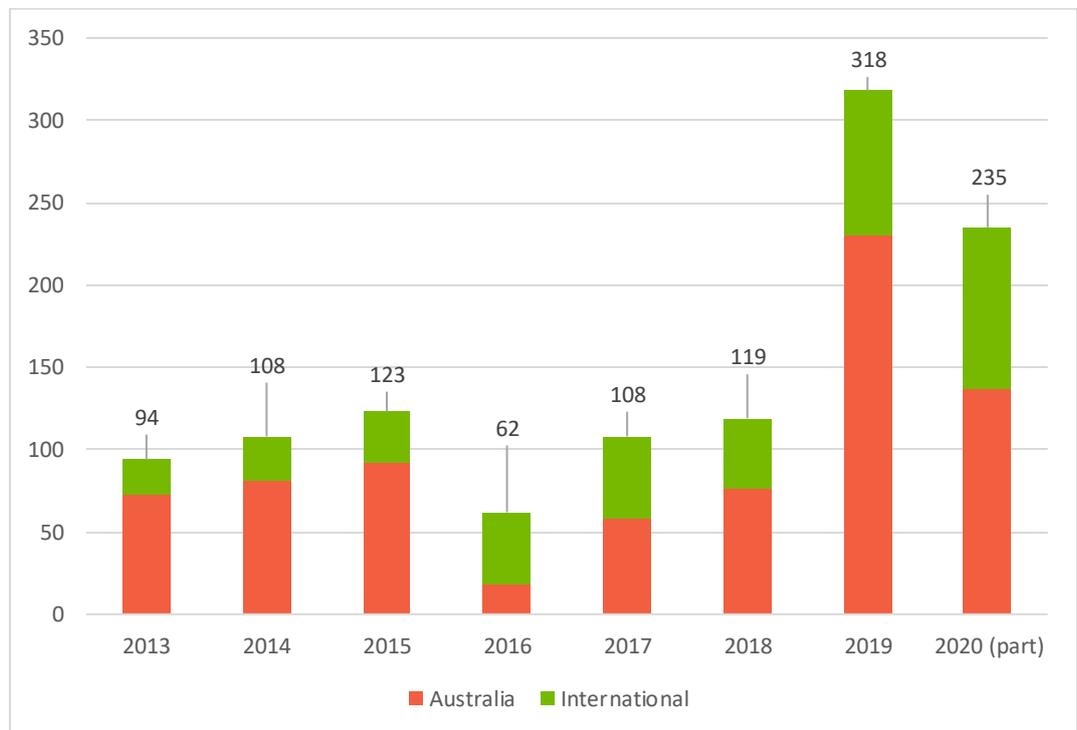
The CRC provides trusted and reliable information for the broader community on natural hazards. The value of this benefit is reflected through:

- the increasing prominence of the CRC in the media discourse during and after natural hazards, in particular bushfire events
- the level of community engagement the CRC receives during its research projects
- the level of uptake of key CRC publications from the CRC website.

CRC’s prominence in the media

Since its inception in July 2013, the CRC has been quoted, referenced or discussed in 1,167 media sources (Figure 8). Of these, 66 per cent have been Australia-based media outlets, and 33 percent have been international publications. As shown in the figure below, the number of media references to the CRC has remained relatively stable throughout the years until 2019 and 2020, when a stark increase can be observed. In particular, the number of Australia-based references has more than doubled in 2019, coinciding with the unprecedented 2019-20 bushfire season. It shows the CRC is an important source of information during times of crisis due to natural disasters.

FIGURE 8: ANNUAL COUNT OF MEDIA SOURCES REFERENCING CRC: 1 JULY 2013 TO 21 APRIL 2020



Source: Meltwater, 2020. Search terms: Bushfire, Richard Thornton, Bushfire and Natural Hazards CRC

The Ad Value Equivalency, or AVE², of the media references to the CRC during this same period is estimated to be \$47.94 million AUD; \$31 million of this is from the Australian media coverage, and \$16.94 million from international coverage. More detailed analysis of CRC's growing media profile can be found in Appendix 1.

Community engagement with CRC projects

The CRC is able to leverage its position as trusted adviser through its research programs, as community members are willing to participate in research that carries the CRC brand. Through a series of behaviour change research projects (see the case studies in Appendix 1), the CRC facilitated important connections between end users and had a large role in promoting the research to the broader community. The study was able to gain high participation rates by providing trusted and invaluable information to the wider audience through promotion via the website and social media platforms.

PHOENIX RapidFire, a tool developed by the Bushfire CRC, the CRC's predecessor, has proven to be a highly persuasive tool when talking to community members about fire risk and prevention. Being able to visually demonstrate risk, including the demonstration of scenarios, improves awareness and reduces community scepticism.

Uptake of CRC publications

The CRC has seen a dramatic rise in the use of its publications, especially during the 2019-20 bushfires during which the community turned to the CRC to seek trusted information. CRC publications are well established as a source of reliable, evidence-based information around bushfire and natural hazards. As CRC publications are available via its website, it is useful to look at website traffic to see the publications' growing level of visibility. The table below shows unique website visits from 6 September 2019 to 13 February 2020 and compares data to the same period in 2018-19.

In the 6 September 2019 to 13 February 2020 reporting period, the website had 174,447 unique page views, an increase of 204 per cent from the same period in 2018-19. The reporting period coincides with the 2019-20 bushfire season, when the CRC further established itself as a key source of information for many different users.

TABLE 2: MONTH BY MONTH BREAKDOWN OF UNIQUE PAGE VIEWS COMPARED WITH 2018-19

	2018-19	2019-20	Increase	Percentage increase
September	20,254	23,825	+3,571	18%
October	16,025	21,559	+5,534	35%
November	17,593	27,050	+9,457	54%
December	12,638	23,383	+10,745	85%
January	13,378	69,852	+56,474	422%
February (1-13)	7,963	13,494	+5,531	69%
Total (6 Sep - 13 Feb)	87,851	179,163	+91,312	204%

A vast majority (88 per cent) of these visits were new visitors (i.e. they had not visited the website before).

² AVE is used to estimate the amount of revenue attributed to an article. This value is used to quantify the success of PR efforts as a monetary value. The formula that is used to calculate an online AVE is: $X * 0.025 * 0.37$

X (the reach/unique visitor figure)

* .025 (standard error, assuming that 2.5% of any given audience will view a particular article on average)

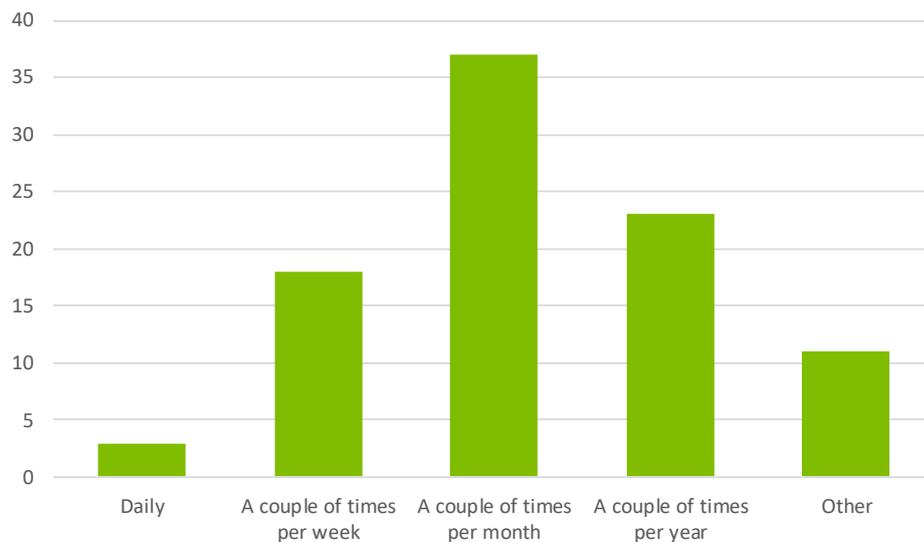
* .37 (37 cents is the dollar value for each visitor).

The most popular pages on the website in the reporting period include:

- Hazard Note 63 (Australian Seasonal Bushfire Outlook: August 2019)
- Hazard Note 68 (Australian Seasonal Bushfire Outlook: December 2019)
- Research
- Inquiries and Reviews Database
- Publications.

End-user survey respondents noted that they regularly accessed CRC reports, briefs, commissioned research, reference material, forecast and season outlooks, hazard notes, conference proceedings and presentations and more. The figure below demonstrates the high frequency of end-user access to such publications (Figure 9).

FIGURE 9: FREQUENCY OF USE OF CRC SERVICES/PRODUCTS/RESEARCH



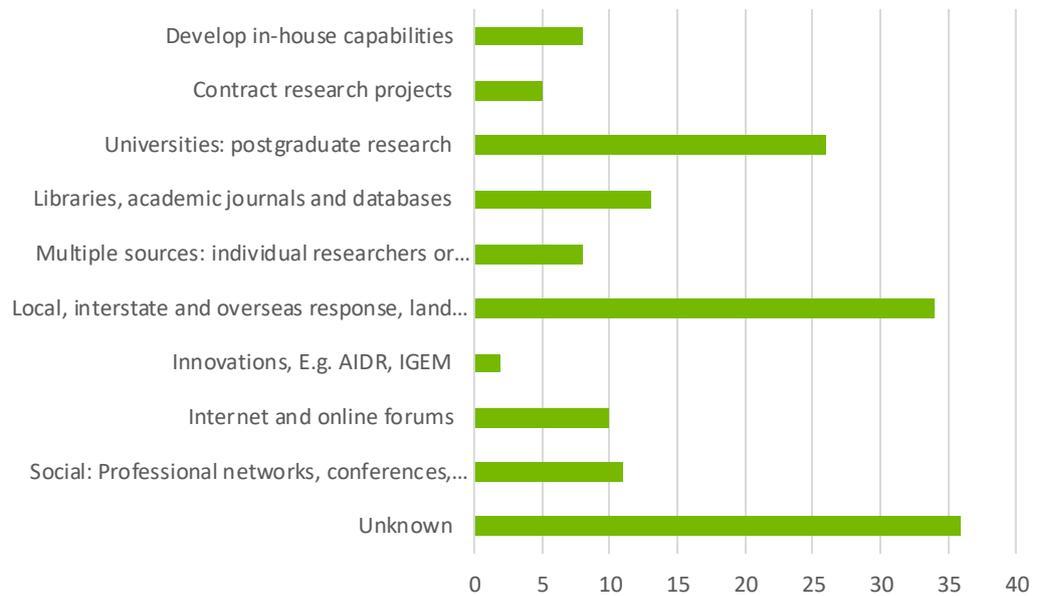
Source: SGS Economics & Planning, 2020

End users were also asked about available alternative options for sourcing similar information to that provided by the CRC. The results were highly informative. While a broad range of free local and international sources, such as academic journals and government agencies were pointed to, many respondents responded that they didn't know where they could find reliable alternatives. This information is displayed in Figure 10.

The CRC's SAVANNA PROJECT

"The Savanna Monitoring and Evaluation Reporting Framework (SMERF) is providing invaluable information to planners and operational staff across northern Australia. The 2019 fire weather was extreme and lasted much longer than previous years, and the information from SMERF and NAFI was often the only information around."

FIGURE 10: RESPONDENT COUNT OF CRC ALTERNATIVES



Source: SGS Economics & Planning, 2020

Efficient planning and decision-making

Due to the CRC's reputation and high-quality research and data, government and emergency services can make decisions and plan more efficiently. This reduces staff time in government agencies and other organisations, but also provides government departments and agencies with the most up to date information.

A clear example of this benefit is that over the past three bushfire seasons (2018- 2020) CRC researchers have been embedded into state control centres and agencies to provide a variety of essential services. In the 2019 bushfires, the New South Wales Rural Fire Service, Queensland Fire and Emergency Services and the South Australia Country Fire Service requested the assistance of CRC researchers, Dr Marta Yebra, Dr Jason Sharples and Dr Mika Peace, at their respective state operations centres (CRC 2019). Each researcher provided advice according to their expertise:

- Dr Yebra from the Australian National University and lead researcher from the Mapping bushfire hazards and impact project spent NSW's peak fire day, Tuesday 12 November, at the New South Wales Rural Fire Service (RFS) headquarters in Sydney. Dr Yebra worked with fire managers analysing data on vegetation conditions and how this might affect bushfire spread. Dr Yebra commented, "Our research is being used here by the RFS to make informed decisions about where a fire may spread, and what areas should be prioritised when sending resources and equipment," (CRC, 2019).
- Dr Sharples from the University of New South Wales, lead researcher on the Fire coalescence and mass spotfire dynamics project, was a part of the constant dialogue between fire behaviour analysts and ground operations at the RFS. Dr Sharples' focus during NSW's peak day was on the Gospers Mountain and Myall Creek Road fires, working alongside ACT Government Risk Analyst Rick McRae and pointing out extra risks firefighters may face with spotfires and fire coalescence. He also provided the RFS with expert scientific assistance on the potential for dynamic fire propagation giving real-time recommendations and support to the incident control and operation officers (CRC, 2019).
- Dr Peace, who heads the Coupled fire-atmosphere modelling project, was called in to assist with emergency planning and forecasting for Queensland before the series of bad fire weather days in mid-November (CRC, 2019).

The CRC also provides specific research project outcomes to federal agencies that improve their outputs to end users and the wider community. In particular, the CRC have been the key organisation in coordinating and developing research into extreme weather and natural hazards that the Bureau of Meteorology (BoM) use to improve their services. This partnership allows the BoM to capture and operationalise new and emerging science (CRC, 2015). Current projects between the CRC and the BoM include:

- Impact-based forecasting for the coastal zone: East Coast Lows
- Improving land dryness measures and forecasts
- Improved predictions of severe weather to reduce community impact
- Threshold conditions for extreme fire behaviour
- Improving flood forecast skill using remote sensing data
- Effective risk and warning communication during natural hazards
- Predicting fire danger ratings from physical measures of fire behaviour
- How do wet eucalypt forests burn? Managing Tasmania's most dangerous fuel type
- Improving decision-making in complex multi-team environments
- Improved decision support for natural hazard risk reduction
- Using pre and post fire LiDAR to assess the severity of the 2019 Tasmanian Bushfires (CRC, 2020).

A number of the case study projects demonstrate how the CRC has led to more efficient planning and decision-making around bushfire and natural hazards:

- The CRC's information modelling framework in natural hazard exposure was critical to the development of the **Australian Exposure Information Platform (AEIP)** because of its spatial data capabilities. AEIP automates a previously manual process and helps government and emergency agencies undertake rapid and efficient emergency response. During a crisis, when demand for information to inform decisions is extremely high, the AEIP is invaluable. By speeding up the delivery of vital exposure information in an automated format, its nationally consistent and easily accessible approach to data ensures that information and decision making across jurisdictional borders can be done in a way that is comparable and quantifiable.
- The **Answering the Call** project enabled the development of a national baseline database centred around mental health and wellbeing of police and emergency service workers and volunteers. The research findings enable a collective, national approach to improve mental health outcomes in agencies.
- **PHOENIX RapidFire** instrumentally changed fire responses across Australia. It allows emergency responders to obtain immediate information regarding fire risk and assess the priorities of different fires. It also informs resource allocation and emergency warnings that are sent to the community. This is particularly important when there are multiple fire fronts as were seen in the 2019-20 bushfires. PHOENIX RapidFire has been heavily influential in informing risk planning, particularly in Victoria. The Department of Environment, Land, Water and Planning run fuel load assessments across small grids over the whole of Victoria to identify high risk areas. RapidFire informs fire prevention tasks such as prescribed burning, and is being explored as a means of informing infrastructure asset protection and replacement programs. PHOENIX RapidFire is also an example of how investment made into research now will undoubtedly have impacts on the way natural hazards managed and disasters are planned for in the future.

Other research projects that end users noted have resulted in substantial policy or strategy changes are the Australian Disaster Resilience Index, and advice leading to improved decision support for natural hazard risk reduction more generally.

Overall, end-user survey respondents noted the large role that CRC resources have in helping end users develop processes and practices for better warning communication as well as hazard mitigation planning. One respondent mentioned: "CRC research has been fundamental to developing our Volunteer Recruitment Website and Volunteer Recruitment

Campaign. While this is not daily work, they are very significant pieces of work that have short and long-term impacts on our volunteer workforce.”

Valuable inputs into advisory bodies and inquiries

Staff from the CRC regularly present and provide crucial evidence and information to advisory bodies and inquiries. The value of this can be reflected through the staff hours that are committed to these efforts, the sheer number of advisory bodies that the CRC sits on, and the number of inquiries it has provided advice on.

At present, the CRC sits on the following Australian bodies:

- Editor in Chief of Australian Journal of Emergency Management
- Australian Institute for Disaster Resilience Management Committee
- Australian Institute for Disaster Resilience Handbook Advisory Group
- Ministerial Bushfire Science Roundtable
- Integrated Research on Disaster Risk (IRDR) National Committee for Australia
- Experts Advisory Committee to CSIRO
- National Flood Risk Advisory Group
- Australian Institute for Disaster Resilience
- Victoria University Industry Advisory Board for the Centre of Environmental Safety and Risk Engineering
- CRC Association Board
- Australian Fire Danger Ratings System, Board Observer
- Prescribed Burning Centre of Excellence Advisory Group.

And the following international bodies:

- International Association of Wildland Fire Board (x 2 positions)
- International Journal of Wildland Fire Editorial Board
- Forest Fire Management Group
- Organising Committee for the International Forest Fire Research Conference (Portugal)
- International Science Advisory Group for the New Zealand Resilience to Nature's Challenges Centre
- National Fire Protection Association (USA) International Wildfire Group
- Invited presenter to OECD Conference on adapting to a changing climate in the management of wildfires
- Program Committee for Australian and New Zealand Disaster Management Conference.

In addition, over the past seven years, the CRC has provided expert advice to 1 Royal Commission, 5 Parliamentary Inquiries, 5 Independent Inquiries, and 3 general Government Inquiries.

A smaller burden on public funding sources

Being a large body with a high level of expertise on a specific topic (bushfire and natural hazards) allows for efficiencies to be gained in research, as the CRC has direct access to all relevant resources and expertise, compared with less specialised organisations. Due to its expertise, the CRC also generates revenue through its commissioned research from paying clients. In 2019, CRC earned \$1.6 million in revenue from contract research, up from \$1.2 million the previous year. Both factors reduce the funding burden on government through time savings and revenues generated. Again, case study evidence validates this benefit:

- The CRC's reputation in the emergency services sector contributed significantly to the response rate to the **Answering the Call** survey from police, emergency employees and volunteers. This reduced the financial burden on governments, as well as the time and resources from undertaking a similar project.
- The CRC's work in **child-centred disaster risk reduction** focused on building the knowledge base on best-practice strategies. The study has been applied in cost-effective

programs that aim to reduce risk and resilience for children, schools, households and communities, and has reduced the funding required from government agencies.

2.3 A network of knowledge holders for natural hazards

Since its inception, the CRC has put effort into building a network of knowledge holders. Today, the CRC has a strong and extensive network that includes academia (domestic and international) and a wide range of end users that act as partners. Through this network the CRC promotes knowledge sharing and collaboration, educational opportunities for PhD candidates and other students, and Australian research globally.

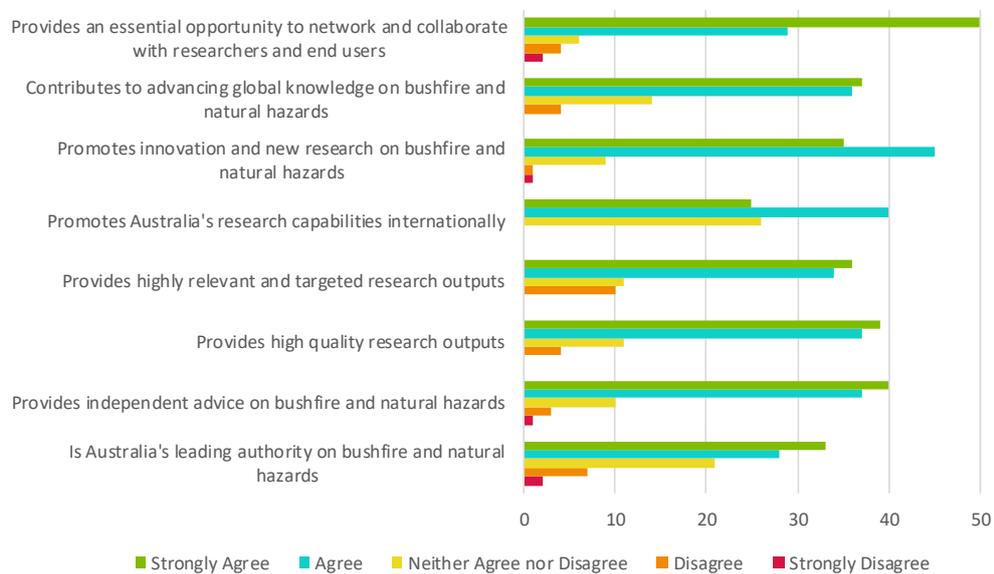
The benefits of this role include:

- higher use of research outputs
- innovations and research
- better products for end users
- leveraging of in-kind contributions
- valuable education
- advancement of global knowledge, and
- promotion of Australia’s research capabilities.

CRC’s network is highly regarded, as evidenced by the survey results. Survey respondents place a high value on the CRC providing networks and relationships with people for collaboration (Figure 11). Additionally, end users noted that the CRC allows for small agencies to participate and collaborate in much larger, national projects.

Half of the respondents strongly agree, and 29 per cent agree, that the CRC provides an essential opportunity to network and collaborate.

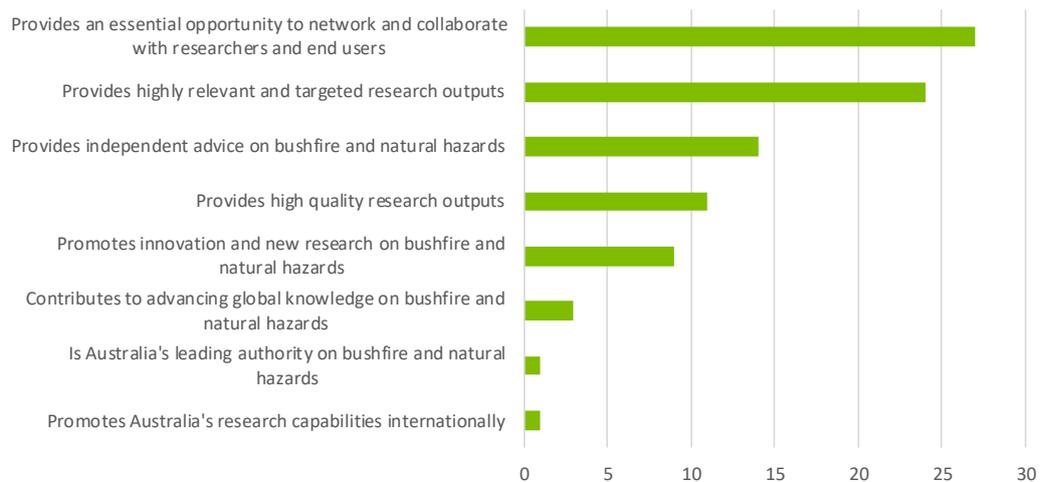
FIGURE 11: RESPONDENT SENTIMENT ON THE CRC



Source: SGS Economics & Planning, 2020

For many stakeholders, the CRC network and opportunities for collaboration is its most valuable role. Figure 12 identifies what respondents individually believe is the CRC’s most valuable role. Twenty-seven per cent of respondents found value in the opportunities that CRC provides for networking and collaboration with researcher and end users. This is closely followed by the CRC providing highly relevant and targeted research outputs (24 per cent).

FIGURE 12: THE MOST VALUABLE CRC ROLE



Source: SGS Economics & Planning, 2020

Key reasons defining why this is the most valuable role according to stakeholders are summarised (in direct quotes) below:

- The formation of excellent collaboration and working relationships with end users is critical. The end-user engagement structure and process of the CRC has vastly increased researcher collaboration and transformed Australia's capacities over the past decade. To have impact, research should not be a one-way process. Projects need to be targeted at meeting the end user's needs. Hence, end users need to understand and contribute to the research process, which requires collaboration towards tangible products. This in turn allows end users to keep ahead of the planning and preparedness cycle.
- The CRC provides an opportunity to discuss research projects that are pertinent to the industry and enable the 'big problems' to be tackled collaboratively. Most of the time, individual organisations, departments and agencies tend to work in silos. The CRC provides the opportunity and a mechanism for learning and maximising research funding and outputs that is more useful and likely to be adopted.
- It puts a face to the research and enables a forum for research to be tested, challenged, practised and appreciated. A cross-disciplinary network of like-minded and similarly challenged individuals provides the most efficient method for research quality assurance.
- Engaging with others, learning from their experiences and research and understanding different perspectives, is hugely important in professional development. The ability to discuss at length with other professionals or participate in site visits and experience the research is more profound than reading an article.
- Networking takes time and relationships are built over collaborating and engaging on personal levels. The CRC's research events, annual conferences and joint research projects are critical in formulating and strengthening such networks. Research tests assumptions and can promote much-needed change and innovation.

Many relationships and collaborations were achieved through the CRC. Respondents nominated the following (directly quoted) relationships that existed due to the CRC:

- awareness and connection to a network of various research groups, institutions and over 40 government agencies across Australia and internationally: BoM, CSIRO, Geoscience Australia, NSW RFS, DELWP, DFES WA, QFES Qld, NT Fire and Emergency Services
- closer links with universities: ANU, RMIT, VU, UniMelb, UQ, UWA, Curtin University, Uni of Wollongong
- stronger ties to academic, researchers, practitioners, stakeholders and end users on a personal/professional level as opposed to agency level
- opportunities to collaborate with other agencies

- resource sharing assisting with engagement programs including capabilities for leadership
- research proposals in new areas e.g. livestock health and wellbeing.

The **Answering the Call** case study provides further insight into this benefit. CRC brought together a partnership between organisations with specific specialities, with the aim of increasing the knowledge around the mental health of the emergency services sectors. The project resulted in a collaboration between Beyond Blue the University of Western Australia and Roy Morgan Research. The success of Answering the Call can be attributed to the collective knowledge and expertise of each organisation.

YORKE EARTHQUAKE MITIGATION STUDY

“The Yorke earthquake mitigation project enabled a new partnership between the University of Adelaide, CRC and Geoscience Australia.” (CRC End User Survey direct response, 2020)

Higher use of research outputs

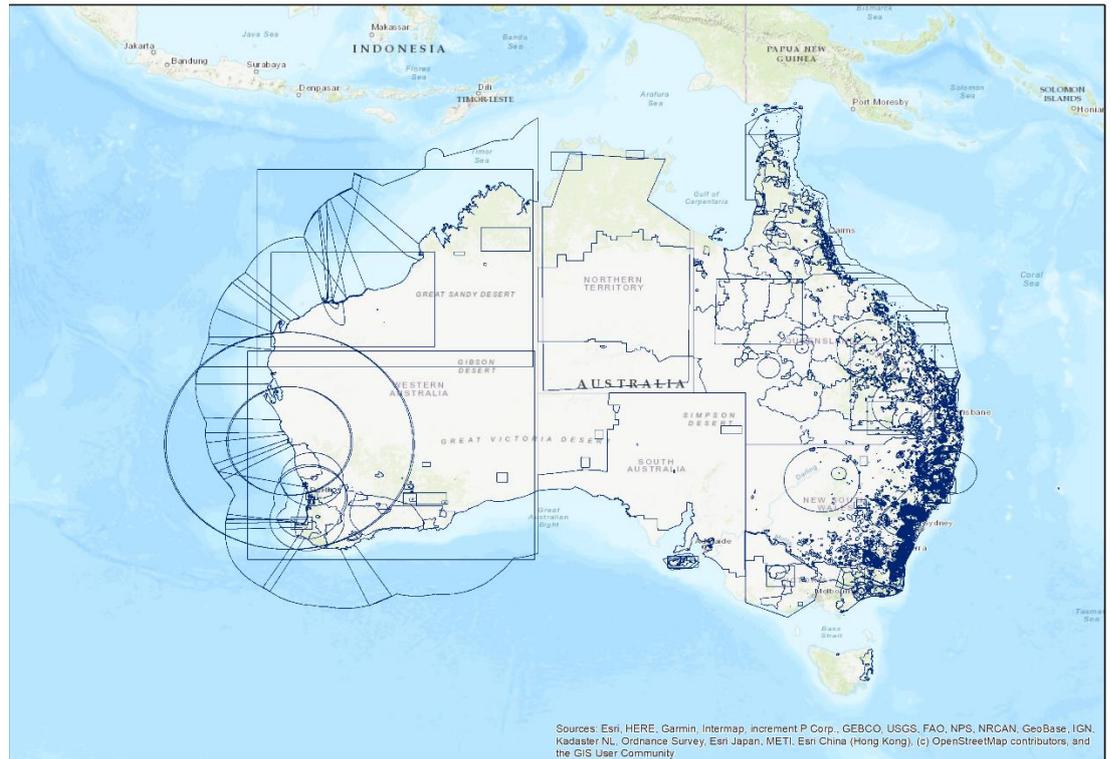
Having a wide network of both researchers and end users means that research outputs are used by a wider array of people and organisations. This makes the research more valuable as it reaches more people and is applied more often.

The accessibility and ease of the AEIP platform has allowed many organisations access to information on hazardous events. The system allows reports to be generated any time for any area in Australia, thus allowing use by a wide network of end users across Australia. During the 2019/20 bushfire season, the number of exposure reports produced from the AEIP was in excess of 14,500 by more than 200 individual users. Some users such as NSW RFS have integrated the API with their own applications and have been producing thousands of valuable reports each month, particularly during the 2019/20 bushfire season. Western Power, a WA-based energy provider, has recently utilised the platform to create 700,000 reports (CRC, 2020). With the infrastructure already in place, a vast array of end users will be able to continue to use the platform during emergencies in the future.

The figure below represents the aggregated use of AEIP web mapping between December 2019 and March 2020. The lines on the map show the areas that exposure reports were generated for. Exposure reports were generated for both small and large areas, covering all states and territories. Dark-blue areas show multiple AEIP queries, correlating with extreme weather events e.g. 2019/20 bushfires.

During a crisis, when demand for information to inform decisions is extremely high, the AEIP is extremely valuable. By speeding up the delivery of vital exposure information in an automated format, its nationally consistent and easily accessible approach to data ensures that information and decision making across jurisdictional borders can be done in a way that is comparable and quantifiable.

FIGURE 13: AGGREGATE USE OF AEIP WEB MAPPING ACROSS AUSTRALIA: DEC 2019 TO MARCH 2020



Source: CRC, 2020

The CRC's behaviour change projects have reached a wide array of people and organisations. For example, the extensive research undertaken in child-centred disaster risk reduction has already been implemented in Victoria as a pilot project, and all through New South Wales via a 'Guide to Working with School Communities'. This will place primary school students at the centre of bushfire mitigation strategies.

Innovations and new research

The knowledge sharing and collaboration enabled by the CRC means that innovations and research ideas are generated. This research, which would have otherwise not occurred, is a benefit of the CRC. All five project case studies SGS researched include substantial examples of innovative and new research:

- The success of **AEIP** is largely contributed to the spatial data capabilities generated by CRC in partnership with Geoscience Australia. For the first time, users have direct access to nationally consistent exposure information via a user-driven, on-demand interface.
- The **Answering the Call** project developed the first national database around mental health and wellbeing of police and emergency services workers. The project was initiated as a partnership between Beyond Blue and CRC. It has generated significant knowledge and insights surrounding mental health on a national scale.
- CRC's **Influencing Behaviour Change** projects addressed a knowledge gap around community behaviour in terms of disaster preparedness, responsiveness, and resilience by undertaking the three projects; Warning Systems Research, Managing Animals in Disaster and Child-Centred Disaster Risk Reduction. The research has resulted in tools that will help progress behaviour change at the national level.

Importantly the CRC has been undertaking research into warnings systems since around 2005, however efforts substantially ramped up after the 2009 Black Saturday fires. In doing so, the CRC has developed a valuable longitudinal study data set that has influenced community preparedness messaging and warnings.

- **PHOENIX RapidFire** represents a step change in the way that fires are prevented and managed across Australia. Before its development, fire prediction calculations were made manually, with the skills to undertake this task held by a small number of individuals across Australia. RapidFire is recognised internationally and was successfully commercialised; it is currently run by a private company to which agencies subscribe.
- The **ReCap** project addressed the missing link between existing community resilience indicators and disaster resilience frameworks. It also provided further insight into long-term disaster recovery response. The study addresses questions about the mobility of households, and different enablers and barriers to a successful recovery after a disaster occurs. The work facilitated by CRC has produced new and critical information that can further assist communities to build resilience and support recovery efforts.

Finally, a survey respondent noted in relation to the CRC's innovative approach to improving community resilience: "CRC's approach to community development moves away from just marketing and delivers more tailored and targeted warnings and messaging, especially to vulnerable communities, leading to communities being empowered to take action to mitigate their risks."

PHOTOGRAMMETRIC TOOL TO EVALUATE FUEL LOADS (RMIT)

"The partnership with RMIT to develop a photogrammetric tool to evaluate fuel loads is a great example of being able to work together to take research and develop a tool that can be used by agency personnel. RMIT's operational research into bushfire fuel load and satellite imagery are used to inform our operational systems.

This application will improve productivity of our staff allowing them to capture more data in the same time window which will improve our understanding of fuel loads due to higher sampling rates compared with traditional survey methods." (CRC End User Survey direct responses, 2020)

Better products for end users

By working with a wider range of experts and directly with end users, the CRC generates bespoke and high quality research outputs. The quality and applicability of the outputs are a benefit to end users. Again, all five case studies provide examples of better products for end users:

- The interface of the **AEIP** allows for quality information to be produced rapidly, aiding decision-makers to plan a response before, during and after a hazard occurs. The platform provides a user-focused service, which enables greater benefit for agencies. Organisations can select the area of interest, the type of exposure data themes they require and contextual information. The automated report tailored to the end user is generated and delivered by email. This has produced a better product for end users.

For example, the Community Preparedness Branch within the WA government used AEIP to identify vulnerable communities and tailor community engagement based on demographic information during Cyclone Veronica in March 2019. The AEIP includes a complex model of how various assets are vulnerable to a number of hazards.

It was an AEIP report estimated that had a bushfire destroyed the town of Gracemere township (the town was saved due to the application of RapidFire), the following assets would have been destroyed:

- residential dwellings reconstruction value: \$1,506, 830,000, contents value: \$281,230,000
 - commercial reconstruction value: \$464,960,000
 - industrial reconstruction value: \$307,430,000
 - agricultural commodity estimated value: \$42,000.
- **Answering the Call** has led to greater knowledge about mental health issues of emergency service workers. This will enable better services that can be developed for

employees and volunteers. For example, the research showed that many employees found the workers compensation process to be insufficient and often damaging to their mental health. By improving the workers compensation process, some mental health issues may be prevented.

- The CRC's **Influencing Behaviour Change** studies involved end users at all stages of the project.
- **PHOENIX RapidFire**, built by the Bushfire CRC, was made specifically for the use of end users to aid in planning and bushfire management. The CRC has also been involved in developing updates and conducting research for inputs into the model throughout the subsequent years, improving its usability for end users and increasing its accuracy across different scenarios and landscapes (Esnouf, 2020).
- The final stage of CRC's **ReCap** project will involve collaborations with researchers and end users to understand how to efficiently communicate messages. This will achieve a better product for stakeholders. The aim is to achieve end-user orientated action research to improve planning and decisions for community recovery.

Enables in-kind contributions

The collaboration focus of the CRC sees other organisations and researchers contributing in kind to research and other activities. The value of this is equivalent to the staff hours and monetary contributions made. Two case study examples of this benefit are:

- the **ReCap** project, for which CRC's reputation and reach enabled an extensive network of organisations to collaborate. CRC was able to extend collaborations to stakeholders and end users, which provided in-kind contributions. The value these organisations brought enabled greater efficiency through their unique specialisations and experiences. The partnerships resulted in time and resources saved, which reduced the burden on public funds that the research would have otherwise cost.
- **PHOENIX RapidFire's** development received in kind development support from the University of Melbourne and DELWP.

The value of education provided

The CRC has a large program of student research. To date, Sixty-one PhD and nine Master's students have graduated through CRC research programs. The benefit is equivalent to the market value of the education received by the students given the opportunity.

The CRC also provides a central role in building and maintaining the capacity and working knowledge of bushfire and natural hazard industry members across Australia. It is the combination of all of the CRC's activities that enable this, from the dissemination of their research outputs, their calendar of events and conferences throughout the year, through to their media presence.

Two research based case studies point to the educational benefits of the CRC:

Answering the Call involved universities collaborating on the project. The results provide a national database that will be used for future research. Phase 3 will enable further collaborations with universities in developing a framework. In partnership with the University

VOLUNTEER FIRE BRIGADES IN REMOTE ABORIGINAL COMMUNITIES

"Collaboration with DFES WA has provided valuable information describing the formation of volunteer brigades in remote Indigenous communities in northern Australia. This work provides a model of an already operational example, which could potentially be applied elsewhere to increase resilience in these vulnerable communities by developing the capacity to prepare and respond to natural hazards, particularly bushfires and cyclones.

Charles Darwin University is currently developing financial models to determine the savings, but as the NT government alone spends nearly \$300 million annually, we estimate this could be at least halved if remote Indigenous communities were better able to self-manage some of these events." (CRC End User Survey direct responses, 2020)

of Adelaide, the CRC has recently begun a project to extend this research, to develop an approach to maintaining good mental health in young volunteers, which will be undertaken by the University of Adelaide in collaboration with the University of Western Australia. As part of this project, the CRC is offering a three-and-a-half year full-time scholarship of \$28,092 per annum for a social scientist to conduct a PhD project, which will contribute towards Australia's research capacity. Key researchers from the University of Western Australia who were active contributors to the Answering the Call project have recently gained funding from the MRFF to extend that work, and follow the ongoing wellbeing and resilience of Australian's first responders after the 2019-20 bushfires.

The CRC's **Influencing Behaviour Change** projects have provided ample opportunities for student research through PhD research projects across a variety of universities and organisations.

Advancing global knowledge

The knowledge sharing and collaboration enabled by the CRC extends globally. The CRC is a leading global contributor to the knowledge base around bushfires and wildfires. As described above, this is attested to by both its presence in international media (approximately one-third of references are in international media), and the number of international advisory boards and panels its members sit on (six international boards and panels).

In addition, the CRC has formal Memoranda of Understanding with the following international organisations:

- New Zealand Natural Hazards Research Platform
- United States Forest Service
- Association for the Development of Industrial Aerodynamics (Portugal)
- Coastal Resilience Centre of Excellence (USA).

The CRC has also provided central advice to two key international bushfire strategies: the recently published Canada Wildfire Blueprint, and the United Nations International Strategy for Disaster Reduction.

Three of the five project based case studies attest to the CRC's global influence:

- The **Warning Systems** research as part of CRC's **Influencing Behaviour Change** series study has been referred to extensively in international disaster risk programs. Lead researcher Professor Kevin Ronan represented the CRC at several forums worldwide, including at the United Nations Integrated Research on Disaster Risk committee, United Nations World Conference on Disaster Risk Reduction in Japan (2015) and the Global Platform for Disaster Risk Reduction in Mexico (2017).
- The **ReCap** project aimed to increase the understanding relating to the long-term recovery of both Australian and New Zealand communities. This research is expected to add to global knowledge of natural hazards, where critical insights can be used by communities across the globe. It is expected to add invaluable information to the global pool of knowledge about the mobility of communities and how enablers and barriers can affect recovery efforts (and long-term recovery is an area with a shortage of available literature). This will contribute positively to Australia's recognition within this field of study.
- Finally, **PHOENIX RapidFire** is recognised as a leading fire simulator across Australia.

Promotion of Australia's research capabilities

The international reach of the CRC's reputation and research provides benefits to Australia as the nation's scientific and research capabilities are promoted to the world. One of the ways the CRC does this is by hosting large annual events that serve to bring together end users and showcase new research. Key events hosted by the CRC include:

- Research Advisory Forum

- CRC-AFAC Conference
- Australasian Natural Hazards Conference
- International Fire Behaviours and Fuels Conference.

Two case studies SGS researched have achieved international acclaim:

- The CRC’s **Animal Emergency** study was presented the Emergency Media and Public Affairs research award. The Annual EMPA Awards recognise those who have made a significant contribution to emergency communication in Australia and New Zealand. The leading research was found to provide critical strategies for advancing emergency communication to improve resilience in the community. The emergency warnings and flood fatalities research were highly commended. The series has reflected greatly on Australia’s scientific and research capabilities.
- **PHOENIX RapidFire** is an example of the knowledge that is present in Australia’s bushfire research network. Its recognition internationally promotes Australia’s capabilities, further entrenching Australia as a world leader in bushfire knowledge.

Two statements from survey responders also point to this benefit:

“The CRC’s research is used to inform business cases and set priorities as well as conferences and forums promoting evidence-based decision-making. The CRC has improved the voice for fire research in the national context by being a focal point where governments can come to”.

“The CRC has improved the visibility of fire research from Australia in the rest of the world through fostering international collaborations, knowledge sharing and practical solutions” (CRC End User Survey, direct responses, 2020)

2.4 Higher impact and new research

The research undertaken and models created by the CRC have resulted in better public policy to mitigate hazard risks, behavioural changes in the community around disaster readiness and resilience, allowed for informed decision-making during natural hazards, and improved disaster recovery. This is critical and core work for the CRC and for Australia.

The benefits of this work include:

- reduced natural hazard impacts on property and infrastructure
- reduced impacts on health and wellbeing
- reduced disruption of economic activity
- reduced impact on the environment, and
- more efficient emergency management.

BUSHFIRE READY NEIGHBOURHOODS

“The Bushfire Ready Neighbourhoods project began as an integrated pilot project and Bushfire CRC PhD study with an ‘embedded’ researcher. After a five-year pilot it was funded as an ongoing state wide program, based on the quality (and quantity) of research evidence supporting a targeted community development approach to increase community preparedness and capacity to respond to bushfires. The program has continued to participate with and utilise The CRC and other research to support evidence-based service delivery.” (CRC End User Survey direct response, 2020)

Reduced natural hazard impacts on property and infrastructure

Work by the CRC has led to a reduction in the direct damage to property and infrastructure during natural hazard events. By using PHOENIX RapidFire, state agencies can reduce damages to property and infrastructure both by ensuring appropriate measures are taken before the fire season begins, and by making more informed decisions about areas at risk when a fire has taken hold. For example, the community of Gracemere in Queensland was saved from destruction when PHOENIX RapidFire predicted that a seemingly small bushfire near the town posed a real threat to the town. As a result of this warning, the decisions and actions undertaken by QFES to suppress the fires around the town, and the presence of an experienced weather forecaster, the threat was identified early and the town saved.

In responding to SGS's survey, one end user noted that the "integration of vulnerability and exposure data against physical hazard data provided an important step in providing the community with more relevant information to assist them in making smart decisions to mitigate hazards."

Another end user commented, "CRC staff expertise and shared networks (nationally and internationally) of researchers, practitioners and disaster managers puts end users in contact with researchers, which provides the understanding and evidence base needed to assess the relative merit of different long-term mitigation strategies and continuity."

End users also noted the following research projects that have resulted in reduced impacts:

- Better warnings to ensure action
- School-based education for disaster risk reduction
- Strength in the face of high winds
- Better Fire Danger Ratings
- Emergency planning for animals
- Preventable residential fire fatalities in Australia
- Analysis of building losses and human fatalities from natural hazards
- Improving decision-making in complex multi-team environments
- A new model for helping.

Additionally, the following research projects are touted as leading to increased knowledge of natural hazards:

- Seasonal Bushfire Outlook
- Finding fires faster
- Satellites to help show when the bush is ready to burn
- Carbon abatement through better fire mapping
- The Australian Disaster Resilience Index: A system for assessing the resilience of Australian communities to natural hazards
- Mapping and understanding vulnerability and risks at the institutional scale.

Reduced impacts on health and wellbeing

The CRC work, including on changing behaviours, increases resilience, but also leads to less death and injury during events, and a reduction in mental health and other community factors. Case studies attest to this benefit:

- The **Answering the Call** initiative and its findings are expected to help agencies, both individual and collectively, to refine and implement strategies to reduce long-term mental health impacts for employees and volunteers.
- The CRC's **Influencing Behaviour Change** series has resulted in a better understanding of how community warnings and safety messages inform and raise awareness in communities. Better preparedness results in lower community exposure and better health and wellbeing outcomes.
- **PHOENIX RapidFire** directly informs the emergency advice and warnings that are sent to the community in the event of a bushfire. This has a direct link to reducing health and wellbeing losses during events.

Reduced disruption of economic activity

A reduction in direct impacts on assets and infrastructure from hazards will also result in a reduced loss of economic activity after an event, as

TACTICAL RESEARCH ON SMOKE ALARMS

"The Tactical Research project on smoke alarms, which is just commencing, will help fire services understand how well smoke alarms manufactured to various global standards perform in simulated residential fire settings.

Although the project is not specifically related to natural hazards, working smoke alarms lead to a 50 per cent improvement in occupant survivability, and you are still more than twice as likely to die in a typical house fire than a bushfire." (CRC End User Survey direct response, 2020)

businesses and services can resume activity quicker and at a lower cost. In addition, economic disruption can be minimised through better-planned emergency responses and evacuations enabled through the CRC's research, models or programs.

The Answer the Call project is a key example of this benefit. The findings of the Answering the Call national survey now act as the baseline for mental health frameworks, which will set to improve the mental health and wellbeing of police and emergency services. It can be argued that research into mental health can lead to improvements in productivity and contribute towards greater efficiency of economic activity.

The research showed that roughly a third of employees have taken time off due to mental health problems. The data also highlights how important it is for employees to receive adequate support, including a tailored compensation process that assists their recovery.

Reduced impact on the environment

The CRC research has led to the better protection and management of the natural environment during and after natural hazard events. Preventative measures, such as prescribed burning and other preparatory activities, have been undertaken in high risk areas due to the insights that the CRC has provided, along with the utilisation of PHOENIX RapidFire.

More efficient emergency management

The modelling and research undertaken by the CRC enables better decision-making and improved allocation of scarce emergency management resources. End-user focused resources can be shared throughout networks and operations to support communities. More efficient decision-making will lead to greater community resilience in future crises. This will likely result in reduced impacts on infrastructure, human health, economic activities and the environment as a result of future hazards.

Case studies researched by SGS contain a wealth of evidence to substantiate this benefit:

- The **AEIP** has enabled key decision-makers access to rapid and essential information for more efficient emergency management. By providing a service that is 24/7, government and emergency service agencies can understand what is exposed at any location. This targeted information directs mitigation and operational decision-making for any hazardous situation within the defined area.
- The platform, through the CRC's **Natural Hazard Exposure Information Framework**, provides users with direct access to risk information on buildings, businesses, people, public facilities and infrastructure assets, agricultural commodities and environmental holdings in Australia. With agencies quickly understanding the potential risks, they can take decisive actions that can reduce the impact on infrastructure, human lives, economic activity and the environment. Not only can decision-makers make informed decisions during emergencies, but this can aid the recovery phase based on information surrounding recovery.
- Bushfire Prediction Services recently commissioned a CBA on the economic benefits of fire simulators (such as **PHOENIX RapidFire**). Early results suggest any investment on building and operating a fire simulator results in benefits 10 times that investment due to saved costs. This is due to simulators being able to be run tens of thousands of times to provide greater accuracy of results. These rates of scenario tests are not achievable by traditional manual methods (AFAC, 2020).

- The research and findings taken from the **ReCap** project will be used by decision-makers through a long-term recovery guide for communities. By increasing the knowledge of stakeholders, they will be able to make more informed decisions as to when and where to implement strategies.

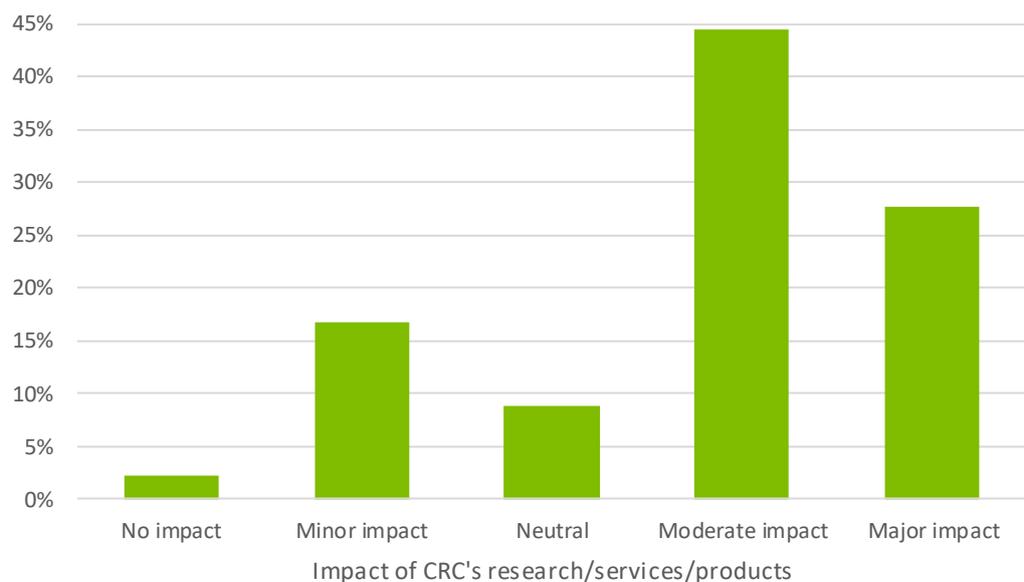
EXTREME FIRE BEHAVIOUR RESEARCH

“A stand-out example is the insights into extreme fire behaviour developed by one of BoM's CRC researchers, Mika Peace, which led to her providing expert advice to QFES during Queensland's extreme fires and more recently during the Black Summer fires in south-eastern Australia.

Predictive analytics used in the fires were impressively accurate. They led to the successful development of a national services capability beyond that available seven years ago. The benefits described earlier all came into play for BoM during the last season. The Pyrocumulonimbus Firepower Threshold, in particular, got a good workout with many pyrocumulonimbus events occurring. It proved its utility in anticipating fire blow-ups. This is a nice new tool in our toolkit.” (CRC End User Survey direct responses, 2020).

Figure 14 shows that respondents overwhelmingly found that CRC's research/services/products have a moderate to major impact on natural hazard management (72 per cent of respondents).

FIGURE 14: CRC'S IMPACT FOR ORGANISATIONS



Source: SGS Economics & Planning, 2020

Note: Responses were scored as follows: No impact (Score 0); Minor impact (Score 1); Neutral (Score 2); Moderate impact (Score 3); and Major impact (Score 4).

The SGS survey asked end users whether the work of CRC had influenced the way in which they prepared, responded and started recovery in relation to the recent 2019-20 bushfires. The majority (56 per cent of the respondents) agreed that CRC contributed to their decision-making.

According to respondents, the following CRC work contributed to their decision-making:

- The Pyrocumulonimbus Firepower Threshold diagnostic proved its utility in anticipating fire blow-ups
- Animal Emergency Management project

- Fire behaviour analysis, rating to assess risk and allow the strategic deployment of additional ground and aerial resources and hazard reduction plans
- Bushfire planning and logistics from predictive analytics
- Better approaches to urban planning developed in a research project were included in policy advice to government and the new AIDR handbook
- Emergency warnings and communications
- Atmospheric influences on bushfire behaviour were a significant consideration in the preparation and response for WA fires in the Goldfields
- Soil moisture characterisation by JASMIN
- Information from the Savanna Monitoring and Evaluation Reporting Framework (SMERF) for planners and operational staff across northern Australia.

2.5 Potential future benefits

Findings from the case study research highlighted areas for possible future focus by the CRC:

- **Equipping local government with the tools they need in the future.** As local government plays such a large role in community preparedness and future land-use planning, it is important for councils to be engaged with the CRC and its research on bushfire and natural hazards. Local government staff were noticeably absent in the group who responded to SGS's survey, indicating that the level of engagement is limited at present.
- **Planning for the unexpected (looking forward, not backward).** Historically, the majority of the research into bushfire and natural hazards has been undertaken by looking back at past events (namely through a Royal Commission process) to understand what lessons can be learned. However, past events are unlikely to be representative of the future, as it is highly likely that due to climate change, conditions will become vastly different. Bushfire and natural hazards researchers must therefore shift to looking at future scenarios and conditions, planning for the 'unprecedented', to make us as equipped as possible for the future.
- **A focus on preparation of the community through human behaviour research.** A critical piece of information required in the discourse about bushfire and natural hazards is how humans behave in times of crisis. In the Black Saturday fires in 2009, human behaviour was seen to be more critical than the fire itself. CRC's research on Planning for Animals in an Emergency also attests to the need to address human reactions during crises. This behavioural research needs to continue to be a priority in the future, building on the work already completed by the CRC.

Through the survey, SGS also asked end users what they thought the opportunities were for further research on bushfire and natural disasters. Prominent responses included engaging the community in long-term strategic planning that is more proactive, and less reactive.

End users also noted that the recent bushfires in Australia highlighted the importance of community inclusive models and the need to repurpose research to model extreme weather considering climate change. Further opportunities and lessons learnt from recent natural disasters by respondents are shown in Table 3 in five broad categories: Environmental, Social/Community, Scientific, Economic/Planning and Governance.

TABLE 3: OPPORTUNITIES FOR FUTURE NATURAL DISASTER RESEARCH

Theme	Opportunities for further research
Environmental	<ul style="list-style-type: none"> ▪ Impacts of climate change on the workforce ▪ Analyse patterns of burning in relation to outputs from the Australian Flammability Monitoring System, particularly for forest types with a dense canopy cover ▪ Influence of topography, weather and fuels on fire spread and growth of large-scale fires, especially the influence of fuel moisture ▪ Further research on cultural burning, with cooler burning and higher frequencies ▪ Role of fires to generate local destructive wind fields ▪ Detailed impacts from global warming to be well quantified, as the ferocious impact of the last fire season took well-informed practitioners by surprise ▪ Pollution forecast ▪ Long-term dryness and its contribution to megafire potential ▪ Downslope wind and its connection to ember storms ▪ Weather prediction in extreme conditions due to climate change ▪ Effects of prescribed burning on bushfire severity ▪ Compound events and rapid switches between atmospheric states
Social/ Community	<ul style="list-style-type: none"> ▪ How emergency response is managed in communities that are facing depopulation or an ageing community ▪ Influence of children and young people on household action and decision-making ▪ How to engage schools (both government and private) in emergency planning and link to disaster resilience education and how this could be applied in all states looking at all levels of PPRR ▪ Methods to change community behaviour of disengaged and how best to support communities post incident and prepare for the next one ▪ Assessment into how volunteers are best supported and impacted, as they are the first to respond and last to leave ▪ Re-evaluate current volunteer model to assess whether it will work with the emerging intensity of natural hazards and whether it is sustainable ▪ Behaviour of residents during bushfires and warning messages ▪ Volunteer firefighters have a much higher incidence of PTSD and psychological distress as a result of the recent bushfires. Speedy investigation into this issue would assist government in designing appropriate responses and strategies for future bushfire events. Early intervention and treatment can prevent PTSD from becoming chronic and harder to treat ▪ Evacuation messaging and people movement ▪ Evacuation shelter resourcing and sustainability ▪ Need to reframe approach to better reflect the key local issues that communities encounter and build this into a wider approach in terms of how to work with

	<p>communities prior to and during bushfires, and how significant events are investigated</p> <ul style="list-style-type: none"> ▪ Relevance of local practice and Indigenous knowledge
Scientific	<ul style="list-style-type: none"> ▪ Detailed and objective reconstruction of the spread of fires at daily resolution or better to understand the factors contributing to the scale and impact of the recent bushfires ▪ More effort to predict, warn and protect from smoke and better understand the long-term health impacts of smoke ▪ Coordination of real-time data capture during disasters and immediately after. This data provides vital information for future research and reconstructions and would require a much larger amount of funding than the small grants currently available. ▪ Field data collection to improve modelling of new fuel types created by severe fire (subsequent fires) ▪ Assessment of the quality of predictive work done by the CRC ▪ Detection/monitoring of dryness of fuel (use of both remote sensing and technology) and strategies to deal with that in a range of locations from those that could be suppressed with adequate resources to those that couldn't be, and hence, avoid waste of limited resources
Economic/ Planning	<ul style="list-style-type: none"> ▪ Design of domestic dwellings in bushfire prone areas ▪ Effectiveness of aerial suppression during different fire regimes, including re-evaluation of fire retardants, agency utilisation, operational decision-making processes and strategic location of aircraft ▪ Potential for residential sprinklers for bushfire-prone construction ▪ Better methods for broadscale fire severity mapping through a consolidated, national bushfire field data database for the calibration of satellite earth observation data ▪ The adequacy (survivability) of houses designed/constructed to the various editions of AS 3959 when subjected to recent bushfires. For those houses that did not survive, what were the factors that led to their destruction, and how could the standard be improved to mitigate those factors? ▪ Research into what makes an area not suitable for residential buildings ▪ In the bushfire-prone areas, what materials should/should not be used for the road network? Can recycled materials be used in the bushfire-prone area? If used, what are the inspection and maintenance routines required, etc? ▪ More detailed and operationally relevant research on evacuations from bushfires would help evidence-based decisions regarding access infrastructure and design ▪ Consequences of storms/cyclones being better quantified to improve community preparedness and operational readiness
Governance	<ul style="list-style-type: none"> ▪ What are the political impediments of the Royal Commission and how can they be satisfactorily addressed given the growing threat arising from climate change? ▪ How would Australia respond to natural hazards during a pandemic?

Source: CRC End User Survey, SGS Economics and Planning, 2020

3. VALUATION OF THE BENEFITS

This section provides a quantitative assessment of the benefits of the CRC, expressed in monetary values. Collectively, the impacts of the CRC can be quantified, valued and compared to the costs of CRC, to understand the community return on investment in research. The assessment is partial and conservative as not all benefits could be quantified, and some benefits were excluded to prevent double counting.

3.1 Introduction

The general aim of a cost-benefit analysis (CBA) is to measure whether a project, program or initiative has made society as a whole better off, compared to what would have happened without the project, program or initiative. In this case, the benefits analysis will consider the functions of the CRC over the past seven years (2013-20). Benefits will continue to accrue over time, and therefore the benefits and costs of the CRC's research were assessed over a 15-year period, from 2013-14 to 2027-28. Benefits may continue to accrue even beyond 2027-28 but are excluded from the analysis.

PREVIOUS COST BENEFIT ANALYSIS OF BUSHFIRE AND NATURAL HAZARD CRC RESEARCH

The CRC has regularly conducted CBAs of its research outputs. These have been based on assessments by Deloitte Access Economics and the Bureau of Transport Economics which quantify the impact of natural disasters in dollar terms. The methodology behind this research has been peer reviewed then used as a baseline for SGS' analysis.

These earlier CBAs have focused on tangible direct costs (property and infrastructure damage), tangible indirect costs (disruption to businesses and networks, and intangible costs, such as death, injury, impacts on health and wellbeing). This CBA seeks to include the value of the CRC as an academic/research institution, as well as the impacts of the implementation of its research findings.

This benefits analysis was undertaken from a community perspective and considers all impacts on community welfare, whether priced or unpriced in a market. For example, the benefits from ecosystem services or social goods like knowledge transfers.

The CBA reveals the full extent of the positive impact of the CRC in economic, social and environmental terms to Australia since 2013.

Base case

The first step is to define a base case to which the project case is compared. The base case under consideration is where funding was never given to the CRC, and therefore the organisation never came into existence. The benefits that would have occurred irrespective of the CRC's existence (such as other bushfire and natural hazards research) are not included in the benefits analysis.

Project case

The project case is where funding has been provided to the CRC. Due to the funding received, a host of benefits have been generated for Australia that otherwise would not have occurred. The value of the CRC comes not only from the research it produces, but the research's high quality and usefulness for end users, the cooperation and collaboration fostered across organisations, and by the CRC being an overarching, independent and trusted authority on bushfire and natural hazards.

3.2 Costs of CRC

Sources of funding

The main sources of revenue for CRC are government grant income, contributions from participants and revenue from contracting services. Government grant income started out at \$5 million in 2014 and had grown to \$6.8 million by 2019. Core participant contributions grew from \$3.6 million in 2014 to \$4.1 million in 2019 and contract revenue from \$600,000 to \$1.6 million (the latter is excluded from the table below).

TABLE 4: COST OF RESEARCH PROGRAMS – GRANT INCOME AND IN-KIND CONTRIBUTIONS

Research program	Total cost, 2013-2020
1: Economics, policy and decision-making	\$20,736,702
2: Resilient people, infrastructure and institutions	\$62,210,109
3: Bushfire and natural hazard risks	\$55,297,875
Total	\$138,244,685

Source: CRC

There is some uncertainty about incorporating contract revenue into total costs, rather than leaving it out altogether or including it as a benefit. Services contracted by the CRC include a range of public and private benefits, some of which are quantified in this CBA and some are not. To be conservative, contract revenue has been excluded as either a cost rather than a benefit.

On-costs

For CRC's research to have impacts on protecting lives, livelihoods and property from natural disasters, it is not enough for the research to be conducted, it must be applied. For any research program, there is a risk that no matter how significant its findings, it may have no impact if the research is left on the shelf and its findings not applied to real-world situations.

For each potential usage of the research, a cost was estimated for the implementation of the research. For the most part, this was estimated as a function of the FTE staff needed to implement it. This amount was reduced to reflect the possibility that a) the research would not be implemented and b) its implementation would be ineffective.

TABLE 5: ESTIMATED ON-COSTS/IMPLEMENTATION COSTS PER OUTPUT

Output type	Annual costs 2013-2020	Annual costs 2021-2024
1.01: Emergency management (resource pooling)	\$85,500	\$123,500
1.02: Development of policy & decision-making strategies & tools	\$85,500	\$123,500
2.01: Streamlining communications and warning systems	\$17,100	\$24,700
2.02: Capability and capacity building for contingents	\$85,500	\$123,500
2.03: Community assistance for natural hazards preparation	\$85,500	\$123,500
2.04: Policy advice on resilience strategies and tools	\$17,100	\$24,700
2.05: End-use workshops on managing uncertainty	\$17,100	\$24,700
2.06: Improvement of design and building codes with industry	\$17,100	\$24,700
3.01: Hazard monitoring, forecasting, & uncertainty modelling	\$85,500	\$123,500
1.01: Emergency management (resource pooling)	\$85,500	\$123,500

Source: CRC

3.3 Benefits

The following benefits are incremental, being those that would be an additional benefit to society of the CRC compared to the base case, where the CRC was not funded and therefore did not exist.

A large, independent and trusted authority

The impact of these benefits has not been quantified to prevent double counting. These benefits mostly cross over with other benefits, such as higher impact and new research and greater knowledge sharing.

- **The goodwill value of the CRC.** Goodwill has not been quantified as part of this assessment, as it risks double counting with some of the other benefits, such as the value of media coverage.
- **Trusted advice for the community.** This is quantified as part of the assessment of CRC's research outcomes.
- **Efficient planning and decision-making.** This is quantified as part of the assessment of CRC's research outcomes.
- **Valuable inputs into advisory bodies and inquires.** This is quantified as part of the assessment of CRC's research outcomes.
- **A smaller burden on public funding sources.** This has not been quantified to avoid double counting.

A network of knowledge holders for natural hazards

These benefits have generally not been explicitly quantified as part of previous assessments of the benefits of the CRC. These are focusing on benefits from the CRC that do not specifically relate to the reduction in risk of natural hazards. These relate to the benefits to Australia generally from producing academic research and analysis, and contributing to the global body of knowledge.

Knowledge sharing and collaboration – value of journal publications

Journal articles are one of the most common outputs of academic research, and one of the most valued outputs in terms of determining promotions or career progression for academics. As such, the expected salary increase for an academic for publishing a journal article can be used as a proxy for the value generated from the publication of an article. This was first discussed in Tuckman and Leahey (1975). Three types of benefits are discussed and quantified: direct salary increments, promotion-related salary increments, and career-related option effects. Using data from a national cross-section of university economists, the authors compute lifetime returns for selected article categories by academic rank. Their results

DOUBLE COUNTING PHD AND JOURNAL ARTICLE IMPACTS?

A PhD student's expected research output will usually consist of at least two journal articles, or three for PhDs by publication. If they remain in academia, part of their PhD wage premium will be based on their journal publication output. Attributing benefits evenly to both could result in double counting of the benefits of academic outputs.

However, almost all of the CRC's journal articles were multi-authored. Even if one author was a PhD student, and so the professional benefits of their research were valued as an education opportunity for students, their co-authors would still receive a professional benefit

suggest that the returns to publication of the first article are considerable, ranging from \$12,340 for an assistant professor, to \$10,256 for an associate professor, to \$6,958 for a full professor, based on a 5 per cent discount rate. The returns to additional publication diminish rapidly at first but at a lesser rate as the number of publications continues to increase.

A more recent study finds that a publication in a top-10 economic journal increases annual base salary by 1.5 per cent, or \$2,053 (O'Keefe & Wang, 2013).

From 2014-15 to 2019-20, a total of 300 journal articles were published as a result of CRC, two-thirds of which were published in Q1 impact factor journals. These articles are unlikely to provide the same wage premium as the O'Keefe and Wang study, as the CRC publications considered are not limited to the top-10 publications. Instead, a smaller wage premium of 0.5 per cent per Q1 journal article was estimated for this research in the Australian market. This premium was calculated for the average wages of a higher education sector worker with a postgraduate qualification for each year of age 30-50, drawn from wage distributions in the 2016 Census. The present value was calculated with a discount rate of 7 per cent and inflated to 2019 wages, for a total present value per article of \$5,535 per article published in a Q1-ranked journal.

Educational opportunities for students – increased lifetime earnings from further education

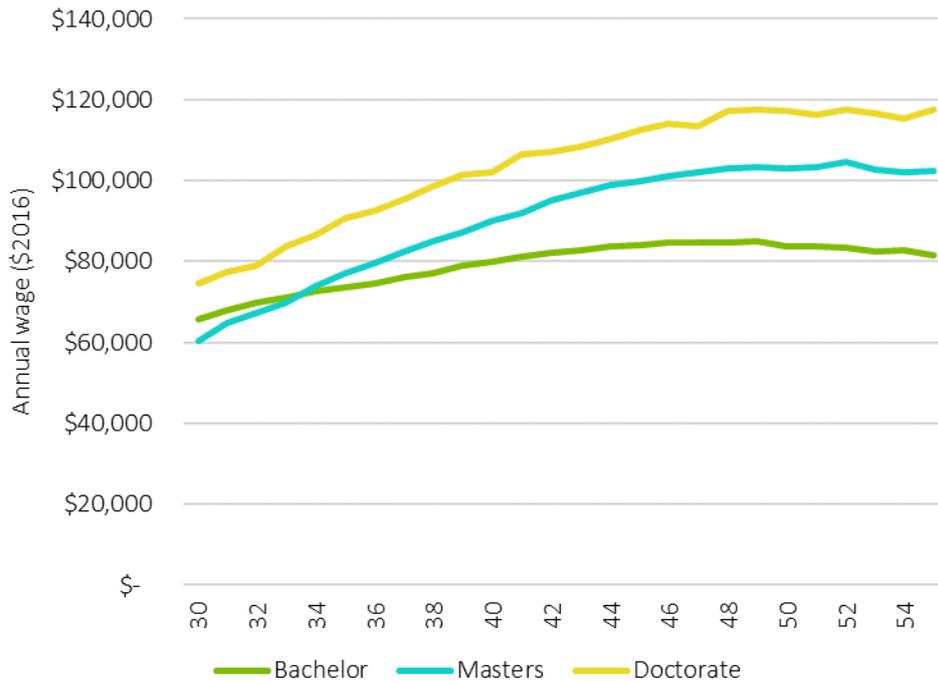
CRC has sponsored 70 students since its establishment, with 61 students completing PhDs and 9 students completing Master's degrees as part of the program. These students cover a range of disciplines, from engineering and data modelling to architecture, environmental sciences, climate, psychology, health and social work.

Additional education in a field of study relevant to a person's future occupation leads to higher wages, as it provides additional skills to the student and indicates to future employers that the student is clever, diligent and so forth. Carnevale, Rose and Cheah (2011) provide an overview of salaries in several different fields for both Master's and doctoral degree holders in the US. In communications and journalism, industrial arts and consumer services, and education, holding a doctorate only increases earnings potential by up to \$15,000 per year, while PhDs in engineering, physical sciences, social sciences and biological sciences can increase earnings by \$30,000 per year over a Master's degree. UK data showed that while the

earnings premium for a PhD was 26 per cent higher than a bachelor's degree, it was only 3 per cent higher than a Master's degree (Casey, 2009).

To estimate the productivity improvements from skills gained through doing a PhD with the CRC, and from graduates being better able to signal their innate skills to employers through a PhD, the difference between average earnings of PhD graduates aged 30-55 was compared to average earnings of Master's graduates.

FIGURE 15: EARNINGS OF PHDs, MASTER'S AND BACHELOR'S DEGREE HOLDERS



Source: 2016 Census

A PhD holder earns, on average, around \$10,000 - \$15,000 per year more than a Master's degree holder from age 30 to 55. The earnings premium of a PhD over a bachelor degree starts at only around \$9,000 in the early 30s but grows to a premium of over \$30,000 per year by the time the graduate is in their 50s.

The present value of the wage premium expected from a PhD qualification over a Master's from age 30-55 is \$167,043, in 2019 dollars, and for a Master's over a bachelor's degree is \$90,328. These wage premiums were multiplied by the number of Master's degrees and PhDs completed through CRC, to estimate the increase in research productivity generated through training the next generation of researchers, scientists and analysts.

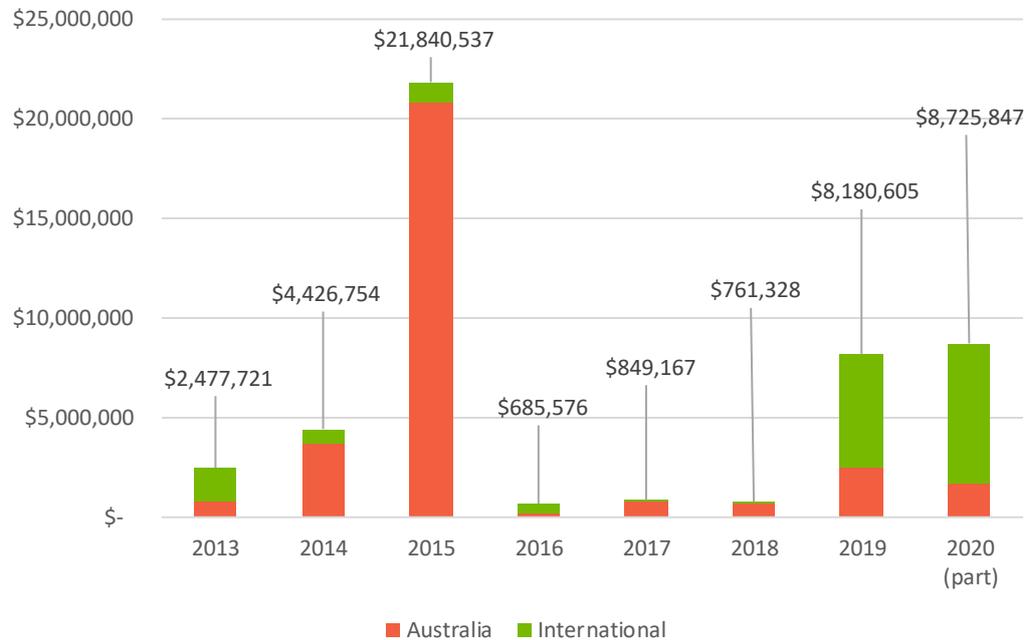
The benefit for these students is calculated at their year of completion. In addition, a further thirteen PhD students – the average number of completions from 2016-2020 – are expected to complete their study in 2021 and 2022, and an additional two Masters students in 2020 and 2021.

Promotion of Australia's research capabilities – value of media coverage

Universities, research organisations and think tanks will often pay for advertising to promote their brand and accomplishments, raising the profile of Australian research capabilities both locally and overseas. If a published research finding is of particular interest or relevance to the general public, this promotion can be done virtually for free through interest and promotion generated through the media, both in Australia and overseas.

In this analysis, the Ad Value Equivalency (AVE) is used as a proxy for the value of the benefit of CRC promoting Australia’s research in Australia and overseas. The method used to calculate this and more information on CRC’s research output are found in Appendix 1. A summary of the values used in the CBA is shown in Figure 16.

FIGURE 16: ANNUAL VALUE OF MEDIA SOURCES REFERENCING CRC: 1 JULY 2013 TO 21 APRIL 2020



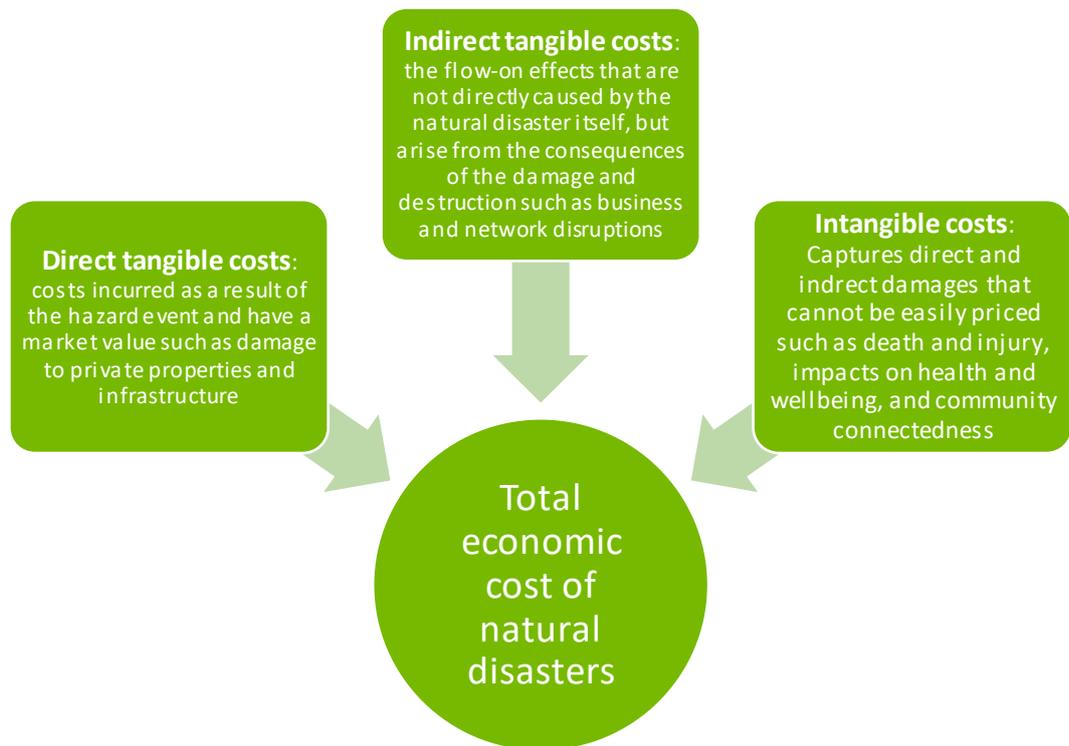
Source: Meltwater, 2020. Search terms: Bushfire, Richard Thornton, Bushfire and Natural Hazards CRC

It is expected that CRC research that has already been completed will be newsworthy in different forms for another three years, particularly with investigations into the Black Summer bushfires still ongoing. The average value of media coverage since 2013 was used to estimate the next three years’ promotion benefit.

Higher impact and new research

As noted earlier, the following benefits have already been estimated by an existing model of CRC research. This was drawn from research by Deloitte Access Economics (2016) and from the Bureau of Transport Economics (2001). The Deloitte Access analysis classified the costs arising from natural disasters as direct tangible costs, indirect tangible costs, and intangible costs, as shown in Figure 17.

FIGURE 17: ECONOMIC COST OF NATURAL DISASTERS



Source: Deloitte Access Economics, 2016

It is estimated that in 2015, intangible, direct tangible and indirect tangible costs of natural disasters exceeded \$9 billion and is expected to grow to \$33 billion in real terms by 2050.

The Deloitte Access classifications of costs of natural disasters line up with the classification of CRC's benefits as follows:

- **Reduced natural hazard impacts on property and infrastructure.** This is quantified as the estimated reduction in direct tangible costs of natural disasters as a result of CRC research findings and actions.
- **Reduced impacts on health and wellbeing.** This is quantified as the reduction in intangible costs of natural disasters as a result of CRC research.
- **Reduced disruption of economic activity.** This is quantified as the reduction in indirect tangible costs of natural disasters.
- **Reduced impact on the environment.** These impacts are discussed qualitatively.
- **More efficient emergency management.** This will be reflected in reduced direct tangible, indirect tangible and intangible costs of natural disasters.

The CRC's research program is designed to reduce the costs associated with natural disasters. The model built to assess this program estimates how a completely successful and implemented research program reduces the direct and indirect tangible and intangible costs of natural disasters. It then substantially moderates through conservative estimates of:

- the probability of the research findings being used in a way that allows them to have impact, and
- the probability that research findings, if used, will successfully reduce the costs of natural disasters.

As research takes time to complete and be implemented, the CRC's findings are not expected to have an impact until 2018-19. In this year, the expected impacts of the implementation of

CRC's research are a reduction in direct tangible impacts of \$70 million, a reduction in indirect tangible impacts of \$35 million and a reduction in intangible impacts of \$5 million.

How the impacts are estimated, using 2019-20 as an example

The model draws on Deloitte Access Estimates which projected \$5.8 billion in insurable losses in 2019/2020 for all natural hazards. Insurable losses are less than insurance claims, as a great deal of damage occurs to property that is uninsured.

This is reduced by two risks – the risk that the research will not be used in a way that allows it to have impact, and the risk that monetary impacts do not occur, assuming it has been used. In this case, The CRC have provided estimates that there is:

- a 75% chance that research will not be fully implemented to reduce property damage, and
- a 95% chance that monetary impacts will not occur.

In other words, it anticipates that of the \$5.8 billion in insurable losses expected as a result of natural hazards in 2019-2020, it expects that the CRC's research will prevent 1.25% of these, or \$72.9 million in insurable losses. This is explained in more detail in Table 6.

TABLE 6: METHOD OF ESTIMATING IMPACTS OF RESEARCH

	Total costs projected from natural hazards across Australia (\$millions)	Probability that research will be fully implemented	Probability that monetary impacts will occur	Modelled impact of CRC research on avoided costs (\$millions)
Reduction in Government, business and economic losses	\$14,327	5%	5%	\$35.8
Avoided costs of deaths and injuries	\$400	25%	5%	\$5.0
Reduction in insurance losses	\$5,807	25%	5%	\$72.6
Total	\$20,534			\$113.4

Source: SGS modelling, 2020

Likewise, the model estimates that the research will reduce projected deaths and injuries from natural hazards by 1.25% of the expected \$400 million in death and injury costs, which amounts to \$5 million in benefits in 2019-2020. For reference, in 2014 the Office of Best Practice Regulation assigned a value of \$4.2 million for each natural hazard disaster fatality, which comes to just under \$5 million when uprated to 2020 dollars.

Deloitte Access estimated that natural hazards would cost \$14.3 billion in lost government and business activity, of which the CRC expected their research would reduce by 0.25% or \$34.6 million.

In total, the model estimates that in 2019-2020, research from the CRC would have saved \$113.4 million in damages to property, human life and health and loss of economic activity.

Comparison of modelled impacts to demonstrated impacts

The methodology as explained above was designed by modellers in the CRC. SGS has reviewed it and considers this to be a reasonable method of estimating the benefits of the research. By estimating the total reduction in Australia-wide losses of the research program as a whole, it avoids the risks of double-counting or missing some of the more diffuse benefits.

SGS notes that the probabilities shown in Table 6 are estimates prepared by the CRC, and advises that the CRC is in a better position than SGS to understand if these estimates are accurate or not. To test their validity, SGS used a real-life example of the way the Bushfire

CRC research was used to mitigate the impacts of a bushfire, and quantified this as a share of total bushfire impacts to verify if the probabilities are plausible.

It is highly likely that the model's estimate of \$113 million in avoided costs is an underestimate of the true reduction in costs as a result of the CRC in 2019-20. From September 2019 to April 2020, insurance claims for fire, flood, hail and other disasters amounted to \$4.6 billion (Rollins, 2020), much higher than modelled or forecast by Deloitte. (It should be noted that there will be quiet years in which the damage caused by natural disasters will be lower than average).

A specific example of this impact is how RapidFire has been widely touted as helping 'save' the town of Gracemere (SBS Australia, 2018). PHOENIX RapidFire was used to identify that a small fire on the outskirts of Gracemere posed a serious threat to the town. This advance warning allowed Gracemere to be swiftly evacuated and emergency services quickly sent to where the fire could best be controlled, and the town was saved. Had PHOENIX RapidFire not been used, it is highly likely the fire would have become uncontrollable before it was recognised as a threat, putting at risk:

- The lives of the town's 8000 residents
- \$1.5 billion worth of residential dwellings and \$281 million in residential contents
- Commercial dwellings that would cost \$465 million to rebuild
- Industrial buildings that would cost \$307,430,000 to rebuild
- Agricultural commodity value of \$42,000³

While it is highly unlikely the town would have been completely destroyed, substantial damage would be expected. If the advance warning enabled by PHOENIX RapidFire allowed a modest two human lives and 20% of insurable assets to be saved, this amounts to a benefit of approximately \$250 million in avoided property damage and \$9.6 million in savings to life and health. Even without including the impacts of lost economic activity, this results in benefits substantially higher than the modelled \$72.9 million in avoided property damage and \$5 million in deaths and injuries avoided.

Based on this, it would appear that the estimates of the probability that CRC research will be implemented, and that monetary impacts will occur, are either reasonable or on the conservative side.

Although Phoenix RapidFire was created in 2012 by the Bushfire and Natural Hazard CRC's predecessor, the Bushfire CRC, the CRC have continued its spread, operation and development, and it provides an example of how CRC research can give advance warning of a bushfire threat and allow lives and property to be saved.

This also does not take into account unforeseen impacts, such as the health impacts of smoke through cities. The model was not updated to take these into account, as the Deloitte Access forecasts are based on projecting average or expected costs, which are necessarily smoothed over time.

3.4 The inclusion of non-quantifiable benefits

It is highly desirable to quantify as many benefits as possible in monetary terms; however, for many benefits this will not be possible.

Environmental impacts

Natural hazards can have devastating impacts on the natural environment, as well as humans and the built environment. Heatwaves can devastate native species, floods trigger erosion and redistribution of soils, and cyclones have killed areas of forest in the Northern Territory.

³ Source: Geoscience Australia - Exposure Report; Event name: Gracemere Bushfire_Town; Event type: Bushfire; Report Date: 19-02-2019 19:59:00 (AEST)

The recent Black Summer bushfires have had a devastating impact on the environment. Millions of hectares of forest were destroyed, resulting in estimates of over a billion native animals killed, either in the fires themselves or from lack of food and water due to habitat devastation. Run-off of ash and sediment into waterways has caused further damage.

The implementation of CRC research undoubtedly has positive impacts on preservation of native forests, native species, the health of waterways, soil quality and other environmental factors. Controlling bushfires results in less habitat loss and fewer native animals killed, flood mitigation measures reduce erosion and so forth. These have not been quantified as CRC's research generally focuses on protecting human life, and the properties that humans may be sheltering in, over animal and plant life, and so research findings have not reported as extensively on environmental benefits.

Companion animals

A section of CRC's research program has studied how people with companion animals, from dogs and cats to horses, react when faced with a natural disaster, particularly one that requires evacuation. Animal owners often did not properly prepare evacuation plans with their animals in mind, which can lead to households evacuating too late or not at all. To consider how this could be incorporated into Australian disaster response preparation, the Managing Animals in Disaster (MAiD) project has worked with community groups to enhance preparedness and planning for animals in emergencies. By highlighting how animals affect the behaviour of humans in response to natural hazards, the project has highlighted how communities need to be supported to be plan for their animals.

People's love for their companion animals can result in them risking their lives to save their companion. Saving a companion animal's life is beneficial and quantifiable – willingness to pay for standard household companion animals is in the order of thousands of dollars per year, and animal companionship brings valuable health benefits.

While companion animal lives have undoubtedly been saved as a result of this research, it was not the aim of the research – the aim was to prevent delays in household evacuation because their animals could not be evacuated quickly. For this reason, the benefits of saving companion animal lives was not quantified.

Benefits of collaboration between researchers and emergency services

In environmental scientific research, barriers can exist in transferring research findings from academia to improvements in effectiveness of field practitioners. These are often due to difficulties in effective communication and collaboration between researchers and field practitioners; including:

- Lack of access to academic literature among field practitioners
- Relevance of research findings to field practitioners
- Flow of findings of field practitioners back to researchers (Sunderland, Sunderland-Groves, Shanley, & Campbell, 2009).

There is a wide body of literature from around the world on how this communication can be improved, including developing trust between researchers and practitioners (McGee, et al., 2016) and embedding researchers in practitioner organisations (van Wilgen, Boshoff, Smit, Solano-Fernandez, & van der Walt, 2016). The benefits of these collaborations include more effective academic research that is more relevant to the needs of practitioners, improved communication between practitioners to researchers and more influential research outcomes.

Keeping these findings in mind, the CRC maintains strong collaborative links with organisations on the ground to ensure that its research meets the needs of the organisations it is designed to serve. For example, the Managing Animals in Disasters project collaborated with the Blue Mountains Animal Ready Community to prepare for animals in emergencies.

During the Queensland bushfires in November/December 2018, the Queensland Fire and Emergency Services (QFES) manager of Predictive Services, Andrew Sturgess, recognised that the heatwave affecting the state in late November was causing unprecedented bad fire weather. To assist, Dr Mika Pearce, a fire weather meteorologist and CRC researcher was embedded in QFES at short notice to map out bushfire spread scenarios, analysing pressure points and assessing how the weather over the Gulf of Carpentaria could affect the behaviour of individual fires. In the 2019 fires, Dr Pearce along with Dr Marta Yebra and Dr Jason Sharples joined NSW, QLD and SA fire services at their state operations centres⁴.

This level of collaboration allows emergency services organisations to have the most knowledgeable researchers in the country at their fingertips when they are trying to minimise the impacts of disasters, and allows researchers to clearly understand the issues faced by organisations with ‘boots on the ground’.

The impact of collaborations is significant, however it has not been quantified separately as its main impacts are reflected in other benefits already quantified, including improved journal article output, improved education opportunities and reduction in physical, economic and human injury from natural disasters.

3.5 Distribution of benefits

Distributional analysis disaggregates the overall benefit of the CRC by groups of beneficiaries. This enables decision-makers to consider the social justice impact on individual groups as well as the overall benefit.

The benefits of the CRC accrue to a wide range of stakeholders including all three tiers of government, universities and other research bodies, students, vulnerable communities, the environment, businesses and the entire Australian populace more broadly. The CRC’s work also benefits the international community.

Table 7 shows the benefits of CRC and its expected beneficiaries. For each beneficiary, the benefits that are expected to impact them most are highlighted. A score of 3 represents a high level of benefit, a medium level of benefit is represented by a 2, and a low level of benefit is given 1 score. The table shows that the many stakeholders of the CRC benefit in various ways and to various degrees. Emergency services, State Governments, the academic world, the Federal Government, regional communities and landowners are benefitting the most from the CRC, if treating all benefits as equal⁵.

The Australian, state and territory and local governments benefit from the CRC as a large, independent and trusted institution (headline benefit 1), and from better decision-making as a result of CRC’s quality and new research (headline benefit 3). Importantly, state governments benefit from higher impact and new research as it can be implemented during natural disaster response (which is primarily state coordinated).

Whereas universities primarily benefit through increased research funding and the network of knowledge holders (headline benefit 2⁶), regional communities and landowners benefit from better decision-making as a result of CRC’s quality and new research (headline benefit 3).

Emergency services benefit in a variety of ways from the quality research, the network of knowledge holders and from the CRC being a large, independent and trusted institution. Emergency services also benefits from the aggregation of research funding generating leverage at the individual agency level.

At a more granular level, it shows that for many of the beneficiaries, the main benefits are the reduction in damage to property, infrastructure, health and wellbeing, economic activity and

⁴ <https://www.bnhcrc.com.au/news/2019/crc-science-making-national-impact>

⁵ i.e. if no weighting of benefits is applied. Some benefits may be deemed more important than others, which would be a reason to apply a weighting system

⁶ see section 2.1

the environment. These impacts also come through in the CBA as having the greatest potential benefit, as measured in dollar values.

Unsurprisingly, the major beneficiaries of a network of knowledge holders are universities, and to a lesser extent, emergency services and state government.

TABLE 7: DISTRIBUTIONAL IMPACT OF BENEFITS

Headline benefit	Sub benefits	Emergency services	Federal gov't	State gov't	Local gov't	Businesses	Households	Regional/rural communities	Landowners	Infrastructure providers	Volunteers	The environment	Universities
A large, independent, and trusted institution	Goodwill value	3	1	1	1	1		1	1		1	1	
	Trusted advice for the community					2	2	3					
	Efficient planning	3	3	3	3								
	Inputs into advisory bodies		3										
	Smaller burden on public funding	3	3	3	3								3
	Sub-total	9	10	7	7	3	2	4	1	0	1	1	3
A network of knowledge holders	Higher use of research	3		3									3
	Innovations	3		3		1			2	2			3
	Better products for end users	3		3		1			2	2			3
	In-kind contributions	3		3									3
	Value of education	3	1	2	1	1	1	1		1	1		3
	Advancing global knowledge		1	1									3
	Promotion of Australian research		2	2	1								3
	Sub-total	15	4	17	2	3	1	1	4	4	1	0	21
Higher impact and new research	Reduced property impacts		2	2	2	3	3	3	3	3			
	Reduced health impacts		2	2	2	3	3	3	3	3	3		
	Reduced economic disruption		2	2	2	3	3	3	3	3			
	Reduced environmental impacts		2	2	2	3	3	3	3	3		3	
	Efficient emergency management	3	3	3	3						3		
	Sub-total	3	11	11	11	9	12	12	12	12	3	3	0
	TOTAL	27	23	35	20	15	15	17	17	16	8	4	24

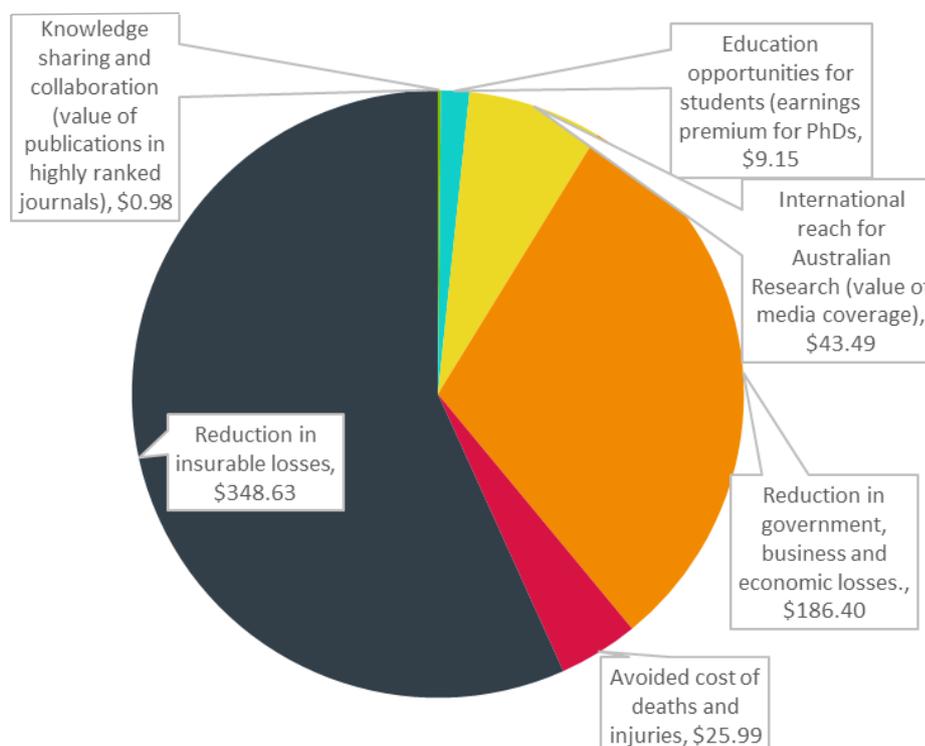
Source: SGS Economics and Planning

3.6 Cost-benefit analysis results

The costs of the CRC’s research were calculated for 2013-14 to 2020-2021. The benefits of CRC’s research were estimated over a 15-year period, from 2013-14 to 2027-28, as CRC activities conducted today are expected to have benefits in the future. It is highly likely that research findings will still be providing benefits beyond this time.

Figure 18 shows that the reduction in insurable losses, or direct tangible costs saved, is the largest benefit provided from CRC’s research, providing a 57 per cent share of benefits.

FIGURE 18: SHARE OF BENEFITS



Source: SGS modelling, 2020

Table 8 shows the results of the CBA, at discount rates of 3 per cent, 7 per cent and 10 per cent. The key indicators are the net present value (NPV) which is the total present value of benefits minus the total present value of costs; and the benefit cost ratio (BCR) which is the total present value of benefits divided by the total present value of costs.

It shows that at a 7 per cent discount rate, each dollar invested in CRC provides \$6.08 of benefits. The total net benefit of CRC’s research program is \$513.57 million, from a present value of investment of \$101 million.

At a higher discount rate, 10 per cent, the benefits are still more than five times greater than the costs.

In addition, as the case studies outlined in this report illustrated, there are a number of specific occasions where CRC’s research outputs resulted in avoided losses of assets, infrastructure and life. Although these specific cases have not been included in the CBA to avoid double counting, these cases demonstrate that the likely benefit of the CRC is substantially higher again.

TABLE 8: COST-BENEFIT ANALYSIS RESULTS

	3%	7%	10%
Research costs	\$118.34	\$97.41	\$84.93
Implementation costs	\$4.95	\$3.65	\$2.96
Total present value of costs	\$123.29	\$101.07	\$87.89
Knowledge sharing and collaboration (value of publications in highly ranked journals)	\$1.25	\$0.98	\$0.82
Education opportunities for students (earnings premium for PhDs)	\$12.36	\$9.15	\$7.38
International reach for Australian Research (value of media coverage)	\$55.19	\$43.49	\$36.84
Reduction in government, business and economic losses.	\$287.61	\$186.40	\$137.09
Avoided cost of deaths and injuries	\$40.10	\$25.99	\$19.11
Reduction in insurable losses	\$529.27	\$348.63	\$259.10
Total present value of benefits	\$925.78	\$614.64	\$460.35
NPV	\$802.49	\$513.57	\$372.46
BCR	7.51	6.08	5.24

Source: SGS modelling, 2020

3.7 Sensitivity analysis

To assess the robustness of the outcomes, a sensitivity test was undertaken. The highest value benefits of the CRC research are reductions in insurable losses and a reduction in government, business and economic losses. However, these results are reliant on CRC estimates of the expected success, implementation and effectiveness of their research program.

To test the impacts of CRC's research program being less effective than expected, the CBA results were recalculated reducing the following benefits by two-thirds:

- Reduction in insurable losses
- Avoided cost of deaths and injuries
- Reduction in government, business and economic losses.

It is also possible that implementation costs will be higher than expected, so the sensitivity analysis has doubled these.

The results are shown in the table below.

TABLE 9: SENSITIVITY ANALYSIS RESULTS

	3%	7%	10%
Research costs	\$118.34	\$97.41	\$84.93
Implementation costs	\$9.91	\$7.31	\$5.92
Total present value of costs	\$123.29	\$101.07	\$87.89
Knowledge sharing and collaboration (value of publications in highly ranked journals)	\$1.25	\$0.98	\$0.82
Education opportunities for students (earnings premium for PhDs)	\$12.36	\$9.15	\$7.38
International reach for Australian Research (value of media coverage)	\$55.19	\$43.49	\$36.84
Reduction in government, business and economic losses.	\$94.91	\$61.51	\$45.24
Avoided cost of deaths and injuries	\$13.23	\$8.58	\$6.31
Reduction in insurable losses	\$174.66	\$115.05	\$85.50

Total present value of benefits	\$351.60	\$238.76	\$182.10
NPV	\$228.31	\$137.69	\$94.21
BCR	2.85	2.36	2.07

Source: SGS modelling, 2020

Even if the benefits of a reduction in disasters caused by natural hazards are reduced by two-thirds and implementation costs doubled, the net benefits are still positive at all discount rates, producing at least two dollars of benefit per dollar invested.

4. OVERALL CONCLUSIONS AND NEXT STEPS FOR THE CRC

This report has taken a wide-ranging view of the benefits provided by the Bushfire and Natural Hazards CRC.

Rather than simply focusing on the impacts of research implementation, this analysis has also considered the benefits of the CRC's status as an academic and research body, and as a trusted and independent source of knowledge. This report has used a series of case studies, a survey of research users and cost-benefit analysis to understand the value and benefits of CRC as an organisation.

4.1 The value of the CRC

As a **large, independent and trusted institution**, CRC has been a source of reliable and unbiased information for a range of stakeholders. During the 2019-20 bushfire season, the CRC website received an increase in visits of 204 per cent over the same period the previous year, as more and more people sought advice on the fire situation. The survey of CRC users shows that many simply did not know where they could find an equivalent to CRC information. Its value as a trusted institution is demonstrated through the Influencing Behaviour Change case study. The success behind the CRC's recent three behaviour change projects (Research into Warning Systems, Managing Animals in Disaster, and Child-Centred Disaster Risk Reduction) has been a result of CRC's reputation within the community.

As a provider of a **network of knowledge holders for natural hazards**, CRC has brought together researchers from a range of fields to share knowledge, form relationships and pursue common research goals, produce new research and innovation and allow better use of existing research. The CRC provides a central role in building and maintaining the capacity and working knowledge of bushfire and natural hazard industry members across Australia. It is the combination of all of the CRC's activities that enable this, from the dissemination of their research outputs, their calendar of events and conferences throughout the year, through to their media presence.

As a creator of **higher impact and new research**, CRC has driven research proven to have saved lives, businesses, property and infrastructure from destruction in natural disasters. The town of Gracemere in Queensland was saved from destruction when PHOENIX RapidFire predicted that a seemingly small bushfire near the town posed a real threat to turn into a blaze and threaten the town. As a result of this warning and an experienced weather forecaster being in the area, the threat was identified early and the town saved.

The value of these benefits is significant, with the expected benefits over a 15-year period of \$614 million dollars, and a net present value of the research program of \$513 million. For each dollar invested in CRC, a return of six dollars is expected.

In addition, there are a number of specific occasions where CRC's research outputs resulted in avoided losses of assets, infrastructure and life, as demonstrated by case studies. Although these specific cases have not been included in the CBA to avoid double counting, these cases demonstrate that the likely benefit of the CRC is substantially higher again.

4.2 Future opportunities

The case studies and survey have identified a number of areas in which there would be a real need for CRC to focus its efforts in the future.

The need to plan for natural disasters in advance to mitigate their impacts, rather than simply to mop up the consequences, was identified in survey findings. This includes the need to consider climate change impacts in plans and designing and constructing disaster resistant infrastructure. Also identified was the need for real-time data during disasters and more detailed studies of the factors affecting bushfire spread. Natural hazards research must shift to looking at future scenarios and conditions, planning for the 'unprecedented', to make us as equipped as possible for the future that lies ahead of us.

The importance of human behaviour in response to a natural disaster was identified as an important area for research. In the Black Saturday fires in 2009, human behaviour was seen to be more critical than the fire itself. CRC's research on Planning for Animals in an Emergency also attests to the need to address human reactions during crises. The impact on volunteers of their contribution has also been identified, with weeks of volunteer work and psychological distress taking a toll on their wellbeing.

4.3 Closing statement

In summary, the CRC brings a range of benefits to the community at large, as an independent institution, a contributor to the local and international research community, and as a provider of knowledge that has saved hundreds of millions of dollars in natural disaster damage. Users of this research have identified many valuable directions for the work of the CRC to continue.

APPENDIX 1: CASE STUDIES

Australian exposure information platform (AEIP)

About The AEIP

The AEIP was built on the CRC's Natural Hazard Exposure Information Modelling Framework. The AEIP was developed in partnership with Geoscience Australia, and uses inputs from Geoscience Australia's National Exposure Information System (NEXIS). Its focus was to provide nationally consistent exposure information for emergency management by supplying key stakeholders with direct access to the information they need at the onset of a crisis via a web platform. The platform allows anyone to generate a report for any area of Australia at any time – before, during and after a hazard event has occurred (Geoscience Australia, 2020).

THE AEIP WEB PLATFORM



Source: AEIP and Geoscience Australia, 2020

The AEIP includes a complex model of how various assets are vulnerable to a number of hazards. The AEIP displays impacts on people, buildings, infrastructure, businesses, hazardous substances, agriculture and environmental assets, resulting from critical infrastructure failures, natural or human-induced hazards. For example, built environment exposure considers usage type, structural system, number of stories, size, age, etc. Business and economics exposure considers the type of business, assets and activities to assess the level of business continuity, disruption and recovery that might occur.

Users are able to rapidly gain a holistic understanding of what is exposed and at risk within an area. End users enjoy the sense of empowerment that the AEIP gives them. They can select the area of interest, the type of exposure data themes they require as well as other

contextual information. The resulting report is generated automatically and delivered by email.

Geoscience Australia and research teams from the University of Canberra and the University of Melbourne collaborated to develop the AEIP. The software has extensive support from end users who are involved in emergency management, risk assessment, impact analysis research and disaster management. These are stakeholders that are required to understand how severe a natural disaster might become and the associated exposure risks. These organisations include the Crisis Coordination Centre of Emergency Management Australia, the insurance sector and several Australian, state and local government agencies, industries and universities (Geoscience Australia, 2020).

Previously, users faced delays while Geoscience Australia manually assembled exposure reports during emergencies. AEIP has sped up the process considerably by enabling users to quickly and easily create customised exposure reports. Organisations have access to on-the-fly scenario event assessments by either completing a simple form through AEIP's web mapping application or by connecting their applications directly via the API.

The AEIP in practice

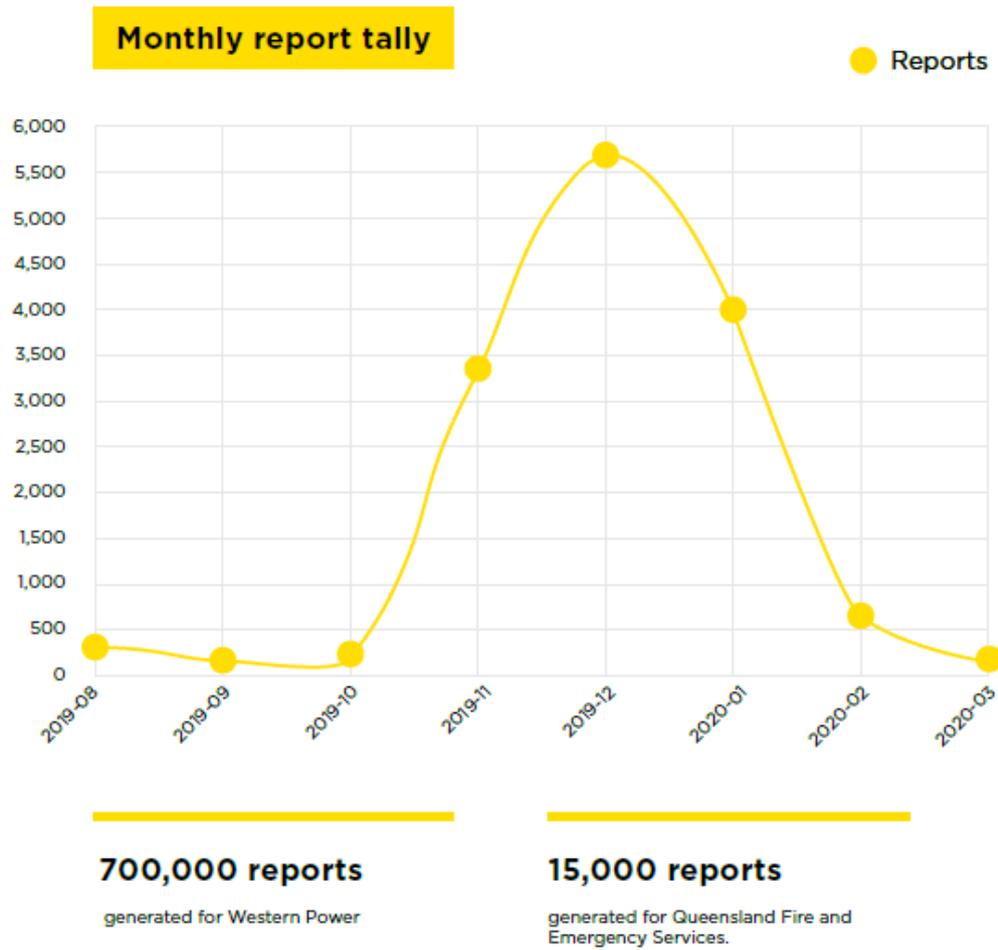
The beta version of AEIP was released in August 2018 and was intended to roll out during the 2018-19 fire season. That season produced more than 1,500 exposure reports by more than 200 users. Improvements were made based on feedback (CRC, 2019).

The platform was a success during the Queensland flooding in December 2018 when 400 exposure reports were created in one week by government agencies. This assisted organisations with rapid and smarter decision-making, which saw a reduction in the loss of life and economic damage (CRC, 2019).

During Cyclone Veronica (March 2019), agencies were able to use the platform to understand exposures in the Pilbara that were under threat. The platform determined the vulnerabilities of structures and the population to tropical cyclones such as Veronica and other hazards. The Community Preparedness Branch within the WA government used AEIP to identify vulnerable communities and to tailor community engagement based on demographic information.

During August and November of 2019, the unprecedented bushfire season saw 3,900 exposure reports produced from the AEIP by more than 120 users (Geoscience Australia, 2020).

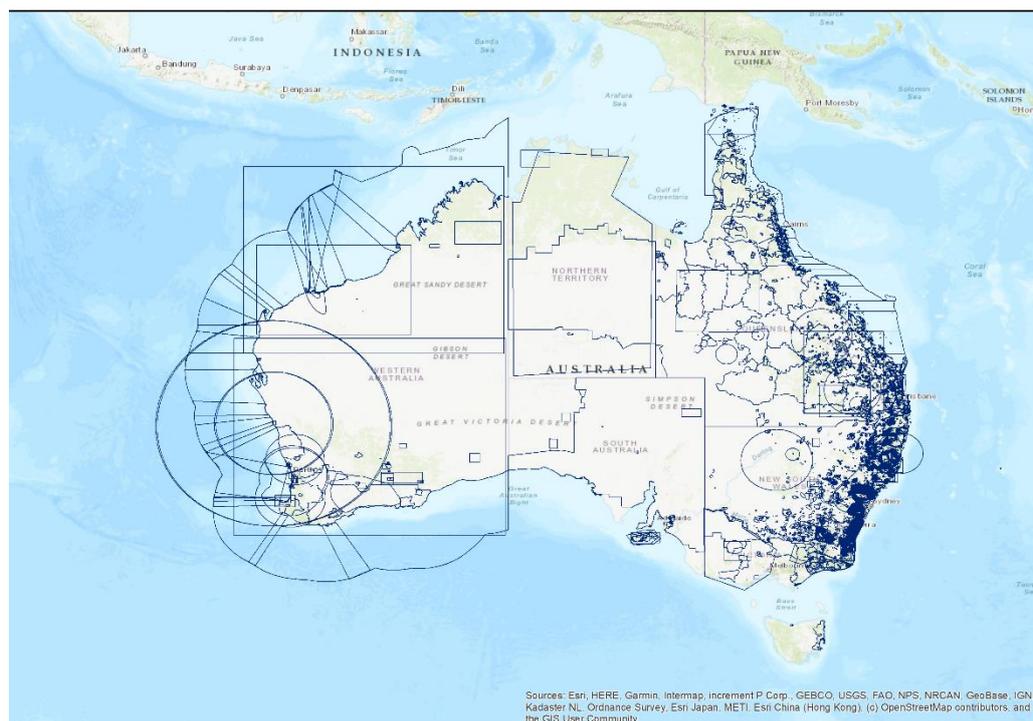
During the 2019/20 bushfire season, the number of exposure reports produced from the AEIP was in excess of 14,500 by more than 200 individual users (90+ domains; 1 August 2019–31 March 2020). Users such as NSW RFS have integrated the API with their own applications and have been producing thousands of valuable reports each month, particularly during the 2019/20 bushfire season. Western Power, a WA-based energy provider, has recently utilised the platform to create 700,000 reports (CRC, 2020).



Source: CRC, 2020

The figure below represents the aggregated use of AEIP web mapping between December 2019 and March 2020. The lines on this map show the areas that exposure reports were generated for. Exposure reports were generated for both small and large areas, covering all states and territories. Dark-blue areas show multiple AEIP queries, correlating with extreme weather events e.g. 2019/20 bushfires.

During a crisis, when demand for information to inform decisions is extremely high, the AEIP is extremely valuable. By speeding up the delivery of vital exposure information in an automated format, its nationally consistent and easily accessible approach to data ensures that information and decision making across jurisdictional borders can be done in a way that is comparable and quantifiable.



Source: CRC, 2020

Geoscience Australia intends to make continuous improvements to the program to better cater to end users' needs. Potential improvements may include:

- ongoing updates and maintenance of data
- the ability to create exposure reports across state and territory borders
- the addition of national comparative demographic statistics
- the ability for drawn areas of interest to receive the spatial data with the report, allowing users to repeat the request and/or distribute to other users
- the ability for users to select existing geographies, such as Local Government Areas, Bushfire Forecast Districts and the ABS Statistical Geographical Standard digital boundaries
- the ability to batch a number of areas of interest in a single process (Geoscience Australia, 2020).

Benefits

By streamlining and automating the process of generating exposure reports, the AEIP provides:

- Faster and more accessible information on natural hazards risks, which increases the chances that lives, property, businesses and the environment can be saved in a natural disaster
- A streamlined delivery mechanism reduces costs of providing this information.

Answering the call

Answering the Call was the first national survey that investigated the factors that affect the mental health of employees, volunteers and former employees in the police and emergency services. Included in the research were personal and workplace factors, stigma and support seeking, workers compensation system experiences, and experience after leaving the service. Answering the Call was initiated in 2018 and conducted as Phase 2 of the Beyond Blue National Mental Health and Wellbeing Study of Police and Emergency Services. The CRC played a vital role by providing partial funding of the Answering the Call project and by partnering with Beyond Blue.

The project received full support from all Australian emergency service organisations that operate with a volunteer workforce, including rural fire services, and state and territory emergency services. Of the 36 agencies in the industry, 33 of these agencies participated in the project. A random sample was selected and contacted to participate in an online survey by email. It attracted a modest response rate: 22 per cent of employees in the sample and 10 per cent of the volunteers submitted a reply. The total number of survey respondents was 21,014.

Project findings

The study found that, across the majority of the workforce in police and emergency services, there were good levels of positive mental wellbeing and resilience, and low levels of distress. However, compared with the general population, the levels of distress and mental health conditions in this sector were higher. One in three employees experienced high or very high psychological distress compared to just over one in eight of all Australian adults. The survey also showed that employees and volunteers are twice as likely to report having suicidal thoughts compared to the general population. The survey addressed areas of improvement to workplace culture, as the findings indicated that physical and verbal assault were fairly common.

Employees tend to stigmatise mental health more than the general population. The study found that by reducing that stigma could promote behaviours positive to each individual's mental health. The majority of employees who made a workers compensation claim reported that the process hurt their recovery, and they found the system to be unsupportive and stressful more often than not. The survey also identified a number of gaps in mental health support, and recommended ways in which agencies can improve risk management and deliver support services. with many employees feeling there was insufficient help for their problems.

The results of Answering the Call include a national database that will be used for future research, both nationally as well as by individual agencies. Phase 2 is intended to act as a catalyst for each agency to review, refine and implement strategies that minimise long-term mental health impacts on employees and volunteers. The research will provide a basis for Phase 3 of the ongoing project, where the focus is on designing a collaborative 'evidence to action' project. A partnership approach will be taken with agencies to develop and implement a framework that aims to improve mental health and wellbeing in police and emergency sectors. The aim will be to understand the current state of knowledge and practices, and then to design strategies. Phase 3 will particularly focus on early career volunteers (aged 16-25).

The Answering the Call initiative has also contributed towards further separate studies. The University of Western Australia was able to gain research funding to follow the ongoing wellbeing and resilience of Australia's first responders following the 2019-20 bushfires, and the CRC has recently initiated a project to develop a framework for protecting the mental health of young volunteers.

Project benefits

The Answering the Call project has not yet been fully implemented, but is showing potential to provide a range of benefits to Australia.

Reducing the economic and social burden of mental health

The costs of poor mental health in the workforce are high. The National Mental Health Commission stated that the cost of mental ill-health in Australia each year was about \$4,000 per person, or \$60 billion in total. KPMG and Mental Health Australia's 2018 report, Investing to Save, looked at how much mental ill-health in the workplace costs Australian employers. The report found that mental ill-health in the workplace costs an average of \$3,200 per employee with mental illness, and up to \$5,600 for employees with severe mental illness.

https://www.aph.gov.au/About_Parliament/Parliamentary_Departments/Parliamentary_Library/pubs/rp/rp1819/Quick_Guides/MentalHealth

There are 120,000 emergency services employees across Australia and an additional 240,000 volunteers, so potential savings from preventing mental health problems from developing and treating them before they become severe are potentially worth millions of dollars. This will potentially save not only costs from lost productivity, but also reduce the burden on the mental health system.

Collaborations, education and efficiency improvements

The research has identified gaps in the existing framework for mental health service provision that will improve efficiency in managing mental health issues. It has created opportunities for organisations to collaborate, in this case Beyond Blue, University of Western Australia and Roy Morgan research worked together on this project.

Influencing Behaviour change

The CRC have undertaken several projects focused on influencing behaviour change. These projects focused on improving preparedness, responsiveness and resilience of communities to bushfire events. All three projects shared the goal of improving how community warnings and safety messages are distributed by emergency service agencies.

Warning systems research

The NSW Rural Fire Service (NSW RFS) commissioned CRC to research community preparedness and response to the 2018 Reedy Swamp Fire. CRC engaged research teams from the University of Wollongong and Macquarie University to conduct this study. The project aimed to investigate information and warnings the community received during the bushfire and to examine the community's level of planning, preparedness and responses.

The CRC conducted 87 semi-structured in-depth interviews with 120 people directly affected by the fires. The research found several opportunities for NSW RFS to improve its community engagement:

- There are opportunities for NSW RFS to increase community awareness and preparedness for bushfires through clearer communications about the potential risks of embers that can spread to settlements.
- Community engagement should be more focused on encouraging communities to develop and update their plans based on the most up-to-date information and advice available.
- Educational resources and campaigns should emphasise that planning and preparation should begin before a bushfire threatens, preferably before the start of the bushfire season. A high level of confusion existed among respondents about the meaning of 'seek shelter', highlighting the need for greater dialogue and clarity about safe shelter practices. The responses showed there were a number of residents who intended to evacuate at the last minute, as well as the tendency for people to observe fires before

making up their mind to leave or defend. This finding shows that educational materials and campaigns should focus on delivering clearer messages about these significant matters.

It is important to note that the CRC has been undertaking this type of research since around 2005, however efforts substantially ramped up after the 2009 Black Saturday fires. In doing so, the CRC has developed a valuable longitudinal study data set that has influenced community preparedness messaging and warnings.

Managing animals in disaster (MAiD)

The CRC's MAiD project was a study of the challenges experienced by animal owners, stakeholders and community members in preparing for and responding to the needs of animals in emergencies. The three-year project aimed to identify and build best-practice approaches to animal emergency management. It focused on the need to improve animal welfare and increase public and responder safety, as it is recognised there is a tendency for animal owners to risk their lives to protect their animals. There were collaborations between Macquarie University, the University of South Australia, Australian National University and RSPCA Queensland. Another collaborator was the newly formed community group Blue Mountains Animal Ready Community, which provided a community approach to enhancing awareness and preparedness in case of an animal emergency.

The project had two phases. The first phase consisted of scoping, auditing and exploring the area, while the second phase comprised a suite of individual projects. As a PhD project, an experienced veterinarian conducted a program of research based around the responder-owner interface.

The research showed huge issues revolved around animal safety when there was a risk of bushfires. The survey showed that 62 per cent of households have pets and 90 per cent of these respondents consider their pets to be family. These special bonds risk households, as animal owners will be motivated to protect and save their animals in an emergency. The research findings showed that 60 per cent of respondents expected emergency services to provide information or advice regarding what they could do with their animals during emergency situations. During the 2013 bushfires, there were low levels of planning among those who evacuated.

Through the survey, most respondents reported taking their animals with them; some reported leaving a person behind, and others chose which animals to leave behind. The information gathered in this study will be applied by producing a community guide to establish an animal-ready community. These resources will be accessible and distributed to communities. It is expected to consist of a brief 'how-to' guide and an accompanying research pack, which will provide helpful advice and the steps involved.

Child-centred disaster risk reduction

It is estimated that 30-50 per cent of disaster fatalities are children. They represent the most vulnerable demographic from casualties as well as psychosocial impacts. CRC facilitated a project conducting a nationwide evaluation of programs and strategies based on a child-centred disaster risk reduction framework. With early research suggesting children are a resource in mitigating current and future disaster risks, developing cost-effective programs will increase the resilience for children, schools, households and communities from hazardous situations.

The project aimed to build on existing capabilities and provide an evidence base for best practice strategies to increase awareness in children. The study was a collaboration between RMIT University, CW University Australia, SES, the University of Melbourne, Massey University and Save the Children. The project also involved end users in all aspects of the study to provide enhanced research that could be used nationally.

The research found that there was a sophisticated level of understanding of bushfire risks when children were involved in developing their family's bushfire plans. The main fallacy uncovered was that while children understand the surrounding bushes may cause bushfires, they did not grasp that the bushfire could spread through the town. The study also showed there is a lack of knowledge among children about how embers could travel and ignite infrastructure. When these misconceptions are uncovered, children demonstrate a good understanding of bushfire behaviour and bushfire risks.

This research has been the foundation of a pilot program run by the Country Fire Authority in supporting bushfire education for primary school students. Through the NSW Rural Fire Service, a 'Guide to Working with School Communities' has also been rolled out to all schools, which will place primary schools at the focus of statewide bushfire plans.

Benefits demonstrated by the case study

The three behaviour change projects undertaken by the CRC demonstrate the following benefits to the Australian society:

- CRC's brand recognition (goodwill value) in the communities resulted in high participation rates in the research.
- CRC used its network to facilitate and attract resources from a range of stakeholders, thereby enabling in-kind contributions from stakeholders and ensuring the results are end-user focused.
- Emergency agencies obtained invaluable information that will help them improve community preparedness and responsiveness to events, and ultimately reduce the risk to life, health and assets.
- The projects drove opportunities for students to pursue PhDs, and the research results were adopted in international committees and advisory bodies. Lead researcher Professor Kevin Ronan represented the CRC at several forums worldwide, including at the United Nations Integrated Research on Disaster Risk committee, United Nations World Conference on Disaster Risk Reduction in Japan (2015) and the Global Platform for Disaster Risk Reduction in Mexico (2017).
- The research was internationally recognised. The animal emergency study was presented the Emergency Media and Public Affairs research award. The Annual EMPA Awards recognises those who have made a significant contribution to emergency communication in Australia and New Zealand.

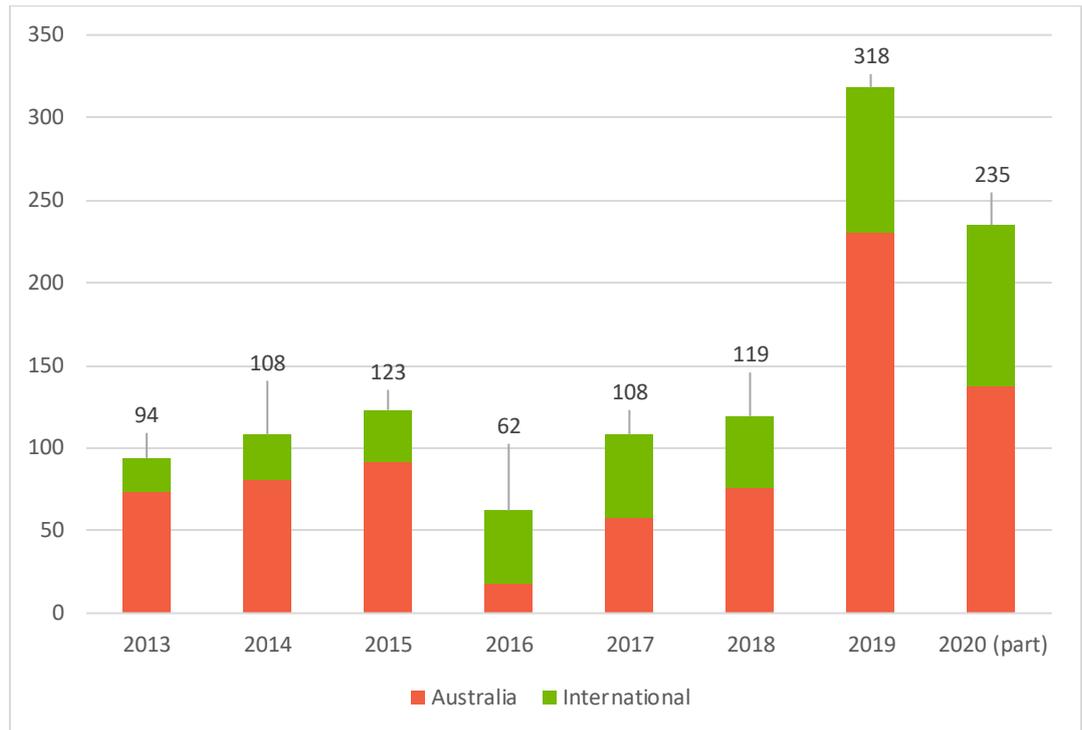
The Bushfire and Natural Hazards CRC's media profile

The CRC is now firmly established as a dependable and independent source of information on bushfire and natural hazards, both nationally and internationally. This case study looks at media data to understand how the CRC's profile has grown, particularly over the last 12 months.

Building the media profile of the CRC

Since its inception in July 2013, the CRC has been quoted, referenced or discussed in 1,167 media sources (Meltwater, 2020). Of these, 66 per cent have been Australia-based media outlets, and 33 per cent have been international publications. As shown in the figure below, the number of media references to the CRC has remained relatively stable throughout the years until 2019 and 2020, when a stark increase can be observed. In particular, the number of Australia-based references has more than doubled in 2019, coinciding with the unprecedented 2019-20 bushfire season.

ANNUAL COUNT OF MEDIA SOURCES REFERENCING CRC: 1 JULY 2013 TO 21 APRIL 2020



Source: Meltwater, 2020. Search terms: Bushfire, Richard Thornton, Bushfire and Natural Hazards CRC

The figure below demonstrates the Ad Value Equivalency, or AVE⁷, of the media references to the CRC during this same time period. In total, the value of media coverage from 1 July 2013 to 21 April 2020 is estimated to be \$47.94 million AUD; \$31 million of this is from Australian media coverage, and \$16.94 million from international coverage. Interestingly, the AVE of media coverage in Australia does not correspond to the increase in the number of media references seen in 2019-20. The largest spike is in fact in 2015, when seven media references to the CRC were in news articles that were each seen by 147 million to 333 million people. However, there has been a noticeable jump in the value of international media coverage in 2019-part of 2020, corresponding strongly to the latest Australian bushfire season and its global significance.

⁷ Ad Value Equivalency is used to estimate the amount of revenue attributed to an article.

This value is used to quantify the success of PR efforts as a monetary value.

The formula that is used to calculate an online advertising value equivalency is:

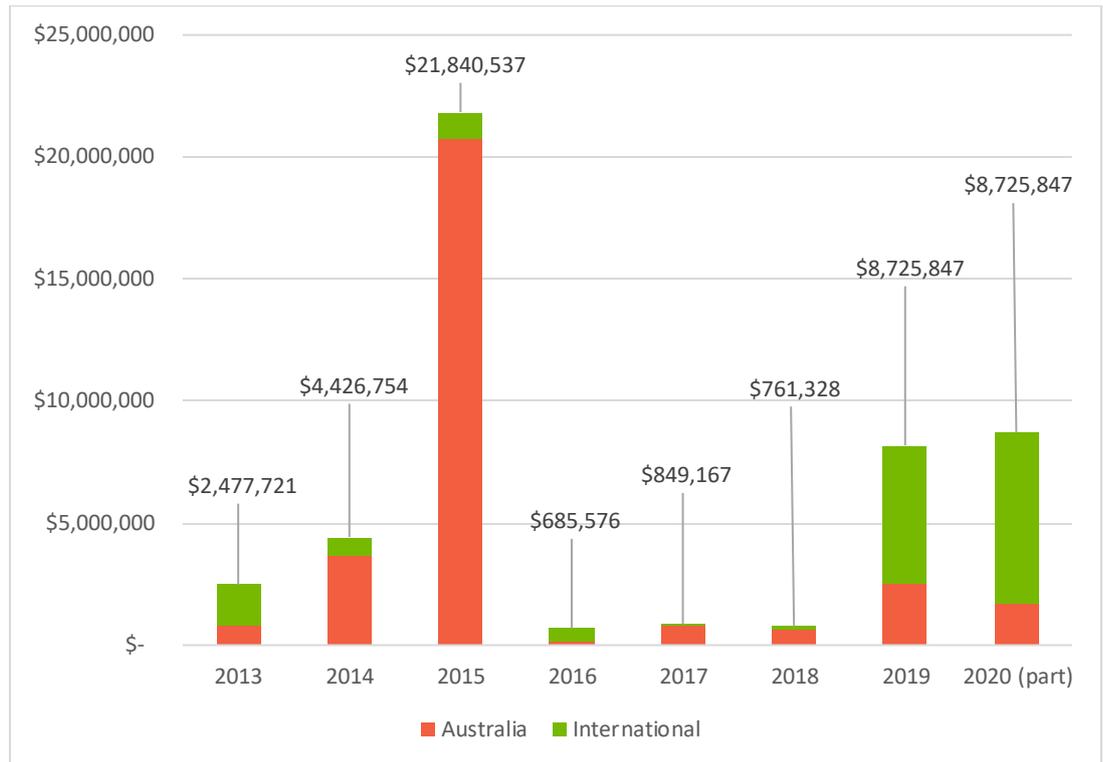
$$X * 0.025 * 0.37$$

X (the reach/unique visitor figure)

* .025 (standard error, assuming that 2.5% of any given audience will view a particular article on average)

* .37 (37 cents is the dollar value for each visitor).

ANNUAL VALUE OF MEDIA SOURCES REFERENCING CRC: 1 JULY 2013 TO 21 APRIL 2020



Source: Meltwater, 2020. Search terms: Bushfire, Richard Thornton, Bushfire and Natural Hazards CRC

The table overleaf lists the top 10 media references to the CRC by reach⁸ and Ad Value Equivalency. It can be seen that all 10 media references are of Australian origin and fall within 2014-15. The top four articles, all published on MSN Australia, are estimated to be worth \$3.086 million each. Interestingly, none of these articles relates to live bushfire events, the natural hazard that the CRC is typically contacted for insights. In fact, one of the top four articles discusses earthquake modelling in Adelaide, South Australia. This points to the CRC being known for offering independent advice about more natural hazards than bushfire alone.

TOP 10 MEDIA HITS FROM 1 JULY 2013 - 21 APRIL 2020 BY VALUE (ALL COUNTRIES)

Rank	Date	Headline	Source	Country	Reach	AVE
1	1-Sep-15	Fire-fighting super plane 'Thor' arrives in Australia ahead of bushfire season	MSN - Australia	Australia	333,631,869	\$ 3,086,095
2	1-Sep-15	Spring brings welcome relief across Australia following record-breaking winter	MSN - Australia	Australia	333,631,869	\$ 3,086,095
3	1-Sep-15	Australia faces heightened bushfire threat as El Niño gets set to fan flames	MSN - Australia	Australia	333,631,869	\$ 3,086,095
4	28-Aug-15	Earthquake in Adelaide could cause deaths and damage, Macquarie University modelling suggests	MSN - Australia	Australia	333,631,869	\$ 3,086,095

⁸ The reach numbers are the unique visitors to each source based on monthly activity.

5	27-Nov-15	SA bushfire: 35 homes destroyed, 42 'impacted' in deadly blaze as roads reopen	MSN - Australia	Australia	333,588,309	\$	3,085,692
6	2-Sep-14	Firefighters bracing for long, dry Canberra summer	PRIME7 - Yahoo!7_v5	Australia	147,385,697	\$	1,363,318
7	1-Sep-14	Australia and NZ 'learning from adversity'	Prime 7 - Yahoo!7_n3	Australia	147,385,697	\$	1,363,318
8	1-Sep-15	Bushfire risk across Australia	Prime7 - Yahoo!7	Australia	100,762,843	\$	932,056
9	1-Sep-15	Forecast warns of increased bushfire risk	PRIME7 - Yahoo!7_v3	Australia	100,762,843	\$	932,056
10	18-Nov-15	New institute for disaster resilience	PRIME7 - Yahoo!7_v5	Australia	99,316,351	\$	918,676

Source: Meltwater, 2020. Search terms: Bushfire, Richard Thornton, Bushfire and Natural Hazards CRC

As shown in the table below, it is clear that the estimated reach of CRC in international media reached new heights in 2019-20. The media reference with the highest estimated reach (97.8 million unique visits) and AVE (over \$900,000) was an article that ran in the US's *Huffington Post* in September 2013 that referenced multiple natural hazards. The remaining top 10 articles all referenced the 2019-20 bushfire season, with estimated reaches sitting between 87.7 million and 94.7 million unique visitors each.

TOP 10 MEDIA HITS FROM 1 JULY 2013 - 21 APRIL 2020 BY VALUE (AUSTRALIA EXCLUDED)

Rank	Date	Headline	Source	Country	Reach	AVE
1	17-Sep-13	Climate Change this Week: Biblical Rains, Another Solar Breakthrough, and More!	Huffington Post	United States	97,825,231	\$ 904,883
2	5-Jan-20	What Brought Hell to Australia?	Medium	United States	94,720,138	\$ 876,161
3	17-Feb-20	The dark shadow of resilience	Medium	United States	93,302,522	\$ 863,048
4	16-Jan-20	A climate change turning point in Australia, but is it too little, too late?	Medium	United States	93,302,522	\$ 863,048
5	17-Dec-19	Inferno from hell: Boy, 12, survives raging bushfire that spread to his home by driving through a burning paddock as hundreds of residents are evacuated overnight and mega blaze continues to burn	Daily Mail Online	United Kingdom	92,675,523	\$ 857,249
6	7-Jan-20	500 million animals burned by wildfires in Australia, scientists predict Australia will emerge more in this century	Sohu	Mainland China	88,332,072	\$ 817,072
7	15-Sep-19	Don't politicise the bushfires? The alternative is to sit back while more severe events happen	The Guardian	United Kingdom	87,719,547	\$ 811,406
8	15-Sep-19	'Going to the streets again': what you need to know about Friday's climate strike	The Guardian	United Kingdom	87,719,547	\$ 811,406
9	12-Sep-19	Australian natural disasters minister's complete about face: 'I believe in climate science'	The Guardian	United Kingdom	87,719,547	\$ 811,406
10	11-Sep-19	John Hewson urges Liberal conscience vote on climate emergency motion	The Guardian	United Kingdom	87,719,547	\$ 811,406

The 2019-20 fire season

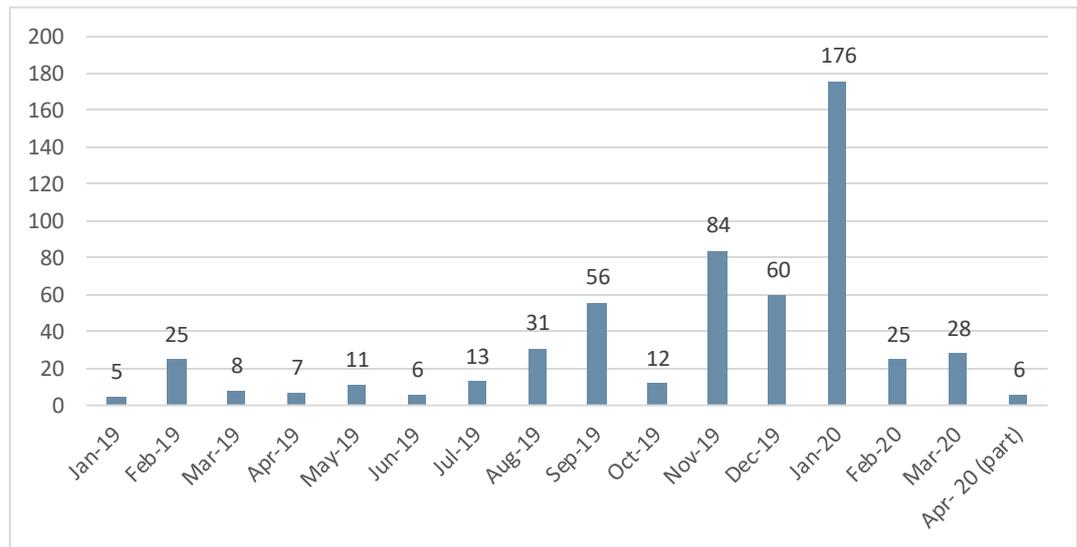
It is clear that the 2019-20 Australian bushfire season resulted in a step change for the CRC's voice in the media, particularly around bushfire advice. It is therefore important to interrogate the years of 2019 and the beginning of 2020 more closely.

Australia's severe 2019-20 bushfire season generated headlines across the world. Now established as a leading authority in bushfires, the CRC was often called upon to provide expert comment to local, national and international media.

Throughout the bushfire season, CEO Richard Thornton, the Research Director and individual researchers appeared regularly on TV and radio, and in print and online articles, to discuss science and research and their role in natural hazards management. The CRC was consistently approached by major Australian media outlets including the ABC, *The Guardian*, *The Sydney Morning Herald*, *The Age* and *The Australian*, and increasingly by prominent media outlets overseas such as *The New York Times*, *The Washington Post*, the BBC, *Aljazeera* and *The Washington Times*. Emphasising how much of a global story Australia's bushfire season was, the CRC also featured in coverage by *Japan Today*, *Liberation* (France), *Die Zeit* (Germany), the *Sri Lankan Guardian* and Channel News Asia.

As shown in the figure below, peak periods coincided with the release of the *Australian Seasonal Bushfire Outlook: December 2019* on 16 December 2019 and much of January 2020 in response to the bushfires that were, and had been, burning in New South Wales, Queensland and Victoria.

COUNT OF MEDIA SOURCES REFERENCING CRC: 1 JAN 2019 TO 21 APRIL 2020



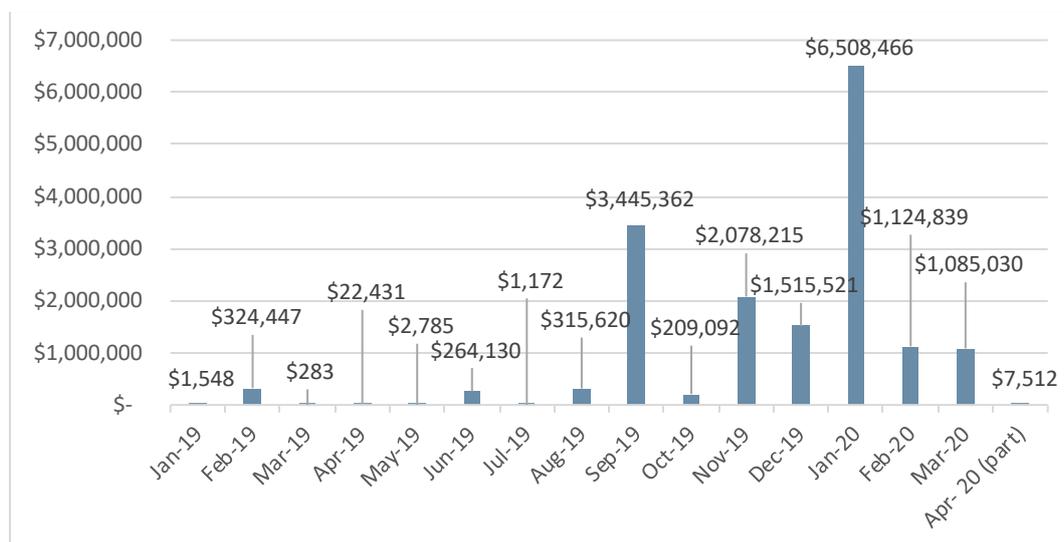
Source: Meltwater, 2020. Search terms: Bushfire, Richard Thornton, Bushfire and Natural Hazards CRC

Additional noteworthy pieces appeared in *The Washington Post* on 23 November 2019 and 9 January 2020, BBC World News on 20 December 2019, 3AW Mornings with Neil Mitchell on 3 January 2020, *The Atlantic* on 7 January 2020, ABC News Breakfast on 8 January 2020, ABC PM on 15 January 2020, *Good Weekend* on 25 January 2020 and *The Guardian* on 13 February. A jump can also be seen in August 2019 that corresponds to when the August seasonal outlook was published. This outlook was shared and referenced widely due to its dire message regarding the sheer amount of the Australian landscape that was at an elevated

risk of bushfire in the coming season. It was to be a foreshadowing of the events that transpired from November 2019 onwards into the new year.

Ad Valuation estimates for the 2019-part 2020 period align with the number of media references achieved in each month.

MONTHLY VALUE OF MEDIA SOURCES REFERENCING CRC: 1 JAN 2019 TO 21 APRIL 2020



Source: Meltwater, 2020. Search terms: Bushfire, Richard Thornton, Bushfire and Natural Hazards CRC

The CRC, understanding the momentum and reach they were enjoying, used the opportunity to publish a quite significant thought piece aimed at reframing the way Australians manage fire risk. A considerable coup was the CEO’s opinion piece in *The Australian* on 4 January 2020, outlining that for Australia to move forward on bushfire management, the country must build on the knowledge that it already has to find new ways of managing fire.

An additional measure to estimate the growing level of influence the CRC experienced is the number of website visits. The table below shows the unique website visits between 6 September 2019 and 13 February 2020, and compares data with the same period in 2018-19.

In the 6 September 2019 to 13 February 2020 reporting period, the website had 174,447 unique page views, an increase of 204 per cent from the same period in 2018-19. The visits are the highest ever recorded to the CRC site in a five-month period – more people have visited the website than ever before.

MONTH BY MONTH BREAKDOWN OF UNIQUE PAGE VIEWS 2019-20 COMPARED WITH 2018-19

	2018-19	2019-20	Increase	Percentage increase
September	20,254	23,825	+3,571	18%
October	16,025	21,559	+5,534	35%
November	17,593	27,050	+9,457	54%
December	12,638	23,383	+10,745	85%
January	13,378	69,852	+56,474	422%
February (1-13)	7,963	13,494	+5,531	69%
Total (6 Sep - 13 Feb)	87,851	179,163	+91,312	204%

The vast majority (88 per cent) of these visits are new visitors (i.e. they have not visited the website before).

The most popular pages on the website in the reporting period include:

- [Hazard Note 63](#) (*Australian Seasonal Bushfire Outlook: August 2019*)
- [Hazard Note 68](#) (*Australian Seasonal Bushfire Outlook: December 2019*)
- [Research](#)
- [Inquiries and Reviews Database](#)
- [Publications](#)

It is clear that the CRC is firmly cemented as a trusted source of evidence on bushfires. This provides benefits to the Australian and international community, as described in the table below.

Benefits demonstrated by the case study

The CRC's media profile demonstrates that the CRC provides trusted advice for the Australian community and can shape the narrative via its trusted voice on bushfires. This has reduced the burden of media engagement on state agencies and first responders. Its activity in the international media space promotes Australia's credentials as a leader in understanding and responding to bushfires.

PHOENIX RapidFire

Since 2011, Phoenix RapidFire has been used by land and fire managers to support fire management and land-use planning and to support decision-making during bushfires.

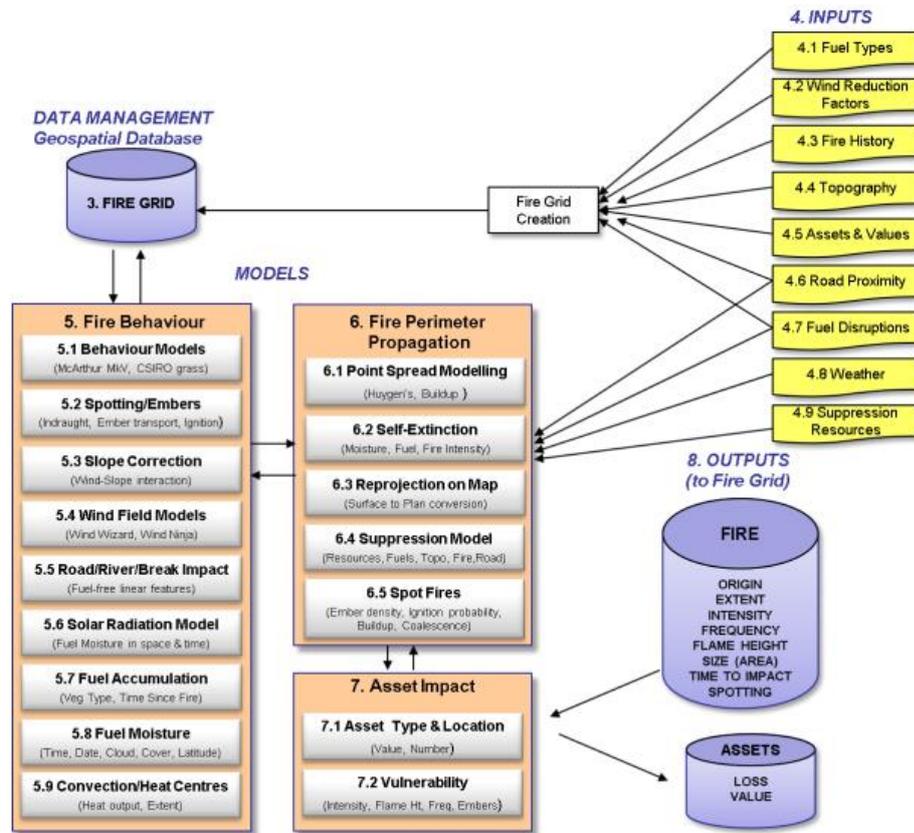
An introduction to PHOENIX RapidFire

PHOENIX RapidFire is a model that simulates bushfires. It integrates fuel, terrain, weather conditions and suppression to simulate a fire's development and progression in the landscape. It is used by land and fire managers to support fire management and land-use planning and to support decision-making during bushfires (Fire Prediction Services, 2020).

The model is mechanistic, continuous, dynamic and empirically based. It simulates fire characteristics such as fire spread, flame height, intensity, size and ember density, and stores the results in a database (using spatially gridded data). It can also simulate some of the effects of suppression efforts and the impact of fire on various values and assets (Fire Prediction Services, 2020).

At a minimum, PHOENIX RapidFire requires fuel data as an input. However, inputs including terrain, weather, suppression, fire history and assets are required for realistic simulations. PHOENIX RapidFire produces outputs such as fire spread, intensity, flame height, ember density, burn frequency and asset impact (Fire Prediction Services, 2020). These inputs and outputs are described in the figure below.

THE PHOENIX MODEL: INPUTS AND OUTPUTS



Source: Fire Prediction Services, 2020

The development of PHOENIX RapidFire

The development of PHOENIX RapidFire was driven by the need to realistically describe bushfires across the Australian landscape. Land and fire managers needed to assess the relative bushfire risks to a wide range of values and assets in the landscape under a range of possible fire management regimes (Fire Prediction Services, 2020).

A review was undertaken in the late 1990s of the elements contributing to bushfire risk and the current state of knowledge (Shields, 2000; Shields and Tolhurst, 2003). With the establishment of the Bushfire Cooperative Research Centre (Bushfire CRC, the predecessor of CRC) in 2004, funding was made available to continue with Bushfire Risk Assessment research. The first stage of this work was defining the Fire Management Business Model, which showed how 54 factors (or elements) of bushfire risk management interacted to reduce bushfire risk for a given level of resources allocated to each element (Tolhurst et al., 2006).

Having established a bushfire management business model, it was necessary to characterise and quantify the effect of different bushfire management strategies on reducing the level of bushfire risk. It was seen that the best way to characterise fires across the landscape was to use a fire simulator. This would allow analysis to be spatially and temporally explicit and would also be objective and repeatable. Two international fire simulators were considered, but they were thought to be too difficult to adapt to Australian conditions (Fire Prediction Services, 2020).

As no suitable bushfire simulator was found, in 2005, Professor Kevin Tolhurst (member of the Bushfire CRC) and programmer Derek Chong built and merged two models: PHOENIX, which described what a bushfire is like at any point in the landscape, and RapidFire, which analysed how a fire interacts with important assets, such as houses, powerlines, catchments and biodiversity (Tolhurst et al., 2008).

Initially, PHOENIX RapidFire could only be used as a fire characterisation simulator. Once that was adequately established, more functionality was added to assess the relative level of bushfire risk. This allowed the model to be used for planning, rather than just response (Esnouf, 2020).

At the end of the Bushfire CRC's funding in 2013, the IP for PHOENIX RapidFire was handed over to three joint parties: the University of Melbourne, the Victorian Department of Environment, Land, Water and Planning, and AFAC (the Australian and New Zealand National Council for fire, emergency services and land management). The model's use is now licensed out commercially by an entity named Fire Prediction Services, which is owned by the three IP owners (Esnouf, 2020).

PHOENIX RapidFire in action: Saving Gracemere

The use of PHOENIX RapidFire has resulted in a vast number of benefits for Australian communities, with no example more illustrative than the town of Gracemere.

On Wednesday 28 November 2018, a small fire started outside Gracemere, Queensland, a town of 8,000 people located just south of Rockhampton. Conditions that day were unlike any seen in the region since the 1960s (Smith, 2020). Usually, hot air bubbles that develop over the Pilbara head south, bringing heatwaves to Melbourne followed by a cool change. However, due to climate change, these heat bubbles now remain over Queensland, bringing a new kind of very dry heat that results in a drying out of the landscape (Smith, 2020).

That Wednesday, these conditions caused the forest fire index informed by PHOENIX RapidFire to assess the situation as catastrophic, a category not used in Queensland before (Smith, 2020). Fire Inspector Andrew Sturgess noted that the PHOENIX RapidFire modelling allowed emergency responders to realise that a small fire west of Gracemere reported to triple-O had the potential to turn into a blaze that could threaten the town (SBS, 2018).

The swift evacuation of the community has been hailed as an example of the simulator's success. Inspector Sturgess noted the fire was "predicted to impact the township of Gracemere, and that's what happened" (SBS News, 2018). He also said the software predicted the path and intensity of the fire "very well" on Wednesday which then allowed appropriate efforts to be enacted by fire crews on the ground.

Deputy Queensland Commissioner Doug Smith, who led the emergency response during the 2018 fires and is a current board member of the CRC, notes that without PHOENIX RapidFire the "seemingly very small bushfire would have been treated in a traditional Queensland way", which would not have been sufficient to save the town (Smith, 2020). Smith continues: "The heatwave that came was unusual. We didn't have experience with it. PHOENIX RapidFire made it possible for us to apply the learnings from Victorian bushfires that often occur in these conditions, and apply that to a new situation unfolding in Queensland. Firefighters then fought the fire in a way that was very unfamiliar to Queenslanders. That is the true value of the model" (Smith, 2020).

Greg Esnouf, senior bushfire advisor at AFAC and member of the CRC notes that saving Gracemere from disaster cannot be completely attributed to PHOENIX RapidFire; coincidentally, an experienced weather forecaster happened to be in the Gracemere area who could provide nuanced forecasts (Esnouf, 2020). Mr Esnouf notes that predictions could not have been anywhere near as accurate without those insights (Esnouf, 2020).

However, Queensland emergency services has credited PHOENIX RapidFire for enabling its quick responses to rapidly evolving fire threats that occurred across the entire state during the summer of 2018, including the situation that unfolded at Gracemere.

Relationship with the CRC

Although the model was developed before the CRC was created, Phoenix RapidFire is an example of how investment and research made in the days of the Bushfire CRC are continuing

to benefit the Australian community. Thus, it can be assumed that the research the CRC is investing in now may also continue to deliver benefits for years to come.

The CRC has also been involved in developing updates and conducting research for inputs into the model throughout the subsequent years, increasing its accuracy across different scenarios and landscapes (Esnouf, 2020). Current research projects that the CRC is undertaking that will inform the model include:

- fire coalescence research
- wind reduction in tree canopies
- research into soil moisture
- fire event spotting (Esnouf, 2020).

Benefits

PHOENIX RapidFire is considered to be one of the best fire simulators in the world. This has promoted Australia as a leader in developing wildfire tools and analysis. Fire Prediction Services bring researchers together in biannual research advisory forum to further develop the tool, promoting relationships and collaborations between researchers. Its design, in particular its visual demonstration of risks, allows it to be used as a communications tool with the general public to improve awareness of bushfire risks.

The major benefit of PHOENIX RapidFire is that the speed, accuracy and user-friendliness of its information allows quick, informed decisions to be made that save lives and properties. By using PHOENIX RapidFire, state agencies can reduce natural hazards impacts on property and infrastructure both by ensuring appropriate measures are taken before the fire season begins, and making more informed decisions about what areas are at risk when a fire has taken hold. The Australian Exposure Information Platform (AEIP) has provided an exposure report that highlights the value of elements that would have been destroyed had a bushfire destroyed the town of Gracemere township:

- Residential dwellings reconstruction value: \$1,506, 830,000, contents value: \$281,230,000
- Commercial reconstruction value: \$464,960,000
- Industrial reconstruction value: \$307,430,000
- Agricultural commodity estimated value: \$42,000⁹

Fire Prediction Services have recently commissioned a Cost benefit analysis on the economic benefits of fire Simulators. Early results suggest any investment on building and operating a fire simulator result in benefits ten times that investment due to saved costs. This is due to simulators being able to be run tens of thousands of times to provide greater accuracy of results. These rates of scenario tests are not achievable by traditional manual methods (AFAC, 2020).

Recovery Capitals (ReCap)

About ReCap

The Recovery Capitals (ReCap) project began in 2017. It investigated two complementary areas of research relating to the long-term recovery of communities in Australia and New Zealand after a disaster. It sought to increase understanding about interacting influences of different forms of capital (community capital) on mental health and wellbeing. To help guide decision-making, it addressed the missing link between existing community resilience indicators and disaster resilience frameworks. The project aim is to produce resources to guide long-term recovery strategies for communities post-disasters.

⁹ Source: Geoscience Australia - Exposure Report; Event name: Gracemere Bushfire_Town; Event type: Bushfire; Report Date: 19-02-2019 19:59:00 (AEST)

CRC funded the project, and the University of Melbourne and Massey University in New Zealand were the lead collaborators. The project has encouraged new partnerships with Northeastern University, Deakin University and Wellington Emergency Management Office, Fire and Emergency NZ and NZ Red Cross. A range of organisations endorsed the project, including Australian Red Cross (lead end user), NZ Red Cross, emergency service agencies, national and state government departments, and various university groups.

Massey University investigated how a person's history of residential mobility might influence their willingness to dissolve social ties. The primary focus has been to provide answers to the questions why people move, how their history of mobility plays out in disaster situations, how movement affects the social capital of the left-behind community and the community migrated to, and how we can use this learning to increase the social capital in these communities.

The University of Melbourne examined the enablers and barriers to successful recovery by looking into the many forms of capital and their interactions in disaster recovery. The various forms of capital explored included natural, cultural, human, social, political, built and financial resources. The study also used case studies to build understanding of potential areas of improvement and to recognise the features of successfully recovered communities. The research will play a critical role in community recovery efforts.

Project findings

After every major disaster, some people move. While disaster-prone locations are often able to reproduce long-established settlement patterns, the demographic characteristics of residents change. Previous literature reviews showed significant knowledge gaps about demographic issues and a lack of understanding behind temporary displacement, relocation, migration and resettlement after a crisis.

There was also a shortage of research into long-term disaster recovery response, with previous knowledge based on disaster planning, prevention and response. It was also noted that recovery is a complex process, and processes cannot be divided between short and long-term actions. Rather, a transition phase occurs as needs and progress change over time, which can delay the attainment of long-term disaster recovery goals. The recommendations suggested there is a need for a national monitoring and evaluation framework that focuses on long-term recovery, whereas most evaluations actually focused on the immediate and short-term response and lacked consistency.

The overall findings showed that local communities and their associated capitals were a key element to a successful recovery. Community engagement is essential and should be centred around immediate, short, medium and long-term recovery policies and programs. The research also showed decision-makers needed to have a greater focus on restoring the environment and the community. The strategy must be in line with the traditional response to restoring the built environment.

The report highlighted elements that impede community recovery. For example, insecure land tenure, poor land-use practices, inadequate land access and weak administration can increase community vulnerability. Infrastructure planning is essential. Effectiveness in recovery can also be undermined by the community's social and economic conditions before a hazardous event, which can prolong the time it takes to reconstruct. Economic circumstances, population trends and demographics can affect efforts. A firm economic base can help communities that have access to financial assets and a strong business community to rely on. The wealth of the household is a large indicator of the willingness to move elsewhere; other factors are the individual's health, their wellbeing and connectedness to the community.

Governments play a critical role in how communities recover after disasters. Most successful strategies have pre-determined policies, good planning and a degree of flexibility. In

particular, local governments play a leading role, and strong local leadership is paramount to successful long-term recovery.

The ReCap project will use the research to produce resources to guide recovery strategy development that is culturally and socially inclusive and customised to different community contexts. Actions based on the research will be developed with end users. The next steps will involve ensuring the evidence mapping provides adequate coverage and a clear message, before producing this information in an accessible format.

Benefits demonstrated by the case study

ReCap demonstrates that the CRC provides the following benefits to Australian society:

- More efficient planning and decision making by providing local government and other decision-makers with knowledge about successful long term recovery processes. The project delivered new and critical information that can further assist communities to build resilience and support recovery efforts.
- Leveraging of in-kind contributions from stakeholder organisations, and a related reduced reliance on public funding. The initial project funding was complemented by \$1.2 million in-kind contributions from seventeen partners
 - Australian Red Cross – Lead end user
 - New Zealand Red Cross
 - Wellington Region Emergency Management Office (WREMO)
 - Fire and Emergency New Zealand
 - Emergency Management Australia, Department of Home Affairs
 - The Leadbeater Group
 - Resilient Melbourne
 - Social Recovery Reference Group
 - Regional Arts Victoria
 - Rural Solutions SA, Department of Primary Industries and Regions
 - Emergency Management Victoria
 - Country Fire Authority
 - State Emergency Service Victoria
 - Creative Recovery Network
 - Department of Economics, Deakin University
 - Professor Aldrich, Northeastern University
 - Department of Social Work, University of Melbourne

The insights generated about long-term recovery in Australia and New Zealand will add to the global effort to improve disaster recovery efforts.

End-user focused resources will be developed to enhance the community's ability to recover and their resilience. Both are expected to help reduce the economic, health and wellbeing costs of disasters.

APPENDIX 2: END USER SURVEY

This appendix provides the introductory text and survey questions as sent to the end users.

Introduction

As you are aware, the Bushfire and Natural Hazards Cooperative Research Centre (CRC) coordinates a national research effort in natural hazards, including bushfires, flood, storm, cyclone, heatwave, earthquake and tsunami. Their mission is to provide high quality research and advice on bushfire and natural hazards in order to:

- Reduce risk
- Enhance disaster resilience
- Reduce negative social, economic and environmental impacts, and
- Build an internationally renowned Australian and New Zealand research and utilisation capacity and capability.

The CRC is undertaking work to quantify the value it has delivered as part of its future scoping. SGS Economics and Planning (SGS) has been commissioned to undertake one study of the value of the CRC; other research bodies have also been commissioned for separate but related pieces of work. It is known from past analysis that the CRC creates value by contributing to disaster management and resilience and associated prevented damages such as:

- Government, business and economic losses
- Loss of life and injury, and
- Insurable losses.

In addition, the CRC creates value by fostering networks and communities of natural hazards researchers and practitioners, and for their role as an independent authority for natural hazard research and evidence-based advice.

This is where you come in. We are seeking your unique insights as an end user to understand the range of benefits the CRC may be providing to you and your organisation.

The following survey will guide you through a series of questions aimed at understanding from your perspective:

- Key challenges / problems linked with bushfires & other natural hazards
- Key operational challenges in managing these problems
- Current and potential solutions for overcoming these challenges/ problems
- The contribution of the CRC in developing these solutions
- The extent to which the CRC's research has been used and made an impact
- Past and current case studies of CRC research use and impact
- Benefits of the CRC beyond their research functions.

This survey will take around 15- 20 minutes to complete. Depending on your answers (and willingness to participate), you may be contacted by SGS to follow up on additional details for specific case studies.

Thank you in advance for your contribution to this project. Your insights are greatly appreciated.

Survey

Q1: Please tick the following that best describes your organisation:

- Australian Government department or agency
 - New Zealand Government department or agency
 - State Government department or agency
 - Local Government
 - Industry Association
 - University or Research body
 - Private Organisation
 - Not for Profit Organisation
 - Other – please specify
-

Q2: Where is your organisation based? (you can tick multiple, however if Australia wide please tick National)

- Australian Capital Territory
- New South Wales
- Northern Territory
- Queensland
- South Australia
- Tasmania
- Victoria
- Western Australia
- National
- New Zealand
- Other overseas

Q3a. Please tick the following that best describes your relationship with the Bushfire and Natural Hazards CRC (you can tick multiple):

- Research partner
 - Core Participant in the CRC
 - Collaborating organisation
 - Other (please detail)
-

Q3b. On a scale of 1-10, what is your personal level of engagement with the CRC?

0	1	2	3	4	5	6	7	8	9	10
Not at all engaged										Extremely engaged

Q4a: What products, services or research from the CRC have you used and/or do you use?

Q4b: Over the past seven years, how often have you utilised the services/products/research by the CRC?

- Daily
- A couple of times per week
- A couple of times per month
- A couple of times per year
- Other (please detail)
- _____

Q4c: If the CRC did not exist, where would you source these services/products/research?

Q5a: What natural hazards are your organisation concerned with? (you can tick multiple)

- Bushfire
- Flood
- Storm
- Cyclone
- Heatwave
- Earthquake
- Tsunami
- All of the above

Q5b: What is your organisations role(s) in responding to these hazards (e.g. preparing communities for evacuation, sharing information on disaster readiness, active front-line response and defence, planning and strategy, recovery, etc)?

Q5c: What is your individual role in responding to these hazards?

Q6a: From your individual perspective, what do you think were the key challenges/problems linked to natural hazards over the past decade?

Q6b: How important has the CRC been in finding solutions to these challenges with you?

- Not at all important
- Slightly important
- Moderately important
- Very important
- Extremely important

Q6c: Can you provide one or more examples of this?

Q6d: To what extent did the CRC’s research/services/products have an impact on how you respond to challenges to do with natural hazards?

- No impact
- Minor impact
- Neutral
- Moderate impact
- Major impact

Q6e: How have the CRC’s research/services/products changed your approach/planning/organisation and/or day to day operations?

Q7a: To what extent do you agree with these statements: The CRC:

	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
Is Australia’s leading authority on bushfire and natural hazards					
Provides independent advice on bushfire and natural hazards					
Provides high quality research outputs					
Provides highly relevant and targeted research outputs					
Promotes Australia’s research capabilities internationally					
Promotes innovation and new research on bushfire and natural hazards					
Contributes to advancing global knowledge on bushfire and natural hazards					
Provides an essential opportunity to network and collaborate with researchers and end users					

Q7b: Of the roles listed above, what role is most valuable to you?

- Australia’s leading authority on bushfire and natural hazards
- Independent advice on bushfire and natural hazards
- High quality research outputs
- Highly relevant and targeted research outputs
- Promotes Australia’s research capabilities internationally
- Promotes innovation and new research on bushfire and natural hazards
- Contributes to advancing global knowledge on bushfire and natural hazards
- Provides an essential opportunity to network and collaborate with researchers and end users.

Q7c: Why is this the most valuable role for the CRC?

Q8a: What benefit has your organisation received from the collaborative nature of the CRC projects?

Q8b: Could this benefit be expressed in monetary terms? (E.g. the value of time saved due to research efficiencies?)

Q8c: What relationships/ collaborations were made possible because of the CRC collaborative network?

Q9a: Do you have a particular stand-out example (past or present) that showcases the value of the CRC? (E.g. how research, a service, product, or collaborative approach was particularly valuable in achieving a better outcome for your organisation, a place or a community?)

Q9b: Do you think there is any way you could quantify this value in monetary terms, or do you have a valuation or data you can provide? (E.g. an estimate of the area of land saved from fire or flooding, homes saved, households able to evacuate in time?)

Q10a. Lessons learnt from natural disasters are important for all organisations. Is there anything you have observed from recent disasters (such as the recent bushfires) that would present an opportunity for further research to investigate?

Q10b. Are there elements in the way in which the preparation for, the response to and beginnings of the recovery of the recent fire events that have been influenced by the work of the CRC?

THANK YOU.

If you are happy to further elaborate on your answers, particularly specific case studies or recent lessons learnt, please include your contact details below:

Name:

Company/Agency/Institution:

Email address:

Phone Number:

Thank you for filling out this survey. Your insights are highly valued and greatly appreciated. If you have any further questions or comments, please contact Paul Perry, Partnership Development Director at the Bushfire and Natural Hazards CRC at Paul.Perry@CRC.com.au

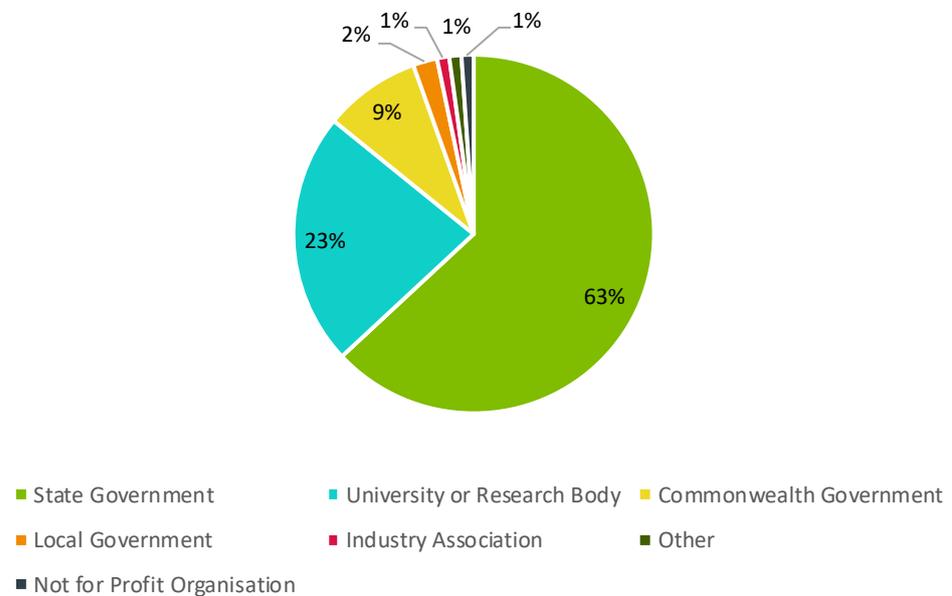
APPENDIX 3: SURVEY REPORT

The following summary discusses the responses to the survey questions provided by the 92 unique responders (out of a possible 406 contacts who were sent the survey). The survey response rate was 22.7 per cent.

Q1: Please tick the following that best describes your organisation:

Respondents work for a broad range of organisations summarised in Figure 19. Sixty-three per cent of respondents work for a state government, 23 per cent for a university or research body and 9 per cent for the Australian Government. Respondents of Other detailed belonging to an Australian Local Government Association (ALGA) or community-led volunteer group.

FIGURE 19: RESPONDENTS BY ORGANISATION

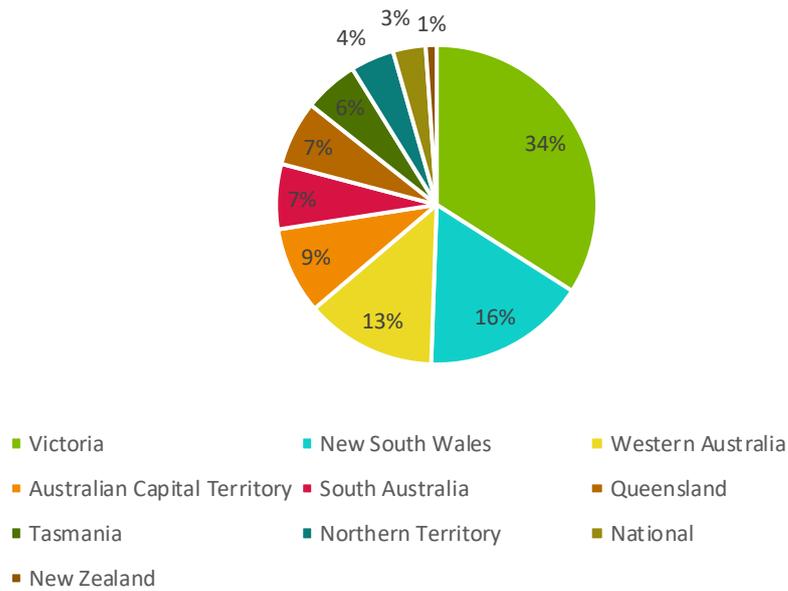


Source: SGS Economics & Planning, 2020

Q2: Where is your organisation based?

Respondents belong to organisations that are either state-based or operating Australia-wide (National). No organisation was based overseas other than in New Zealand. This is summarised in Figure 20 below.

FIGURE 20: ORGANISATION BY LOCATION



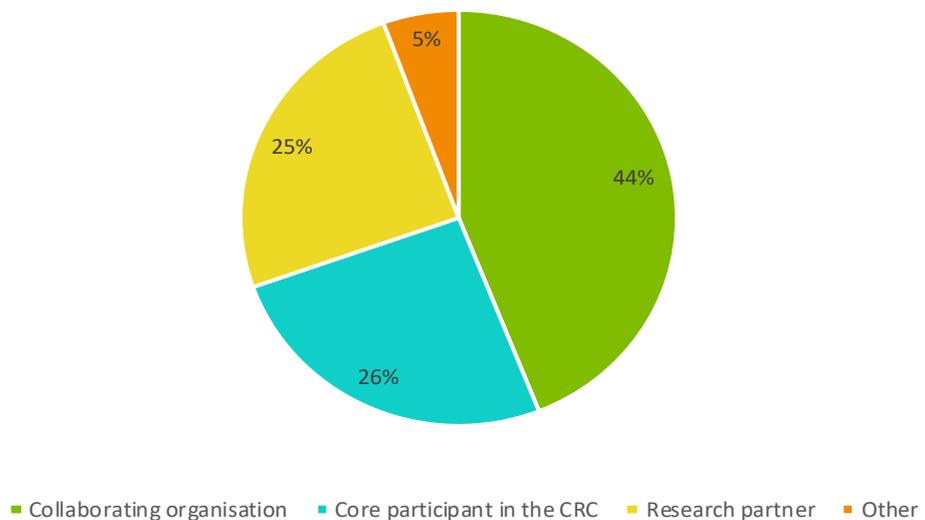
Source: SGS Economics & Planning, 2020

Note: National represents organisations that are based Australia wide

Q3 a: Please tick the following that best describes your relationship with the Bushfire and Natural Hazards CRC (you can tick multiple):

Respondent organisations have a multifaceted relationship with the CRC, with 44 per cent of respondent organisations having collaborated with it. Twenty-six per cent are core participants in the CRC, 25 per cent are research partners and 5 per cent have classified their relationship as Other. Organisations in the Other category have detailed themselves as end users of CRC research and have used CRC outputs to support community response to emergencies, as key stakeholders or project sponsors. Based on these responses, it may be worth interrogating the CRC’s contact lists to ensure there are updated end-user details so that communication is maintained with this important group.

FIGURE 21: ORGANISATION RELATIONSHIP WITH CRC

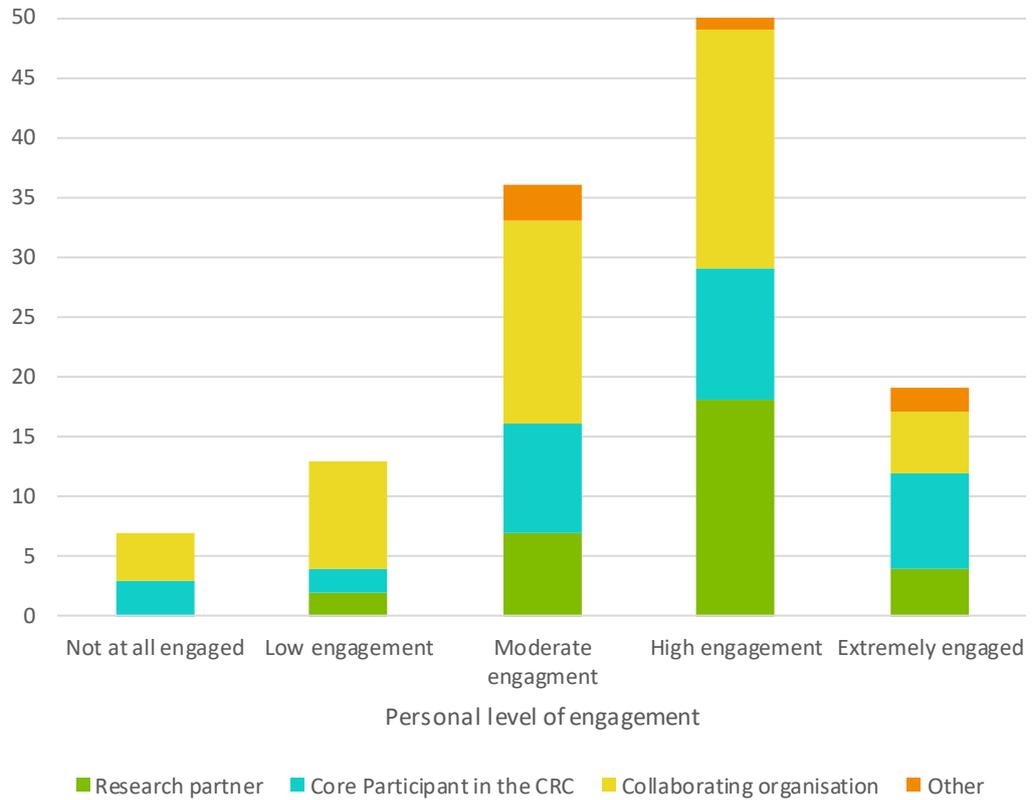


Source: SGS Economics & Planning, 2020

Q3b: On a scale of 1-10, what is your personal level of engagement with the CRC?

The Figure 22 summary below shows that respondents personally engage with the CRC highly: 50 per cent of respondents indicate a high level of engagement, followed by 36 per cent with a moderate level of engagement, and 19 per cent an extremely high level of engagement. It is noted that all end users (respondents who selected 'Other') have moderate or extremely high engagement with the CRC.

FIGURE 22: PERSONAL LEVEL OF ENGAGEMENT BY RELATIONSHIP TYPE



Source: SGS Economics & Planning, 2020

Note: Responses were scored on a scale from 0-10 as follows: Not at all engaged (Score 0) to Extremely engaged (Score 10).

Q4a: What products, services or research from the CRC have you used and/or do you use?

Respondents have used and are using a variety of products, services and research as well as models and tools from the CRC website and social media. As a source of trusted advice, respondents have used CRC research to manage, inform, guide and support both social and personal research. CRC resources have helped organisations develop processes and practices for better warning communication as well as hazard mitigation planning. Resources accessed include reports, briefs, commissioned research, reference material, forecast and season outlooks, hazard notes, conference proceedings and presentations and more. Specific models and tools have also been used and are detailed below in Table 10. Respondents have also been involved with CRC events and networks where they were able to collaborate with researchers and other end users.

TABLE 10: CRC SERVICES/RESEARCH AND MODELS/TOOLS USED

Services/research	Models/tools
Contracting and project management services: e.g. Safer Together funded projects	Coupled fire-atmosphere modelling
Beyond Blue wellbeing studies	Australian Flammability Monitoring System
Project IGNIS – Quantifying Catastrophic Bushfires	JASMIN soil moisture model
CC-DRR – Child-Centred Disaster Risk Reduction Framework	MODIS grass curing
Severe and high impact weather and communication and warnings research	Fules3D – smartphone app coupled with photogrammetry from which fuel hazard metrics are derived
Bushfire predictive services: threshold conditions for extreme fire behaviour	LiDAR – Light detection and ranging remote sensing technology
Fire coalescence and mass spot-fire dynamics	UNHaRMED – Spatial decision-support system
Himawari-8 Report – Detecting Active Fires	PFT – Pyrocumulonimbus Firepower Threshold: a pyroCb prediction tool
MAiD – Managing Animals in Disasters	
AFAC conference	
HCIC reports	
ANDRI reports	
Prescribed Fire Atlas	
Tactical Research Fund project	

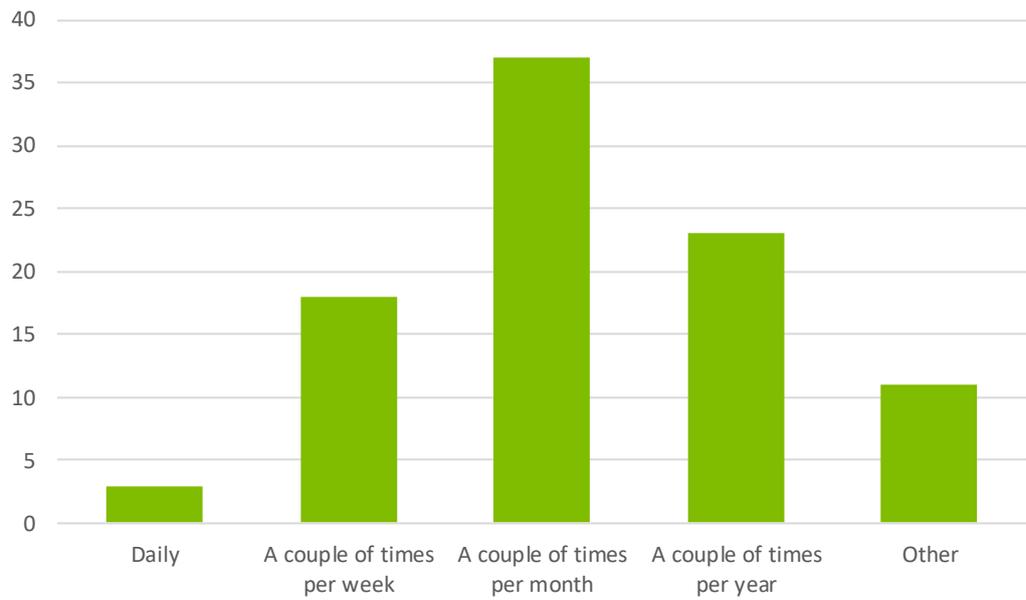
Source: SGS Economics & Planning, 2020

Q4b: Over the past seven years, how often have you utilised the services/products/research by the CRC?

The frequency of use of CRC services, products and research by respondents over the past seven years is summarised in Figure 23, Figure 24 and Figure 25. Forty per cent of respondents use CRC resources a couple of times per month with 44 per cent of respondents in this category being a collaborating organisation. Twenty-five per cent utilise it a couple of times per year, with the majority of respondents (58 per cent) also being a collaborating organisation. Respondents who use CRC services a couple of times per week comprise, almost equally, research partners, core participants and collaborating organisations. Only 3 per cent of respondents cited using the CRC’s products daily. The other 12 per cent of respondents cited utilising CRC resources during severe weather season, or only when required for research for end users.

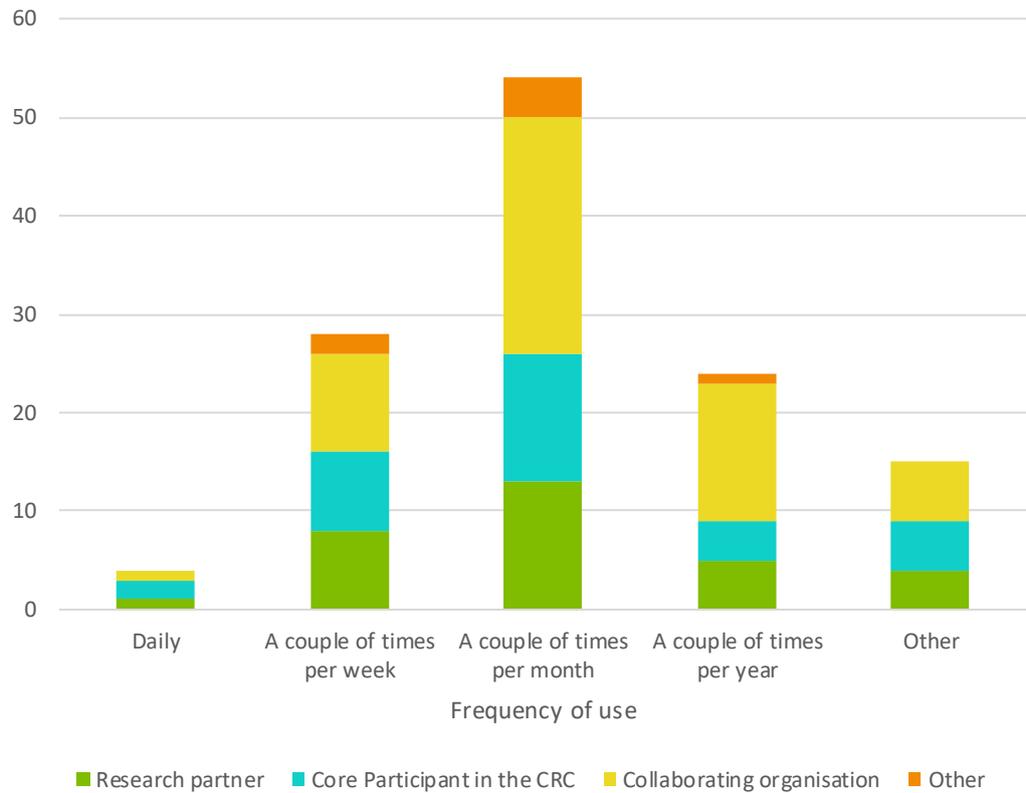
One user remarked: “CRC research has been fundamental to development of our Volunteer Recruitment Website and Volunteer Recruitment Campaign. While this is not daily work, they are very significant pieces of work that have short and long-term impacts on our volunteer workforce.”

FIGURE 23: FREQUENCY OF USE OF CRC SERVICES/PRODUCTS/RESEARCH



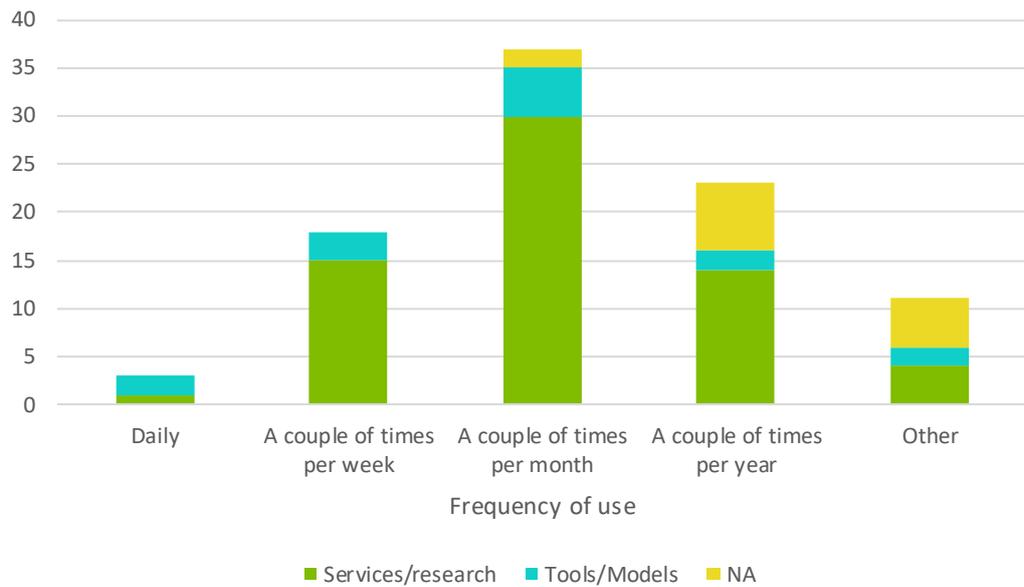
Source: SGS Economics & Planning, 2020

FIGURE 24: FREQUENCY OF USE OF CRC SERVICES/PRODUCTS/RESEARCH BY RELATIONSHIP TYPE



Source: SGS Economics & Planning, 2020

FIGURE 25: FREQUENCY OF USE OF CRC SERVICES/PRODUCTS/RESEARCH BY PRODUCT



Source: SGS Economics & Planning, 2020

Q4c: If the CRC did not exist, where would you source these services/products/ research?

CRC alternatives and their limitations and risks detailed by respondents are summarised below in Table 11. Overall, while a broad range of free local and international alternative sources exists, such as academic journals and government agencies, respondent sentiment towards the CRC is strongly positive.

Importantly, respondents place a high value on the CRC facilitating broad networks and relationships with people who can be contacted for assistance with improving bushfire management systems and outcomes. Additionally, the CRC allows for small agencies to participate and collaborate in much larger national projects where organisational budget constraints may exist.

TABLE 11: CRC ALTERNATIVES AND LIMITATIONS

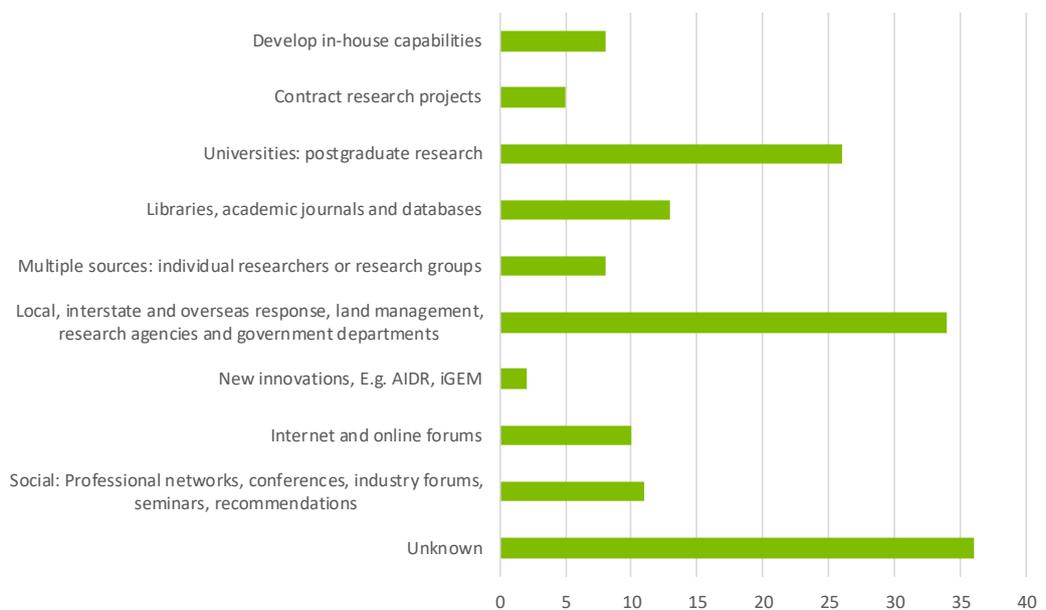
CRC alternatives	Limitations/risks
Develop in-house capabilities	<ul style="list-style-type: none"> Accomplish much less, e.g. some products such as PFT would not exist without CRC; other products like JASMIN are improvements on existing in-house products Limited by budget
Contract research projects	<ul style="list-style-type: none"> Limited by budget
Universities: postgraduate research	<ul style="list-style-type: none"> Will have to facilitate own relationships with universities and maintain ongoing interactions
Libraries, academic journals and databases E.g. Elsevier Scopus, AJEM	<ul style="list-style-type: none"> Time-consuming to subscribe to more journal alerts and find credible sources Most academic journals have a cost for access Narrow view of research and applications
Multiple sources: individual researchers or research groups	<ul style="list-style-type: none"> Limited to known researchers
Local, interstate and overseas response, land management, research agencies and government departments	<ul style="list-style-type: none"> Depends on whether product has been developed Cross-disciplinary research would be extremely difficult – coordination of effort and expenses

E.g. BoM, CSIRO, Geoscience, QFES, Climate Council, RFS, DELWP, CFA	
New innovations E.g. AIDR, iGEM	▪ Credibility and application still unverified
Internet and online forums	▪ Time and effort sensitive
Social: Professional networks, conferences, industry forums, seminars, recommendations E.g. AFAC	▪ Limited networks and small range of communication outlets
Unknown	▪ Not know are unaware of another source that would cover the topics as comprehensively

Source: SGS Economics & Planning, 2020

This information is aggregated into main categories in Figure 26 below. It shows that many respondents are uncertain about how to source their information if the CRC did not exist. This shows the CRC brings a unique value to the user community.

FIGURE 26: RESPONDENT COUNT OF CRC ALTERNATIVES

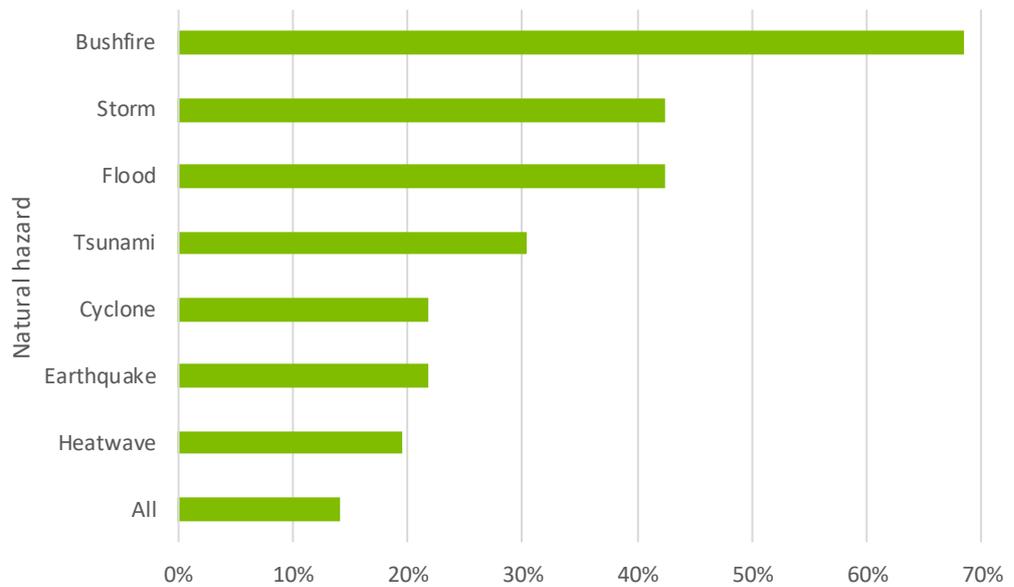


Source: SGS Economics & Planning, 2020

Q5a: What natural hazards is your organisation concerned with?

Figure 27 summarises the natural hazards that concern respondent organisations. Bushfires are the most dominant hazard concerning 68 per cent of respondent organisations, followed by storms and floods (equal 42 per cent), tsunami 30 per cent, cyclone and earthquakes (equal 22 per cent) and heatwave 20 per cent. Fourteen per cent of respondents are concerned with all listed hazards.

FIGURE 27: NATURAL HAZARD AND ORGANISATION CONCERN



Source: SGS Economics & Planning, 2020

Q5b: What is your organisation’s role(s) in responding to these hazards (e.g. preparing communities for evacuation, sharing information on disaster readiness, active frontline response and defence, planning and strategy, recovery, etc)?

The purpose of an organisation’s response to natural hazards is to enhance community safety, quality of life and confidence by minimising the impact of hazards and emergency incidents on the people, property, environment and economy. Respondents’ organisational roles in responding to hazards are broadly categorised and summarised below.

TABLE 12: ORGANISATIONAL ROLE AND RESPONSES TO HAZARDS

Broad hazard role	Activities
Community preparedness and resilience	<ul style="list-style-type: none"> ▪ Prepare community members for emergencies using PPRR and capacity for response ▪ Working with communities to know, understand and accept their risk and to enhance their levels of preparedness so that they can manage situations themselves ▪ Sharing information on disaster preparedness, creating new knowledge informed by researchers and expert practitioners ▪ Educate communities on safe road networks
Preparedness planning and strategy	<ul style="list-style-type: none"> ▪ Operational forecasting and warning ▪ Event modelling and hazard prediction, monitoring, provision of situational awareness products ▪ Measurement of extent and impact ▪ Manage operational response mapping system ▪ Resource allocation and coordination: electricity transmission and distribution ▪ Building assessment and approvals ▪ Fuel management ▪ Advocacy – advice to government ▪ Emergency management policy development, implementation and maintenance
Active frontline response and defence	<ul style="list-style-type: none"> ▪ Taking 000 calls and providing support to other agencies ▪ Modelling of hazards and provision of forecasts, warnings, briefings, and other advice to emergency services during natural hazard events ▪ Combat agency: prepare agencies for these hazard events – respond; organise evacuations; transition to recovery

Broad hazard role	Activities
Recovery	<ul style="list-style-type: none"> Post-event analysis of the forecasts and warnings in view of what occurred Rehab road networks for community benefit
Research	<ul style="list-style-type: none"> Research to improve forecasts and warnings Prescribed burning research Social health research: mental health outcomes of first responders, both current and former and their behaviour/responses to events such as bushfires, extreme weather events Collect data

Source: SGS Economics & Planning, 2020

Q5c: What is your individual role in responding to these hazards?

Individual respondent occupation and roles in responding to hazards are broadly categorised and summarised in Table 13 below. Of note in the responses are the relatively junior levels of responders – there is a noticeable lack of managers and executives. This again may reflect the need to review the CRC’s contact list to ensure the right people are receiving their insights.

TABLE 13: RESPONDENT ROLE AND RESPONSES TO HAZARDS

Broad hazard role	Occupations	Individual roles
Community preparedness and resilience	<ul style="list-style-type: none"> Community volunteer Operational and diversity and inclusion firefighter Regional resilience officer 	<ul style="list-style-type: none"> Direct the community to credible sources of information and provide support for preparedness and planning Building measurement and evaluation into community engagement programs to demonstrate their effectiveness, community liaison, information and warnings Education program design and evaluation relating to prevention and preparedness Increase children and young people’s understanding of disaster risk, to engage schools and education leaders in disaster risks and impacts, to identify and address gaps in school education resources, to increase and improve information available to schools in this space, and to support research, innovation and knowledge, putting research into practice Work with firefighters and volunteers to help them in educating young people Build the capacity of the education sector to actively address risk in their policy and program decisions Support those who work with young people (not only in schools) Providing resources and programs for staff and volunteers to engage with communities to reduce risk and influence reaction and response to bushfire threats Building bushfire resilience in Aboriginal communities
Preparedness planning and strategy	<ul style="list-style-type: none"> Expert Commercial tester Project manager Project member Fire behaviour analyst Risk manager Bushfire mitigation manager Council member Engineering asset owner Mapping officer 	<ul style="list-style-type: none"> Assist with explanations or specific commentary Develop high impact weather forecast systems to improve forecasts and warnings Strategic planning in bushfire prediction, mitigation, prescribed burning and resilience Providing knowledge to support management decisions, derived either from original research undertaken within the organisation or sourced from external partners including the CRC, Bureau of Meteorology, CSIRO and other research providers Managing planned use of fire to achieve land management outcomes Critical asset resilience, asset renewal, new/upgrade of infrastructure, infrastructure planning, coastal hazard adaptation planning due to climate change and shoreline erosion management plans Writing emergency preparedness reports Development of underlying systems and concepts required for hazard prediction

Broad hazard role	Occupations	Individual roles
		<ul style="list-style-type: none"> Managing the development of map and new enhancements to the system Provide advice to the government, local councils or associations Seek and develop partnerships with other agencies, such as Parks and Wildlife (DBCAs) and Australian Red Cross Manage research and evaluation projects and programs that measure the effectiveness and impact of prevention, preparedness and response, and create the evidence base to inform decisions Provide workforce development for the volunteer workforce with a focus on recruitment and retention strategy
Active frontline response and defence	<ul style="list-style-type: none"> Senior command Crew leader: firefighter Incident management team Incident command controller Operations manager Aerial information gathering operator Operational bushfire fighter Operational meteorologists 	<ul style="list-style-type: none"> Coordinating response to bushfires, including interagency response Planning and intelligence support in times of disaster Oversee forecasts and warnings produced for Tasmania and act as a key point of contact for emergency services delivering briefings, attending joint media events etc during hazard events
Recovery	<ul style="list-style-type: none"> Health and wellbeing worker Data/information services Advisor 	<ul style="list-style-type: none"> Response and recovery Natural environment recovery
Research	<ul style="list-style-type: none"> Researcher Bushfire fuel mapper Prescribed burn mapper 	<ul style="list-style-type: none"> Provision of extent and severity products Working closely with the University to identify the stakeholder's challenges and gaps Providing sound scientific research and guidelines Conduct research into social health to help: first responders experiencing mental health problems; psychosocial needs of firefighting volunteers; and the mental health and wellbeing of young adult volunteer firefighters

Source: SGS Economics & Planning, 2020

Q6a: From your individual perspective, what do you think were the key challenges/problems linked to natural hazards over the past decade?

The key challenges/problems listed by respondents that may be linked to natural hazards over the past decade are sorted in Table 14 below into five broad categories: Environmental, Social/Community, Scientific, Economic/Planning and Governance.

TABLE 14: CHALLENGES/PROBLEMS LINKED TO HAZARDS

Category	Key challenges/problems
Environmental Climate change and related lack of action	<ul style="list-style-type: none"> Climate change inaction and lack of leadership in response to climate change Escalation in frequent, catastrophic and cascading events Land use factors

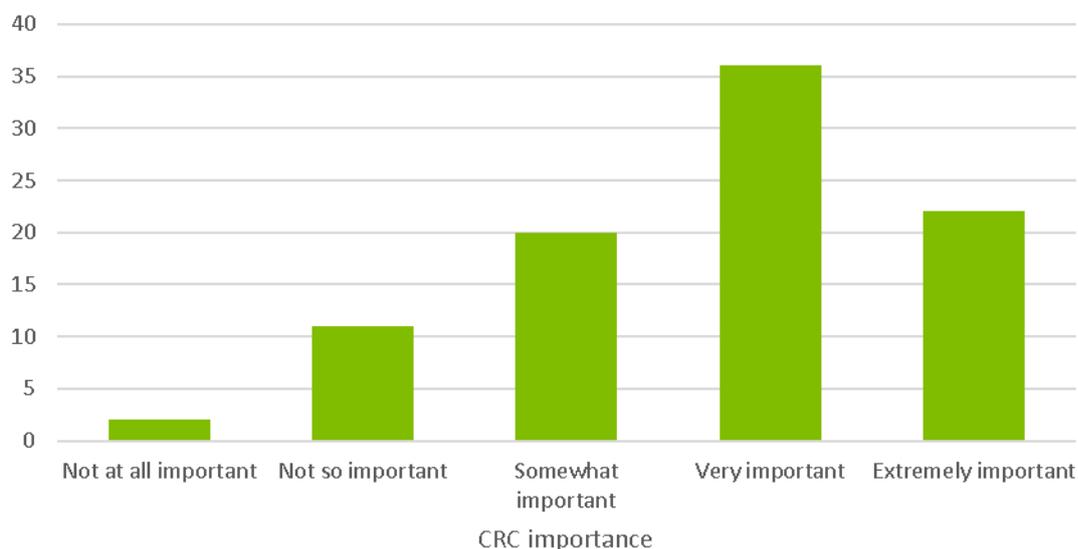
Category	Key challenges/problems
Social/Community Poor community awareness and community responsibility	<ul style="list-style-type: none"> ▪ Public complacency due to lack of major events and lack of awareness ▪ Decline in volunteerism and retention and increase in individualisation ▪ Communication to the general public and achieving the desired response is an increasing challenge in a fracturing media landscape ▪ Lack of inclusion of 'health' and recovery – especially factoring in mental health and long-term community recovery ▪ Public expectation and engagement in prevention and preparation is misaligned ▪ Changing attitudes and community demographics including a steadily diminishing connection with the realities of the natural environment ▪ Evaluation of good resilience practice and methods and its impact on community resilience ▪ Informing communities proactively about their risks and sharing the ethos of shared responsibility in a meaningful way with community ▪ Changing social characteristics of a society, especially the vulnerable after increased exposure to hazards ▪ Providing clear and efficient guidance on what actions/behaviours will do the most to reduce risk ▪ Building a bridge from individual/household actions and behaviours to community resilience
Scientific Insufficient quality data (observations and projections) of natural hazards and impacts	<ul style="list-style-type: none"> ▪ Difficulty in data collection during and after key events ▪ Poor historical research design and records ▪ Provision of timely information in a useful format ▪ Funding limitations to support research and development of new technology ▪ Spatial data support ▪ Need to communicate probabilistic forecasts from ensemble models that leads to effective decision-making by stakeholders is an increasing challenge
Economic/Planning Overinvestment in disaster recovery, underinvestment in prevention/climate change adaptation Risk and risk ownership	<ul style="list-style-type: none"> ▪ Enablement of planners, developers and politicians for communities to be developed in extreme risk areas ▪ Funding streams and investment tied to 'reconstruction and recovery' of infrastructure and not to climate adaptation or mitigation efforts ▪ Lack of strategically directed response and multi-agency coordination resulting in duplication of functions by territorial agencies ▪ Identifying appropriate and cost-effective risk-based design levels for buildings and structures subject to the various natural hazards particularly taking climate change into account ▪ Inability to understand and differentiate between risk to the community and enterprise risk and the need to reach agreement with communities on the desired levels of residual risk
Governance Lack of coordinated and evidence-informed leadership and decision-making	<ul style="list-style-type: none"> ▪ Lack of unified national response and inter-agency collaboration and resource share ▪ Lack of spending on prevention and education ▪ Personalities of elected officials putting uninformed views ahead of science, knowledge and best practice ▪ Inconsistency and instability of personnel and organisational change in the sector, especially in strategic leadership roles ▪ Lack of directive from state governments to address disaster risk in schools ▪ Politicisation of emergency management agencies and public service ▪ Growing influence of an all hazards approach to emergencies within government agencies

Source: SGS Economics & Planning, 2020

Q6b: How important has the CRC been in finding solutions to these challenges with you?

Of the key challenges identified, the Figure 28 summary below shows that respondents found the CRC to be almost very important in finding solutions to organisational challenges. The majority of respondents indicate the contribution of the CRC was moderate to major (58 per cent in total).

FIGURE 28: CRC IMPORTANCE



Source: SGS Economics & Planning, 2020

Note: Responses were scored as follows: Not at all important (Score 0); Slightly important (Score 1); Moderately important (Score 2); Very important (Score 3); and Extremely important (Score 4).

Examples from Q6c: Can you provide one or more examples of this?

Respondents who rated CRC's importance as very and extremely important derived this from:

- Integration of vulnerability and exposure data against physical hazard data provided an important step in providing the community with more relevant information to assist them in making smart decisions to mitigate hazards
- CRC staff expertise and shared networks (nationally and internationally) of researchers, practitioners and disaster managers puts end users in contact with researchers which provides the understanding and evidence base needed to assess the relative merit of different long-term mitigation strategies and continuity
- CRC's ability to pull research partners and collaborating organisations together from various states to work on projects
- Focused research on resilience, methods including risk communication, tools and understandings proved effective in the fire season just gone
- Highlighting the issues in hazard mitigation and providing frameworks on what can be done
- CRC's approach to community development moves away from just marketing and delivers more tailored and targeted warnings and messaging, especially to vulnerable communities, leading to communities being empowered to take action to mitigate their risks
- CRC's reliability as a source of respected truth and knowledge enables it to be a pillar upon which decisions are made by agencies
- CRC research used to inform business cases and set priorities as well as conferences and forums promoting evidence-based decision-making
- CRC has improved the voice for fire research in the national context by being a focal point where governments can come to
- CRC has improved the visibility of fire research from Australia in the rest of the world through fostering international collaborations, knowledge sharing and practical solutions

- CRC's framework for organisations to consider and use when developing resources and programs for children and young people
- CRC provides funding for natural hazard research (detailed case below) and enabled work with remote communities

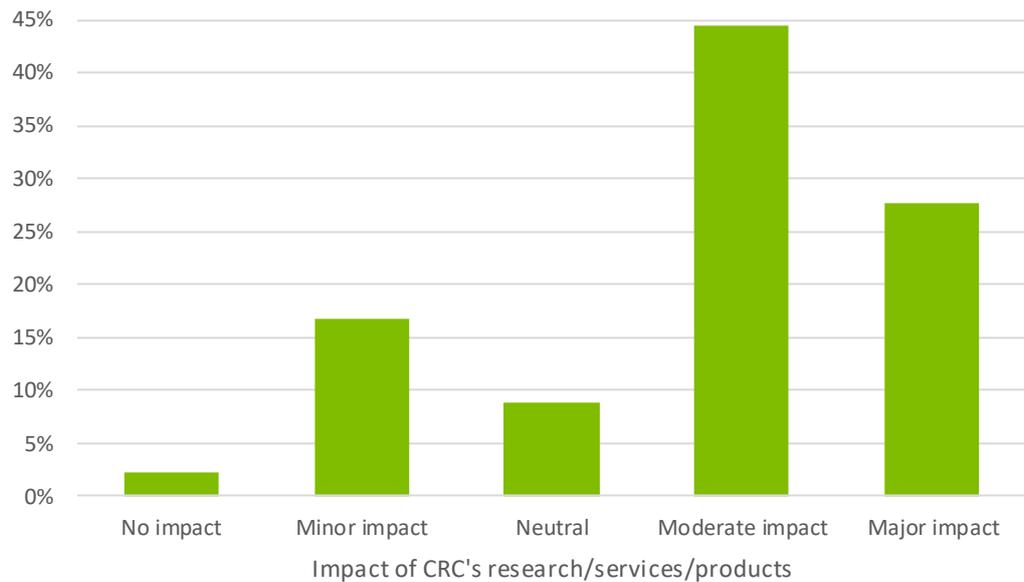
Some specific examples include:

- Development of the PFT diagnostic has provided managers with readily available daily forecasts indicating the likelihood of violent pyroconvective activity arising from interaction between fire and the atmosphere
- Coaching and mentoring opportunities for IMT's resources
- The establishment of AS 3959 in the National Construction Code and its adoption by regulators and response agencies
- CRC has co-funded a national survey on the mental health and wellbeing of police and emergency services and awarded a grant to investigate ways to support the mental health of young adult volunteer firefighters
- Amendments in the development of local fire management plans and the risk assessment process
- Providing a remote sensing approach to measuring fuel load will enable the department to capture and record more consistent fuel load values compared to traditional methods as the research is operationalised over the coming years
- Himawari 8 development of an algorithm is critical in us improving our situational awareness of bushfires, especially when no other field data is available
- CRC provided funding for an instrumental piece of research on community engagement which QFES wishes to implement across all regions
- CRC's understanding of the capacity of ensemble numerical weather prediction systems to characterise the development of east coast lows via the April 2015 study has assisted BoM in progressively developing its ensemble forecast capacity
- New method to map bushfire fuels derived from LiDAR, fire severity of prescribed burns, and assessing bushfire fuel hazard
- Thresholds for extreme fire behaviour project identified what measures of fire behaviour would be useful to collect during the event which assisted in the development of the AFMS and Fuels3D allowed for near real-time mapping of live fuel moisture content which can then be used in predicting and responding to fires
- Pioneering of new methods of engagement with the Aboriginal people supporting cultural burning in Southern Australia
- Project IGNIS: Quantification of costs for catastrophic bushfires

Q6d: To what extent did the CRC's research/services/products have an impact on how you respond to challenges to do with natural hazards?

The Figure 29 summary below shows that respondents found that CRC's research/services/products typically have a moderate impact on natural hazard management (45 per cent of respondents). About 27 per cent of respondents mention the impact is major.

FIGURE 29: THE CRC'S IMPACT FOR ORGANISATIONS



Source: SGS Economics & Planning, 2020

Note: Responses were scored as follows: No impact (Score 0); Minor impact (Score 1); Neutral (Score 2); Moderate impact (Score 3); and Major impact (Score 4).

Q6e: How have the CRC’s research/services/products changed your approach/planning/organisation and/or day to day operations?

The CRC has changed respondents’ approach/planning/organisation and/or day to day operations due to its key roles as a large, independent and trusted institution, its network of knowledge holders and capabilities in producing high quality and new research. Our findings are summarised according to these categories (that also align with our CBA framework) and are provided in Table 15 below.

TABLE 15: IMPACT OF THE CRC

Authority as a large, independent and trusted institution	Network of knowledge holders	Capabilities in producing high quality and new research
Knowledgeable source of credible information from a national point of view increases appetite for high calibre research and evidence-based decision-making	Helping guide current and future research	Provided tools for enhancing future planning to reduce impacts on property and infrastructure
Placed a greater focus on a changing environment	Collaboration to develop new knowledge	Evidence-based publications provided confidence in decision-making and communications on bushfire risk and mitigation
Main influencer in the emergency management sector	Bring stronger focus on research utilisation	Incorporation of community preparedness and warning messaging
Improved BoM approach to forecasting phenomena e.g. pyroCb, downslope winds	Access to people with knowledge/experience not available locally	Improved fire weather risk products assist internal staffing needs for anticipated high impact weather days
Refined BoM understanding of severe weather and bushfire risk and in turn allows for more	Research findings provide insights particularly into public behaviour	Future benefit in the development of improved construction standards and land planning

effective communication to the community	which has influenced community engagement	measures to mitigate bushfire hazard
Fuels3D fuel measurements is being adopted as the new standard in jurisdiction	In the child-centred community engagement space, having an underlying evidence and practice approach has influenced development of major programs. Introducing a paradigm shift with respect to the capacity of young people to be involved in hazard risk reduction which will have effect in years to come	
AFMS is being used to analyse areas which may be suitable for prescribed burning throughout seasons and where bushfires may be more severe than normally expected, allowing for more accurate predictions	Strengthened networks that are critical for positive public policy making and ongoing research	
Research used as a baseline to check and inform planning and operations	Shifted the scope of DRR research in a more nationally coordinated and collaborative fashion where working with end users has become more common and structured	
Better understanding of the possibilities and limitations of urban planning	Better engagement with Aboriginal people in fire management	

Source: SGS Economics & Planning, 2020

Q7a: To what extent do you agree with these statements: The CRC:

The summary table below shows that respondents believe that the CRC has delivered on its role. Responses have been ranked in descending order.

TABLE 16: RESPONDENT SENTIMENT ON THE CRC – AVERAGE RESPONSE

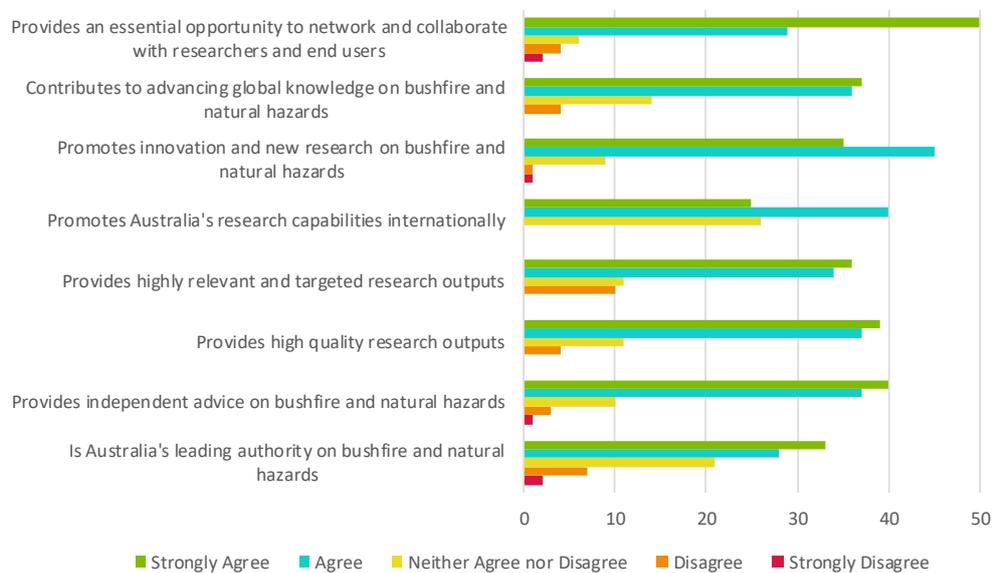
The CRC:	Average response *
Provides an essential opportunity to network and collaborate with researchers and end users	3.3
Provides independent advice on bushfire and natural hazards	3.2
Promotes innovation and new research on bushfire and natural hazards	3.2
Provides high quality research outputs	3.2
Contributes to advancing global knowledge on bushfire and natural hazards	3.2
Provides highly relevant and targeted research outputs	3.1
Promotes Australia's research capabilities internationally	3.0
Is Australia's leading authority on bushfire and natural hazards	2.9

Source: SGS Economics & Planning, 2020

Note: Responses were scored as follows: Strongly disagree (Score 0); Disagree (Score 1); Neither agree nor disagree (Score 2); Agree (Score 3); and Strongly agree (Score 4).

Half of the respondents strongly agree that the CRC provides an essential opportunity to network and collaborate (Figure 30).

Figure 30: respondent sentiment on the CRC

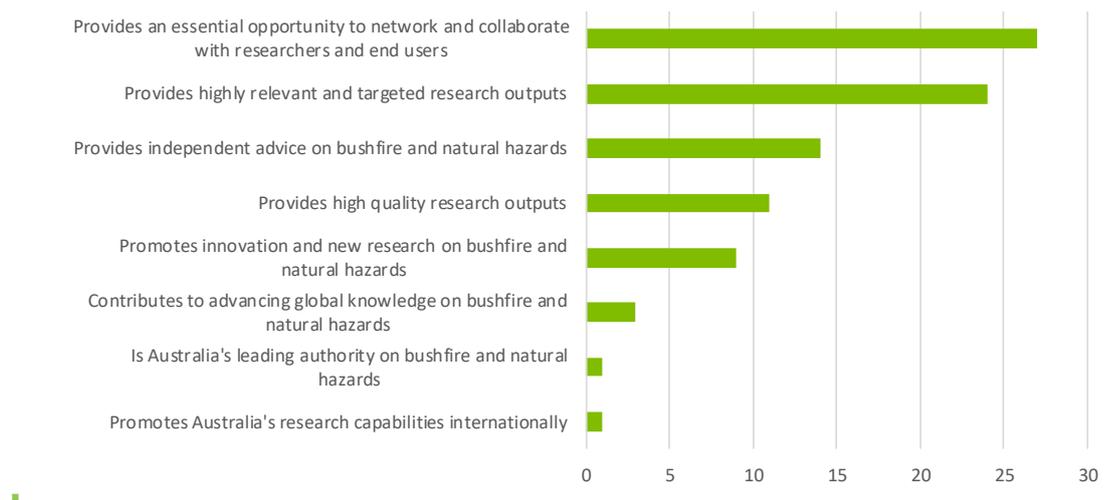


Source: SGS Economics & Planning, 2020

Q7b: Of the roles listed above, what role is most valuable to you?

Figure 31 summarises what respondents individually believe is the CRC's most valuable role of the listed roles. Thirty per cent of respondents found value in the opportunities that CRC provides for networking and collaboration with researchers and end users. This is closely followed by the CRC providing highly relevant and targeted research outputs (27 per cent).

FIGURE 31: THE MOST VALUABLE CRC ROLE



Source: SGS Economics & Planning, 2020

Q7c: Why is this the most valuable role for the CRC?

As per Figure 31, respondents believe the most valuable role of the CRC to be *Provides an essential opportunity to network and collaborate with researchers and end users*. This is validated on the notion that the CRC has built a network of knowledge holders that promotes sharing and collaboration. Key reasons defining why this is the most valuable role are summarised below:

- The formation of excellent collaboration and working relationships with end users is critical. The end user engagement structure and process of the CRC has vastly increased researcher collaboration and transformed Australia’s capacities over the past decade. To have impact, research should not be a one-way process. Projects need to be targeted at meeting the end user’s needs. Hence, end users need to understand and contribute to the research process, which requires collaboration towards tangible products. This in turn allows end users to keep ahead of the planning and preparedness cycle.
- The CRC provides an opportunity to discuss research projects that are pertinent to the industry and enable the ‘big problems’ to be tackled collaboratively. Most of the time, individual organisations, departments and agencies tend to work in silos. The CRC provides the opportunity and a mechanism for learning and maximising research funding and outputs that is more useful and likely to be adopted.
- It puts a face to the research and enables a forum for research to be tested, challenged, practised and appreciated. A cross-discipline network of like-minded and similarly challenged individuals provides the most efficient method for research quality assurance.
- Engaging with others, learning from their experiences and research and understanding different perspectives, is hugely important in professional development. The ability to discuss at length with other professionals or participate in site visits and experience the research is more profound than reading an article.
- Networking takes time and relationships are built over collaborating and engaging on personal levels. The CRC’s research events, annual conferences and joint research projects are critical in formulating and strengthening such networks. Research tests assumptions and can promote much-needed change and innovation.

Q8a: What benefit has your organisation received from the collaborative nature of the CRC projects?

The benefits of the collaborative nature of the CRC’s projects are summarised below in three categories: CRC’s authority as a large, independent and trusted institution; CRC as a network of knowledge; and CRC’s capability in producing high quality and new research. Overall, it was found that respondents predominantly benefitted from the CRC being a vehicle for networking and engaging with other CRC participants.

TABLE 17: BENEFITS FROM COLLABORATIVE NATURE OF THE CRC

Trusted institution	Knowledge network	Quality research
Greater understanding of the benefits of diversity and inclusion within a changing workforce	Funding with the CRC for a research project which is invariably linked with reputation	The development of evidence-based approaches to decision-making for improved planning and hazard mitigation operations
Development of community communication and importance of social messaging through providing trusted advice for the community	Greater network of highly expert individuals for research support, co-design, implementation and end-user engagement nationwide	Reduction of agency duplication allows for more efficient emergency management
Helped to maintain local governments in the mind of researchers and reinforce that Australia operates as a federation and natural disasters are not just a matter of	Funding opportunities to continue research into improving the mental health and wellbeing of first responders	Building and planning in bushfire-prone areas allows for improved disaster recovery and decision-making

Trusted institution	Knowledge network	Quality research
responding to threats when they happen	Network of contacts in the research sector, and identifying the capabilities of different research groups	Fire behaviour research reflected in building design and operational procedures
	Opportunities to engage with postgraduate students and their projects	
	Opportunity to influence direction of research, improvements in innovation and new products	
	Access to researchers to implement and validate outputs	
	Access to research outputs, new projects, datasets and resources that have not been widely available prior to CRC e.g. hazards research specific to combat agencies	
	Increased knowledge and awareness across disciplines	
	Opportunity to share and learn from other CRC participants on implementing good practice	
	Collaboration with end users ensure that the most useful information is delivered to our customers	
	Contribution to research that wouldn't have been undertaken independently, or would have taken many years longer to achieve or simply not happened at all	

Source: SGS Economics & Planning, 2020

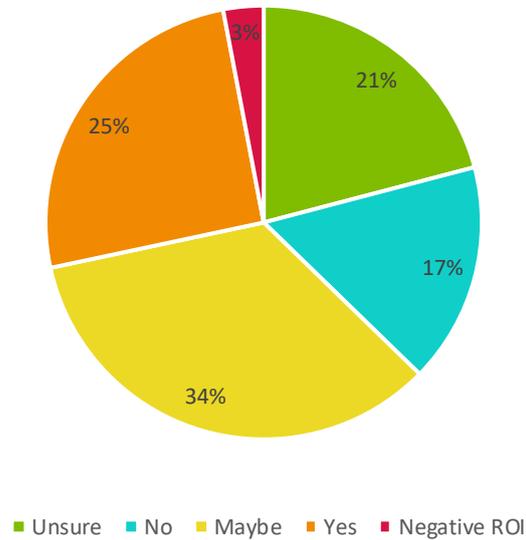
Q8b: Could this benefit be expressed in monetary terms? (E.g. the value of time saved due to research efficiencies?)

Of respondents who answered Q8b, 34 per cent were reluctant to quantify benefits provided by the CRC collaborations. Twenty-five per cent of respondents alluded 'Yes', 21 per cent 'Unsure', 17 per cent 'No' and 3 per cent were categorised as 'Negative ROI' (Figure 32). Respondents who indicated that CRC benefits can be expressed monetarily had the following thoughts on the procedure:

- Difficult to quantify; however, could estimate 12 months saved for a dozen industry representatives, avoiding duplication
- Value of time saved due to research efficiencies
- In the case of Tactical research grants, the sum of the grant – noting that the in-kind support from the lead and research partners far outweighs the funding/benefit
- Scenario where agencies had to replicate the facilitation role of the CRC would require several extra FTE – saving of \$500k per agency
- Research generates information that is valuable – 3 to 10 times the original value of investment into supporting research
- \$10K in development and implementation costs
- Possibly thousands/month
- CRC contributions to 3 salaries and savings in collaborations possibly amounting to another 2 salaries
- Utilising the savings of rebuilding/insurance for housing approved in high risk areas
- Reasons provided why the benefits could/should be expressed monetarily include:

- The agency would not have had the funds to undertake the projects without the research of the CRC
- Enhancing resilience of infrastructure could be monetised (e.g. floodways on roads research) based on historical data and asset inventories of like structures exposed to flooding

FIGURE 32: CAN CRC BENEFITS BE QUANTIFIED?



Source: SGS Economics & Planning, 2020

Note: Open-ended responses were provided and recategorised into four responses: Unsure respondents mostly answered 'Don't know' or 'Not sure'; No respondents provided a firm 'No' or statement beginning with 'Not...'; Maybe respondents provided answers based on difficulty and possibility of benefits being quantified; and Negative ROI respondents appear to be partners with investment with the CRC. Yes respondent answers are explored above. Respondents who answered 'NA' were excluded from analysis.

Respondents who indicated that CRC benefits can be expressed in monetary values found CRC's importance to be derived from the reasons summarised in the table below.

TABLE 18: CRC'S IMPORTANCE QUANTIFIED

CRC's importance
The CRC's strength in pulling research partners and collaborating organisations together from various states to work on projects, such as the quantification of costs for catastrophic bushfires (Project IGNIS).
The CRC is a source of truth and knowledge and provides a ground for credibility. It can be relied upon to support decision-making by agencies.
Focused research on resilience, methods including risk communication, tools and understandings proved effective in the fire season just gone.
The establishment of AS 3959 in the National Construction Code and its adoption by regulators and response agencies.
Research and publications as well as conferences and forums promoting evidence-based decision-making.
Keynote speeches at AFAC19 August 2019 clearly articulated the substantial problems that climate change and its impacts will have on Australia in particular.
Research that addresses what drives the lack of leadership on this front in Australia and how can that be changed.
The CRC has enabled the accessibility to professionals who have been useful in designing and evaluation of programs.
ANDRI's usefulness in understanding resilience, and the role of the emergency services sector.

CRC funding has enabled work with remote communities.

Enabled provision of professional development to professionals within the education sector that centres about disaster resilience education.

Ability to participate in a national study of disaster risk reduction and resilience education implementation.

Ability to discuss projects/programs/research in other states and how we can apply locally.

Source: SGS Economics & Planning, 2020

Q8c: What relationships/collaborations were made possible because of the CRC collaborative network?

The CRC allowed for the following relationships and collaborations:

- Commissioning of own agency research with the CRC
- Awareness and connection to a network of various research groups, institutions and over 40 government agencies across Australia and internationally: BoM, CSIRO, Geoscience Australia, NSW RFS, DELWP, DFES WA, QFES Qld, NT Fire and Emergency Services
- Closer linkages with universities: ANU, RMIT, VU, UniMelb, UQ, UWA, Curtin University, Uni of Wollongong
- Stronger ties to academic researchers, practitioners, stakeholders and end users on a personal/professional level as opposed to agency level
- Opportunities to collaborate with other agencies
- Resource sharing assisting with engagement programs including capabilities for leadership
- Research proposals in new areas e.g. livestock health and wellbeing
- A foundation of trust

Specific mentions and highlights included:

- Research with Briony Towers and UQ, in CC-DRR
- DCBA discussions with fire services in Queensland
- Broadcast of research findings from collaboration with Beyond Blue made possible with CRC facilitation
- Securing the Tactical research grant assisted in gaining the support from key research partners since they were not required to provide funding
- The Seasonal Outlook
- ANDRI and Mapping approaches to community engagement for preparedness in Australia project allow for tangible and practical applications for members across the CRC
- Working with AIDR and the Education for Young People group
- Increased frequency of AFAC collaborations, and activity from ALGA
- Enablement of new Australian Fire Danger Rating System
- The first national gathering of strategic long-term fire management planners hosted at the Melbourne office in late 2019
- The Diversity and Inclusion Project enabled collaboration nationally and abroad and is a very important tool in driving culture change across the EM sector
- Extensive involvement of bushfire science and IT expertise in Bushfire Predictive Services
- International expertise on land use/climate interactions through the UNHaRMED project

Q9a: Do you have a particular stand-out example (past or present) that showcases the value of the CRC? (E.g. how research, a service, product, or collaborative approach was particularly valuable in achieving a better outcome for your organisation, a place or a community?)

Stand-out applications by the CRC are detailed below in Table 19. Applications where respondents have responded 'yes' to being able to quantify the CRC's value have been bolded. Only detailed responses have been summarised.

TABLE 19: VALUE-PROVIDING CRC APPLICATION

Applications by CRC	Value provided
Answering the Call survey – a co-funded national survey of the mental health and wellbeing of police and emergency services	<ul style="list-style-type: none"> ▪ Biggest survey of its kind in the world ▪ Over 21,000 first responders took part and the data was cited by the recent Senate Inquiry into the mental health of first responders ▪ All 33 participating agencies were provided with confidential reports of their workers’/volunteers’ mental health outcomes so that they can formulate individual agency responses and strategies ▪ Result provides a benchmark for how to respond to the recent demands placed on people due to the bushfire season just past
Child-Centred Disaster Risk Reduction project (CC-DRR)	<ul style="list-style-type: none"> ▪ Power that child-centred programs have for growing a whole community’s resilience ▪ Led to the development of the NSW RFS Guide to Working with School Communities; means that NSW RFS can engage with schools in a manner that is based on evidence-based practice and practice-based evidence
Extreme fire behaviour and extreme weather and social vulnerability research	<ul style="list-style-type: none"> ▪ Insights provided expert advice to QFES during Queensland’s extreme fires and more recently during the Black Summer fires in south-east Australia ▪ Predictive analytics used in the fires were impressively accurate ▪ Led to the successful development of a national (and SA) Bushfire Predictive Services capability beyond that available seven years ago ▪ Project IGNIS
Relationships and network developed	<ul style="list-style-type: none"> ▪ Led to collaborative development of important national capability such as the Australian Fire Danger Rating System and the AQFx smoke forecasting system ▪ The first national gathering of strategic long-term fire management planners, hosted at the Melbourne office in late 2019
Behavioural studies	<ul style="list-style-type: none"> ▪ Research into what people pay attention to in warnings has allowed measurable improvements in government agency systems ▪ Research into behaviour surrounding why people drive into floodwater assisted understanding of when to conduct a bridge inspection, especially when the disaster was likely/occurred
ReCap project workshop	<ul style="list-style-type: none"> ▪ Enabled great collaboration between representatives from different agencies, researchers and international participants to develop tools that meet the needs of all stakeholders ▪ Strengthened Australia-NZ linkages
The Seasonal Outlook	<ul style="list-style-type: none"> ▪ Reasonably cheap and functions as an awareness tool ▪ User-friendly interface allows for new information and approaches to retaining simple format and messaging
pyroCb	<ul style="list-style-type: none"> ▪ Has been useful in the last two southern fire seasons ▪ Developed within the framework of CRC work and used by CRC participants due to the excellent collaboration between the severe weather group and end users
Bushfire Ready Neighbourhoods	<ul style="list-style-type: none"> ▪ Began as an integrated pilot project and CRC PhD study with an ‘embedded’ researcher ▪ After a five-year pilot it was funded as an ongoing statewide program, based on the quality (and quantity) of research evidence supporting a targeted community development approach to increase community preparedness and capacity to respond to bushfires ▪ The program has continued to participate with and utilise CRC and other research to support evidence-based service delivery
Collaboration with DFESWA	<ul style="list-style-type: none"> ▪ Provided valuable information describing the formation of volunteer brigades in remote Indigenous communities in northern Australia ▪ Provides a model of an already operational example, that could potentially be applied elsewhere to increase resilience in these vulnerable communities by developing the capacity to prepare and respond to natural hazards, particularly bushfires and cyclones
Australian Disaster Resilience Index (ADRI) and the Mapping approaches to community engagement for preparedness in Australia project	<ul style="list-style-type: none"> ▪ Shared tangible and practical applications for members across the CRC
Tactical Research funded projects	<ul style="list-style-type: none"> ▪ A current project on smoke alarms has yet to inform changes to the Australian standard
Collaborative research teams	<ul style="list-style-type: none"> ▪ Diversity within a community, agency or team markedly improves effectiveness and resilience
Studies of the economics of prescribed burning by University of Western Australia	<ul style="list-style-type: none"> ▪ Provided important insights into the relative economic benefits of prescribed burning close to settlements and built assets compared with a broader landscape approach

Applications by CRC	Value provided
Various research projects on warnings products	<ul style="list-style-type: none"> ▪ Incorporated into messages, products and communication channels allowing for more efficient emergency management
Grassland curing research by the CFA	<ul style="list-style-type: none"> ▪ Informed local state satellite curing programs where the economics of prescribed burning by UWA helped support the case for more mitigation spending in WA
Fuel loads research	<ul style="list-style-type: none"> ▪ The partnership with RMIT to develop a photogrammetric tool to evaluate fuel loads is a great example of being able to work together to take research and develop a tool that can be used by agency personnel
Animals and disaster research	<ul style="list-style-type: none"> ▪ Pets and wild animals have a massive impact on how we respond to bushfires including evacuations
Inquiries database	<ul style="list-style-type: none"> ▪ Now a valuable public and professional resource hosted by the CRC
Education opportunities for students	<ul style="list-style-type: none"> ▪ The placement of two of my former PhD students within land or fire agencies knowing that they have good scientific training and a background that can be used in an operational environment
York earthquake mitigation case study	<ul style="list-style-type: none"> ▪ Have received NDRP funding to extend this project into action and tangible outputs
Series of post incident research projects	<ul style="list-style-type: none"> ▪ Served as input for a much more focused, robust and meaningful 2nd project in 2016
Strategy for School-Aged Education which drew on best practice for 2015-2020	<ul style="list-style-type: none"> ▪ Helping us better place Disaster Resilience Education into the sustainability curriculum space

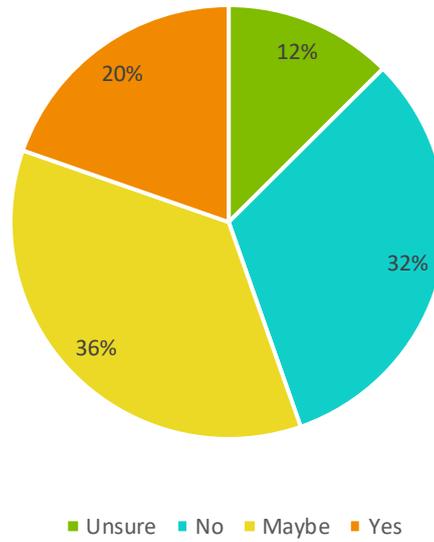
Source: SGS Economics & Planning, 2020

Q9b: Do you think there is any way you could quantify this value in monetary terms, or do you have a valuation or data you can provide? (E.g. an estimate of the area of land saved from fire or flooding, homes saved, households able to evacuate in time?)

Of respondents who answered Q9b, 36 per cent were reluctant to quantify the value provided by the CRC in relation to research, services, products or collaborative approaches utilised. Thirty-two per cent of respondents alluded 'No', 20 per cent 'Yes', and 12 per cent were 'Unsure' (Figure 33). No respondent provided a valuation or data. Respondents who indicated that the value CRC provides can be expressed monetarily had the following thoughts and comments:

- An exact figure would require further study.
- Productivity Commission would be able to quantify this value for a fee; however, the tight coupling of factors that contribute to community wellbeing and disaster resilience makes it challenging.
- The value could be derived on the number of houses saved.
- Measuring the 'calls for assistance' against like events – before and after the use of improved planning and warning products.
- Using productivity as a proxy measure as CRC applications have proven to improve staff productivity and allowed the larger catchment of data which will improve the understanding of fuel loads due to higher sampling rates compared with traditional survey methods.
- To accurately derive a numerical value for CRC, suitable measures would need to be established at the start of a project as part of the monitoring and evaluation process.
- NT government alone spends nearly \$300 million annually on emergency services. Utilisation of CRC services is estimated to halve this figure where remote Indigenous communities can self-manage some of the hazard events.
- A CBA model exists for the AFDRS.
- Better planning and building construction will reduce liabilities for NDRRA funding over time for future cost savings.

FIGURE 33: CAN CRC APPLICATIONS BE QUANTIFIED?



Source: SGS Economics & Planning, 2020

Note: Open-ended responses were provided and recategorised into four responses: Unsure respondents mostly answered 'Don't know' or 'Not sure'; No respondents provided a firm 'No' or statement beginning with 'Not...'; and Maybe respondents provided answers based on difficulty and possibility of CRC's value being monetised. Yes respondent answers explored above. Respondents who answered 'NA' were excluded from analysis.

TABLE 20: CRC'S QUANTIFIABLE VALUES

The overview below lists values that are quantifiable.

CRC's value
Range of a research team and that diversity within a community, agency or team markedly improves effectiveness and resilience.
Power that child-centred programs have for growing a whole community's resilience.
Behavioural research into what people pay attention to in warnings has allowed measurable improvements in government agency systems to help inform an effective public engagement strategy on fire prevention.
Bushfire predictive analytics used in the fires was impressively accurate.
The partnership with RMIT to develop a photogrammetric tool to evaluate fuel loads is a great example of being able to work together to take research and develop a tool that can be used by agency personnel.
The CRC research and collaboration in extreme fire behaviour, extreme weather and social vulnerability has significantly added to the success of the development of a national (and SA) Bushfire Predictive Services capability beyond that available seven years ago.
Collaboration with DFES WA has provided valuable information describing the formation of volunteer brigades in remote Indigenous communities in northern Australia. This work provides a model of an already operational example, which could potentially be applied elsewhere to increase resilience in these vulnerable communities by developing the capacity to prepare and respond to natural hazards, particularly bushfires and cyclones.
The CRC has provided leadership, support and guidance and helped enable the new Australian Fire Danger rating system.
Professor Holger Maier of Adelaide University's work has been critical in helping to improve planning throughout Australia.
The importance of animals and disaster and its impact on how we respond to bushfires including evacuations as seen during the past summer.

Source: SGS Economics & Planning, 2020

Q10a: Lessons learnt from natural disasters are important for all organisations. Is there anything you have observed from recent disasters (such as the recent bushfires) that would present an opportunity for further research to investigate?

Opportunities and lessons continually surface at the tail end of any natural disaster, calling communities to engage in long-term strategic planning that is more proactive, and less reactive. Overall, the recent disasters in Australia realised the importance of community inclusive models and the need to repurpose research to model extreme weather considering climate change. The opportunities and lessons learnt from recent natural disasters identified by respondents are shown below in five broad categories: Environmental, Social/Community, Scientific, Economic/Planning and Governance.

TABLE 21: OPPORTUNITIES FOR FURTHER NATURAL DISASTER RESEARCH

	Opportunities for further research
Environmental	<ul style="list-style-type: none"> ▪ Impacts of climate change on the workforce ▪ Analyse patterns of burning in relation to outputs from the Australian Flammability Monitoring System, particularly for forest types with a dense canopy cover ▪ Influence of topography, weather and fuels on fire spread and growth of large-scale fires, especially the influence of fuel moisture ▪ Further research on cultural burning, with cooler burning and higher frequencies ▪ Role of fires to generate local destructive wind fields ▪ Detailed impacts from global warming to be well quantified, as the ferocious impact of the last fire season took well-informed practitioners by surprise ▪ Pollution forecast ▪ Long-term dryness and its contribution to megafire potential ▪ Downslope wind and its connection to ember storms ▪ Weather prediction in extreme conditions due to climate change ▪ Effects of prescribed burning on bushfire severity ▪ Compound events and rapid switches between atmospheric states
Social/Community	<ul style="list-style-type: none"> ▪ How emergency response is managed in communities that are facing depopulation or an ageing community ▪ Influence of children and young people on household action and decision-making ▪ How to engage schools (both government and private) in emergency planning and link to disaster resilience education and how this could be applied in all states looking at all levels of PPRR ▪ Methods to change community behaviour of disengaged and how best to support communities post incident and prepare for the next one ▪ Assessment into how volunteers are best supported and impacted, as they are the first to respond and last to leave ▪ Re-evaluate current volunteer model to assess whether it will work with the emerging intensity of natural hazards and whether it is sustainable ▪ Behaviour of residents during bushfires and warning messages ▪ Volunteer firefighters have a much higher incidence of PTSD and psychological distress as a result of the recent bushfires. Speedy investigation into this issue would assist government in designing appropriate responses and strategies for future bushfire events. Early intervention and treatment can prevent PTSD from becoming chronic and harder to treat ▪ Evacuation messaging and people movement ▪ Evacuation shelter resourcing and sustainability ▪ Need to reframe approach to better reflect the key local issues that communities encounter and build this into a wider approach in terms of how to work with communities prior to and during bushfires, and how significant events are investigated ▪ Relevance of local practice and Indigenous knowledge
Scientific	<ul style="list-style-type: none"> ▪ Detailed and objective reconstruction of the spread of fires at daily resolution or better to understand the factors contributing to the scale and impact of the recent bushfires ▪ More effort to predict, warn and protect from smoke and better understand the long-term health impacts of smoke ▪ Coordination of real-time data capture during disasters and immediately after. This data provides vital information for future research and reconstructions and would require a much larger amount of funding than the small grants currently available. ▪ Field data collection to improve modelling of new fuel types created by severe fire (subsequent fires) ▪ Assessment of the quality of predictive work done by the CRC ▪ Detection/monitoring of dryness of fuel (use of both remote sensing and technology) and strategies to deal with that in a range of locations from those that could be suppressed with adequate resources to those that couldn't be, and hence, avoid waste of limited resources

Economic/Planning	<ul style="list-style-type: none"> ▪ Design of domestic dwellings in bushfire-prone areas ▪ Effectiveness of aerial suppression during different fire regimes, including re-evaluation of fire retardants, agency utilisation, operational decision-making processes and strategic location of aircraft ▪ Potential for residential sprinklers for bushfire-prone construction ▪ Better methods for broadscale fire severity mapping through a consolidated, national bushfire field data database for the calibration of satellite earth observation data ▪ The adequacy (survivability) of houses designed/constructed to the various editions of AS 3959 when subjected to recent bushfires. For those houses that did not survive, what were the factors that led to their destruction, and how could the standard be improved to mitigate those factors? ▪ Research into what makes an area not suitable for residential buildings ▪ In the bushfire-prone areas, what materials should/should not be used for the road network? Can recycled materials be used in the bushfire-prone area? If used, what are the inspection and maintenance routines required, etc? ▪ More detailed and operationally relevant research on evacuations from bushfires would help evidence-based decisions regarding access infrastructure and design ▪ Consequences of storms/cyclones being better quantified to improve community preparedness and operational readiness
Governance	<ul style="list-style-type: none"> ▪ What are the political impediments of the Royal Commission and how can they be satisfactorily addressed given the growing threat arising from climate change? ▪ How would Australia respond to natural hazards during a pandemic

Source: SGS Economics & Planning, 2020

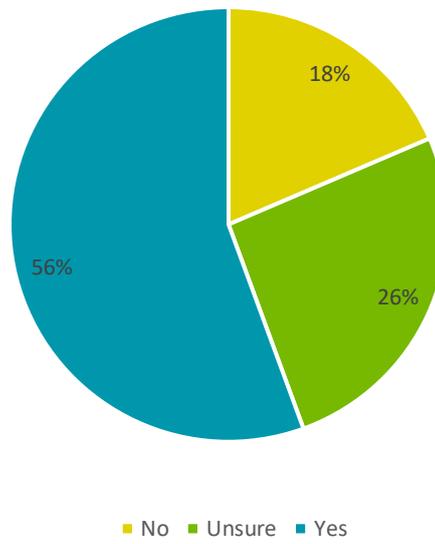
Q10b: Are there elements in the way in which the preparation for, the response to and beginnings of the recovery of the recent fire events that have been influenced by the work of the CRC?

A broad range of responses were provided on whether, in relation to the recent fire events, the preparation, response and recovery have been influenced by the work of the CRC. Fifty-six per cent of respondents believe the CRC has been an influence, 26 per cent are unsure and 18 per cent do not believe the CRC had an influence (Figure 34).

According to respondents, CRC's influence derived from:

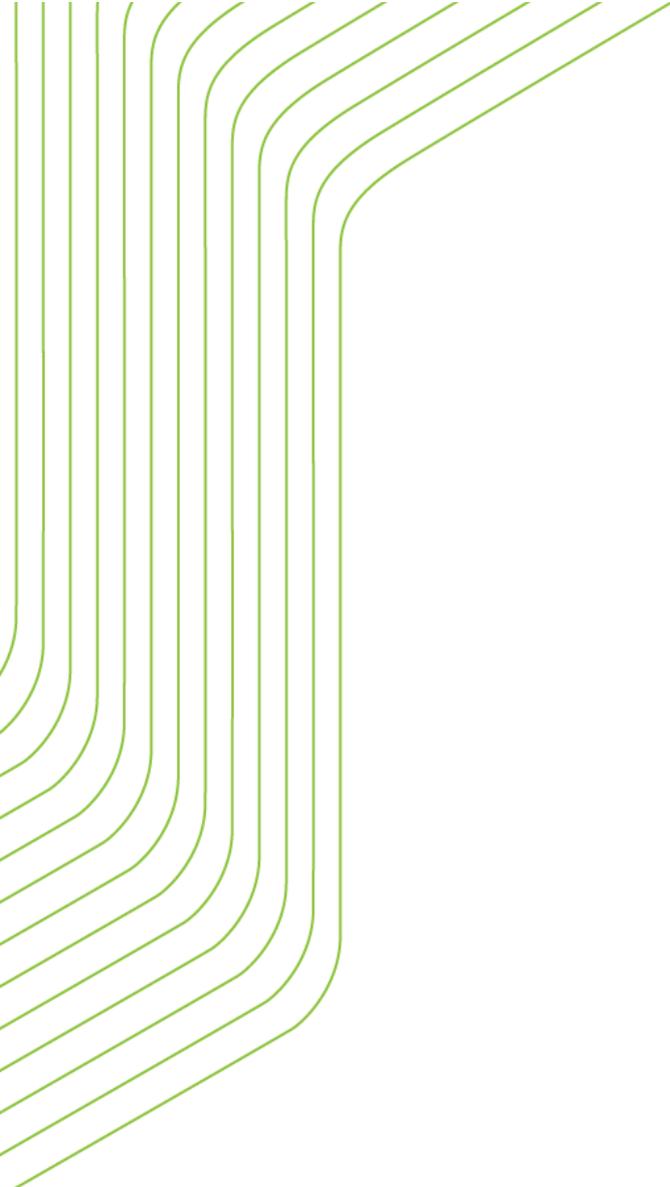
- The Pyrocumulonimbus Firepower Threshold diagnostic, which proved its utility in anticipating fire blow-ups
- Animal Emergency Management project
- Fire behaviour analysis, rating to assess risk and allow the strategic deployment of additional ground and aerial resources and hazard-reduction plans
- Bushfire planning and logistics from predictive analytics
- Better approaches to urban planning developed in a research project, which were included in policy advice to government and the new AIDR handbook
- Emergency warnings and communications
- Atmospheric influences on bushfire behaviour were a significant consideration in the preparation and response for WA fires in the Goldfields
- Soil moisture characterisation by JASMIN
- Information from the Savanna Monitoring and Evaluation Reporting Framework (SMERF) for planners and operational staff across northern Australia

FIGURE 34: CRC INFLUENCE ON RECENT FIRE EVENTS



Source: SGS Economics & Planning, 2020

Note: Open-ended responses were provided and recategorised into three response: Unsure respondents mostly answered, 'Don't know' or 'Not sure'; No respondents provided a firm 'No' or statement beginning with 'Not....'; Yes respondent answers explored above. Respondents who answered 'NA' were excluded from analysis.



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