Research Posters

Promoting key research findings of the Bushfire and Natural Hazards CRC

@bnhcrc bnhcrc.com.au

Australian Government
Department of Industry, Science, Energy and Resources

AusIndustry
Cooperative Research Centres Program

© 2021 Bushfire and Natural Hazards CRC

Publisher: Bushfire and Natural Hazards CRC
Report no. 664

May 2021

All photographs are credited to the Bushfire and Natural Hazards CRC unless otherwise noted.

All material in this document, except as identified below, is licensed under the Creative Commons Attribution-Non-Commercial 4.0 International Licence.

Material not licensed under the Creative Commons licence:

- Bushfire and Natural Hazards CRC logo
- Department of Industry, Science, Energy and Resources logo
- Cooperative Research Centres Program logo
- All photographs
- All figures and graphics
- All organisation logos

All rights are reserved in content not licenced under the Creative Commons licence. Permission must be sought from the copyright owner to use this material.

The Bushfire and Natural Hazards Cooperative Research Centre advises that the information contained in this publication comprises general statements based on scientific research. The reader is advised and needs to be aware that such information may be incomplete or unable to be used in any specific situation. No reliance or actions must therefore be made on that information without seeking prior expert professional, scientific and technical advice. To the extent permitted by law, the Bushfire and Natural Hazards CRC exclude all liability to any person for any consequences, including but not limited to all losses, damages, costs, expenses and any other compensation, arising directly or indirectly from using this publication (in part or in whole) and any information or material contained in it.

INTRODUCTION

Since 2013, the Bushfire and Natural Hazards CRC has hosted an annual conference in partnership with the Australasian Fire and Emergency Service Authorities Council, following a similar 10-year partnership with the Bushfire CRC.

This presented the CRC with an opportunity to demonstrate the latest science and lessons learned on issues of most relevance to all conference attendees. Each year the conference was in a different state or territory, as well as New Zealand, and attendees came from a diverse range of fields, including the emergency management and response sector, governments of all levels, research organisations and universities, volunteer organisations, community and health organisations, fire technology industries and the general public.

A prominent and engaging feature of the conference was the collection of research project and PhD program posters.

Each year, around 100 posters were displayed that summarised the topics, methodology and key findings from across the student and research cohort at the CRC.

This offered a simple but effective way to help researchers explain their findings clearly and concisely to an audience beyond their usual networks.

To ensure that the posters lived on, they were collected into an annual poster book each year – a feature take-away for attendees of each conference's Research Forum.

The 2020 annual conference was cancelled due to COVID-19, so this poster book, the seventh in the poster book series, presents all the final research posters from the CRC's research program. This collection summarises much of the CRC's research and is an invaluable contribution to the better understanding of natural hazard science in our community.

It is supported by three other end-of-CRC publications: *Highlights and Achievements 2013–2021*, *Hazard Notes 2013–2021* and *Postgraduate Research*. These are all available on the CRC's website.

The posters are also available within the themes on the CRC's Driving Change website: www.bnhcrc.com.au/driving-change.

CONTENTS

DISASTER RESILIENCE

ECONOMICS, MITIGATION AND VALUE

EDUCATION AND COMMUNICATIONS

EXTREME WEATHER

FIRE PREDICTIVE SERVICES

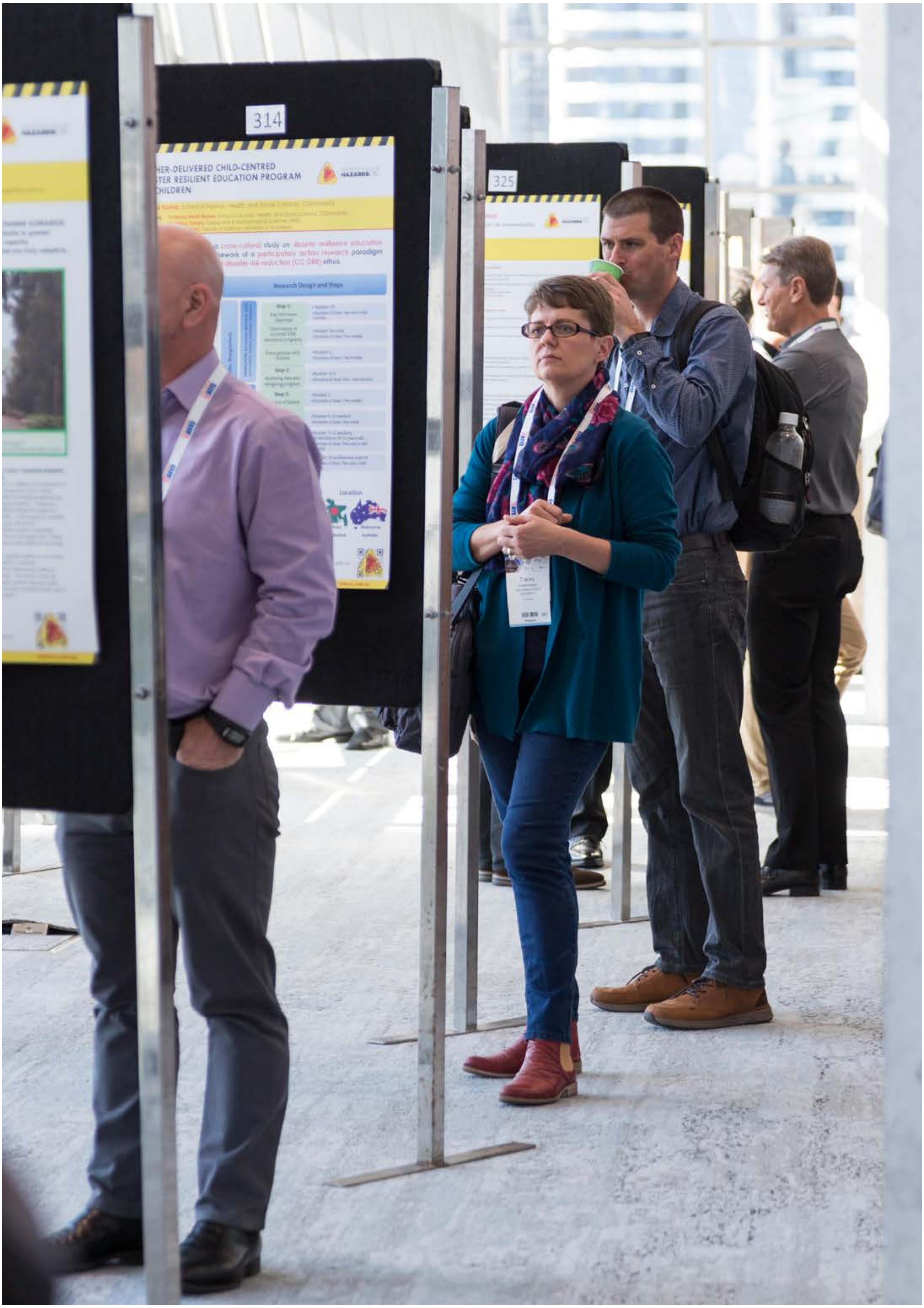
FUTURE WORKFORCE

INDIGENOUS INITIATIVES

INFRASTRUCTURE AND IMPACT

MANAGING THE LANDSCAPE

POLICY, POLITICAL ENGAGEMENT AND INFLUENCE


314
HER-DELIVERED CHILD-CENTRED
STER RESILIENT EDUCATION PROGRAM
CHILDREN
HAZARDS
Research Design and Steps
Location
325

Disaster Resilience

FINDINGS

The Australian Disaster Resilience Index is a snapshot of the capacities for disaster resilience in Australian communities. A dashboard will help communities, governments and industry explore the index and understand the factors that influence disaster resilience around Australia.

The Australian Disaster Resilience Index Dashboard

Melissa Parsons[1,2], Johan Boshoff[3], Ian Reeve[1]

[1] Institute for Rural Futures, University of New England, Armidale

[2] Bushfire and Natural Hazards CRC, Victoria

[3] UNE-CASI (Computation, Analytics, Software, Informatics), University of New England, Armidale

Developed by the University of New England and the Bushfire and Natural Hazards CRC, the Australian Disaster Resilience Index dashboard is free to use and allows anyone with an interest in understanding the resilience of their local community to access this information. The dashboard was released in July 2020.

Introduction

The Australian Disaster Resilience Index is a snapshot of the capacities for disaster resilience in Australian communities. Understanding these capacities, and how they differ from place to place, will help communities, governments and industry work together to cope with and adapt to natural hazards such as bushfires, floods, storms and earthquakes.

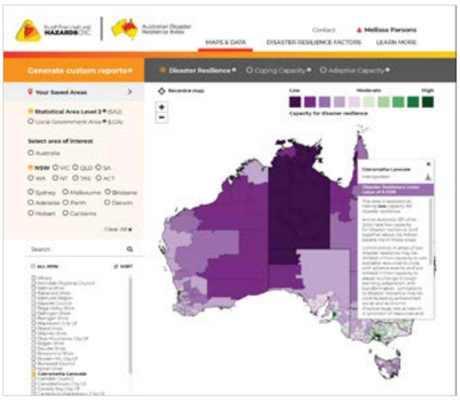
Who might use the index?

What is disaster resilience and how does the index assess it?

Disaster resilience is the capacity to prepare for, absorb and recover from natural hazards, and to learn, adapt and transform in ways that enhance these capacities in the face of future events. Disaster resilience arises from many social, economic and institutional capacities and the mix of these capacities in a community conveys how well it is positioned to absorb and adapt to natural hazards. The dashboard shows how these capacities for disaster resilience are distributed across Australia, and the factors that enhance or constrain disaster resilience in different communities.

Three levels of insight.

Dashboard design.



For more information, please email melissa.parsons@une.edu.au

© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au

OUTPUTS

New evidence-based guide to disaster recovery

Recovery Capitals (ReCap)

Prof Lisa Gibbs[1], Prof David Johnston[2], Phoebe Quinn[1], Dr Denise Blake[2], Emily Campbell[2], John Richardson[3]

[1] University of Melbourne, Victoria
[2] Massey University, Wellington
[3] Australian Red Cross

The Recovery Capitals (ReCap) project applies a Community Capitals lens to disaster recovery to increase understanding about the interacting influences of social, built, financial, political, human, cultural and natural capital on people's wellbeing. Through end user-oriented action-research, ReCap provides evidence-based guidance through the production of a range of resources in different formats that suit different needs and cultural perspectives.

Introduction

Disaster recovery processes are highly complex, presenting challenges in how to achieve holistic and inclusive approaches when working with people and communities. ReCap aims to produce resources to help address these challenges. It is a collaboration between researchers, government and non-government agencies, and end-users from Australia and Aotearoa New Zealand.

Methods

The first step in the project was to develop a framework to guide our approach to reviewing relevant evidence and developing recovery resources. The Community Capitals Framework[1] was taken as the starting point for the ReCap framework. Drawing on the practice expertise of end-users and additional academic knowledge, this was developed into multidimensional approach to disaster recovery that considers people, geographies and temporality, while interweaving issues of access, equity, and diversity (Fig. 1).
Detailed evidence mapping against the ReCap framework was undertaken using previous research conducted by the academic teams and collaborators.
Key findings and considerations arising from the evidence were then distilled, and resources have been designed based on the needs and perspectives expressed by the end-users of this project.

Outputs

ReCap is producing a series of resources that will be in different formats to suit different needs, with versions tailored to both Australia and Aotearoa New Zealand. The pilot Australian edition of the first of these – the 'Guide to Recovery Capitals' (Fig. 2) – was released in July 2020 and can be found at https://www.redcross.org.au/recap.

Next steps

The ReCap project is still in progress. The 'Guide to Post-Disaster Recovery Capitals' is being adapted into an Aotearoa New Zealand edition, and both versions are being distributed to end-users who will pilot it and provide feedback about feasibility, appropriateness and usefulness. The development of the complete set of resources continues.

For more information, please email phoebeq@unimelb.edu.au

Community Capitals Framework

Figure 1: *ReCap model adapted from the Community Capitals Framework*[1]

Guide to Post-Disaster Recovery Capitals

Figure 2: Cover image of the first resource produced through the ReCap project

[1]Flora, C., Flora, J., & Fey, S. (2004). *Rural Communities: Legacy and Change* (2nd ed.). Boulder, CO: Westview Press.

Australian Government Department of Industry, Science, Energy and Resources | Business Cooperative Research Centres Program
The University of Melbourne | Massey University, Te Kunenga ki Pūrehuroa, University of New Zealand | the power of humanity, Australian Red Cross

© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au

bushfire&natural HAZARDSCRC

FINDINGS

Building capacity to prepare: A generative model of community engagement for preparedness

Mapping community engagement for preparedness in Australia

Kim A Johnston[1,2], **Barbara Ryan** [1,3], **Maureen Taylor** [1,4],

[1] Bushfire and Natural Hazards CRC, Victoria
[2] Queensland University of Technology
[3] University of Southern Queensland
[4] University of Technology Sydney

Community preparation for disaster response has been empirically established as a key factor in mitigating risk associated with disasters. Although community engagement is used widely to support communities to build capacity to prepare, approaches to engaging a community have varied widely, with few frameworks empirically built or evaluated for effectiveness. This qualitative study of 30 emergency management agencies and practitioners, and thematic analysis of agency policy documents, investigated current approaches to community engagement to develop a model to help communities mitigate risk. Drawing together key concepts from natural hazard behaviour research, community development, participatory design and codesign, a five step Generative Model of Community Engagement for Preparedness is proposed, based on relationships, networks and shared meaning. The model has both theoretical and practical value for community engagement for risk personalisation and protective action because it not only helps communities prepare for emergencies but also helps build relationships across communities that create social capital for recovery and during nonemergency periods.

Introduction

Community preparation in disaster response has been empirically established as a key factor in the protection of life during a disaster (Coles et al, 2018; Gibbs et al., 2015). Risk management plans identify a clear role for collaborative engagement with local communities (Heath & Lee, 2016) Community engagement (CE) enhances social outcomes through community decision making (Johnston et al, 2018) however, little is known about what makes a CE program for preparedness effective, and what are the attributes of a best practice approach to CE for preparedness. This study addresses this gap and establishes a framework for CE best practice.

Methods

A two-stage qualitative research design featuring 1) semi-structured interviews (N=30) and 2) document analysis, was undertaken between Oct 2018 to Jan 2019. Empirical and grey literature was used to build an interview guide. Data were thematically analysed and coding into core topics (Glaser, 1992) while the second analytical stage applied an inductive analysis.

For more information, please scan the QR code for project documents and publications or email the researchers:

kim.johnston@qut..edu.au
Barbara.ryan@usq.edu.au
maureen.taylor-1@uts.edu.au

SCAN ME

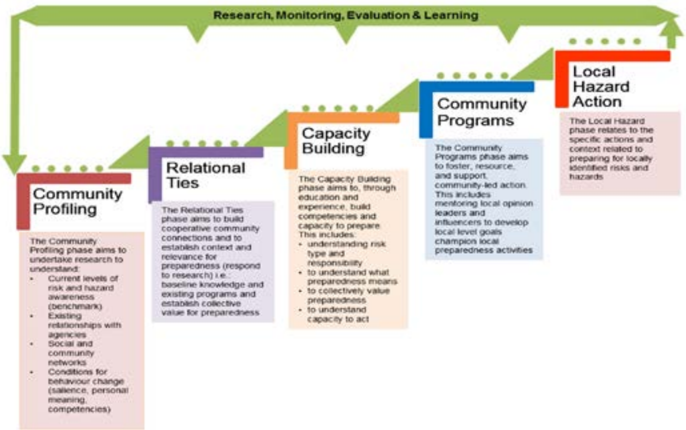


Figure1: Generative model of community engagement for preparedness

Results

Attributes of a best practice approach to CE for preparedness include: Awareness and understanding of risk, recognition of self-responsibility, and the notion that preparation within a community is widely held as desirable and valued. Attributes of a CE for preparedness program should feature

- Community led
- Co-design and community development
- A relational approach
- Recognises the importance of community networks

The model – titled *the Generative Model Of Community Engagement For Preparedness*, (Figure 1) reflects and represents a synthesis from current Australian CE for preparedness practice (interview data and document analysis) and responds to the principles of practice that prefaced successful CE. The model details aims of each step, with an accompanying toolkit of tactics and monitoring/evaluation tools aligned to each step.

Discussion

The findings of this study support a high-level commitment by emergency agencies to engaging with the community in order to save lives and property through risk identification and action. The model brings together the core features and benefits of a common understanding, language and practices used for CE for preparedness in Australia and around the world. There are four key theoretical and practical implications of the findings of this study for CE for preparedness, including systematising sharing of knowledge, the importance of localised approaches, the challenge of shared responsibility, and systematising evaluation.

Australian Government
Department of Industry, Science, Energy and Resources
Business Cooperative Research Centres Program

QUT USQ UTS

© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au

Economics, Mitigation and Value

UNHARMED

A flexible approach to understanding and planning risk reduction for different hazards and from different perspectives

Improved decision support for natural hazard risk reduction

Graeme A. Riddell[1,3], Hedwig van Delden[2,3], Holger R. Maier[1,3], Roel Vanhout[2], Aaron C. Zecchin[1,3], Graeme C. Dandy[1,3].

[1] School of Civil, Environmental & Mining Engineering, The University of Adelaide, South Australia, Australia
[2] Research Institute for Knowledge Systems, Maastricht, the Netherlands
[3] Bushfire and Natural Hazards CRC, Victoria, Australia

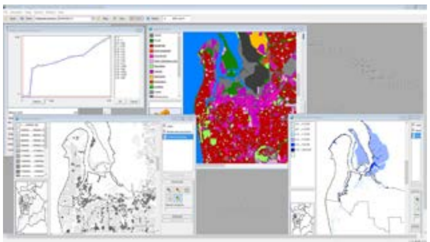
The project has developed a tool for pro-active disaster risk assessment and reduction planning – UNHaRMED. It is based on two driving principles:

1. Prevention is better than cure – "It's better to build a fence at the top of a cliff, than park an ambulance at the bottom." Helen Clark. Challenges: where to build it, how high, how much does it cost…?
2. Tomorrow's risk is being built today. We must therefore move away from risk assessments that show risk at a single, present point, and move instead towards risk assessments that can guide decision makers towards a resilient future. GFDRR (2016)

The software is designed to explore risk into the future, modelling hazard, exposure and vulnerability to provide decision-relevant risk metrics. It is designed with the inputs from over 50 organisations across Australia.

The following highlights some of the applications of UNHaRMED in the last year.

All results shown are indicative.

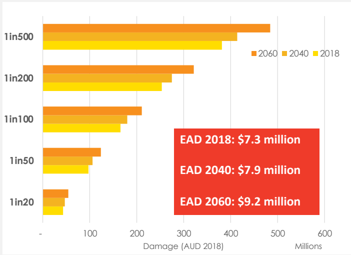


UNHaRMED User Interface showing hazard and exposure maps and vulnerability functions.

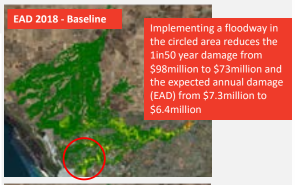
Gawler River UNHaRMED Mitigation Planning - GRUMP

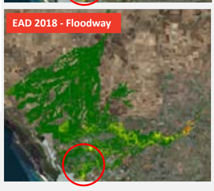
Working with the Gawler River Floodplain Management Authority, its 6 constituent councils and the Department for Environment & Water's Fire and Flood team we have been assessing structural and non-structural risk reduction options against different scenarios of economic and population development in the floodplain.

The results are to be used to build the business case for investment in improved flood defences and to develop a more strategic, long-term approach to understanding and reducing flood risk in a key development area to the north of Adelaide. Risk assessment has included assessing the direct damage to buildings, roads, and agriculture, along with indirect impacts due to service disruption following flood events. Below are results for damages per return period and expected annual damage (EAD) plotted spatially and against time.



Baseline scenario of changing risk due to economic and population growth in the floodplain.





Maps of EAD per hectare across the floodplain

Exercise ForeThought: State Strategic Mitigation Exercise – Coastal Flooding & Climate Change

A two-day exercise was run with stakeholders from across State, and Local Governments, along with private sector representatives and NGOs to better understand and plan for sea-level-rise (SLR) and coastal flooding in Port Adelaide. The discussion exercise was designed to better plan mitigation activities by taking a multi-agency perspective and exploring different scenarios of SLR, population growth and risk reduction actions.

UNHaRMED was used to model these different scenarios and help stakeholders visualise, understand and quantify the trade-offs between different actions. The first day provided a foundation for the group of 50 participants to understand how the risk was changing before day 2 demonstrated the costs and benefits of different mitigation actions.

As the project sponsor, SAFECOM is pleased to have had participants from across State and Local Government, critical infrastructure providers and NGOs contributing real-life input into the practical application of the UNHaRMED tool in the Port Adelaide coastal flooding scenario.

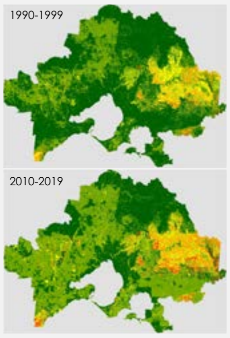
This collaboration facilitated complex discussions that highlighted the need for interconnected planning across agencies and sectors to achieve effective mitigation that also take into account the social acceptability of proposed solutions.

Participants agreed that the flexibility of the UNHaRMED tool allows it to be easily applied to different hazards and geographic areas, limited only by the availability of access to appropriate data.

Brenton Keen, Director Emergency Management Office, SAFECOM.

Climate change and bushfire risk - Victoria

Working the Bureau of Meteorology we explored the impact of climate change on extreme fire weather to better understand potential impacts into the future. Using the BARRA reanalysis dataset we looked at the difference in fire behaviour on the 95th percentile weather between 1990-1995 and 2010-2019. This was to better understand the change that has already happened. These are plotted below.



Fire behavior from 95th percentile weather

We also considered the difference in losses to buildings between these two scenarios.

This assessment was also used as the basis for understanding and modelling future climate projections, not shown here. These results have fed into several assessments for a range of organisations.

Difference in losses from 95th percentile event between 1990-1999 and 2010 - 2019

We would like to thank the many organisations and individuals we have worked with in both developing and applying UNHaRMED. This work would not have been possible without their contributions.

For more information, please email holger.maier@adelaide.edu.au

Australian Government Department of Industry, Science, Energy and Resources
Business Cooperative Research Centres Program
THE UNIVERSITY of ADELAIDE
RIKS

© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au

bushfire&natural HAZARDSCRC

ECONOMICS 101 FOR THE EMERGENCY MANAGEMENT SECTOR

A **free online course** on the **economics of natural hazards** to help practitioners become enthusiastic and **effective utilisers** of economic analysis.

The Economics of Natural Hazards

Veronique Florec[1,2], Abbie Rogers[1,2], Atakelty Hailu[1,2] and David Pannell[1,2]

[1] Bushfire and Natural Hazards CRC, Victoria
[2] The University of Western Australia, Western Australia

This **free online course** on the economics of natural hazards will help natural hazard managers **build their skills** and understanding in the **core economics concepts** and models that are **relevant to natural hazards** management.

Rationale

Emergency management agencies do not necessarily collect their data with strategic economic analyses in mind. Because of this, there can be inconsistencies and holes that make the carrying out of economic analyses difficult. There is a **need for a shift in thinking** among agencies collecting data, to ensure that the data are useful for economic analyses and management decisions. In addition, economic analysis of natural hazards can be complex, and there is a **lack of economics capacity** in the sector.

Aims

The information presented in the course will allow natural hazard managers to become enthusiastic and **effective utilisers of economic analysis**, be able to **interpret and use the results** of economic analysis appropriately, understand the importance and challenges associated with **intangible values**, and understand more broadly the **data requirements** for particular types of economic analyses.

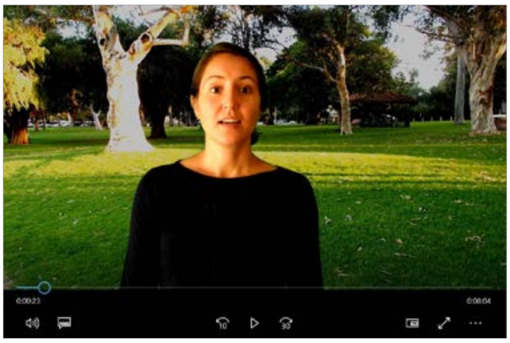
Potential outcomes

These are some of the potential outcomes for participants and the sector as a whole:

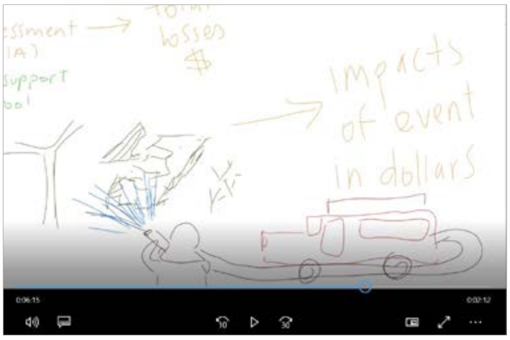
- **Improved ability** for natural hazard managers and decision makers to **frame decision-making problems** appropriately, **choose** the appropriate **economic tools** to define and compare options and **source** and utilise relevant **data**.
- **Improved ability** for researchers and students to **choose** the best **tools and approaches** for economic analyses of natural hazards and their management.
- **Increased economic capacity** within the emergency management sector.
- **Improved data collection** and more data available useful for conducting economic analyses.

For more information, please email **veronique.florec@uwa.edu.au**

Selected images



Above: Economic concepts are explained in simple terms in the videos.



Above: Hand-made graphs and drawings help explain the concepts presented in an engaging and entertaining way.

Australian Government
Department of Industry, Science, Energy and Resources
Business Cooperative Research Centres Program

THE UNIVERSITY OF WESTERN AUSTRALIA

© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au

bushfire&natural HAZARDS CRC

FINDINGS

Small business owners in the Burnett River catchment area suffered income losses of $21,005 following Cyclone Oswald 2013.

Disasters and Economic Resilience: The income effects of Cyclone Oswald on Small Business Owners – a case study on the Burnett River Catchment Area

Mehmet Ulubasoglu[1,2]

[1] Bushfire and Natural Hazards CRC, Victoria
[2] Deakin University, Victoria

Introduction

From 22 to 29 January 2013, Category 1 ex-tropical Cyclone Oswald, depicted in Figure 1, moved across parts of Queensland and New South Wales, causing severe storms, flooding and tornadoes with most of the devastation felt in the Bundaberg and North Burnett regions. The flooding events associated with Cyclone Oswald that occurred in this region present a unique opportunity to causally investigate the impacts of a major disaster on small businesses in a regional community with an important agricultural base. As 98% of Australian businesses are small businesses, this study provides a layer to dissect disaster resilience and recovery on an important section of the community and workforce.

Method

Using the ABS Census Longitudinal Dataset (2006, 2011, 2016) and the 'difference-in-differences methodology, the research explores the income effects of Cyclone Oswald on small business owners residing in the four Burnett River Catchment local government areas (LGAs) depicted in Figure 2. In particular, we estimate the income changes of small business owners in Burnett River Catchment Area (treatment group) between 2001 and 2016, compared to small business owners in a control group who are closely matched on a range of characteristics including income, education, marital status, age, and their mover/nonmover status over time. The Richmond River catchment area LGAs (NSW) are chosen as control group as they closely resemble the treatment group (Figure 2).

Result

Small business owners in our treatment LGAs suffered 45.3% income losses between 2011 and 2016, which corresponds to $21,005, compared to what they would have earnt had the cyclone events not happened.

Discussion

While the estimated income losses appear to be large, they are plausible considering the wide-scale devastation to important infrastructure (including ports and water treatment facilities), that agricultural small businesses are heavily represented in these areas, and that agricultural losses alone in North Burnett and Bundaberg were estimated at $265 million (Queensland Government, 2018a).

These would have had knock-on effects on other sectors in the region. They are also consistent with the low capacity for disaster resilience of the Burnett River catchment area, as assessed by the CRC's ANDRI project.

This finding supports a key insight from our Queensland Floods 2010-11 report (Ulubasoglu and Beaini, 2020), in which we identified three possible channels through which disaster-induced economic shocks can be transmitted to individuals, vis-à-vis income. These are: owning a business, working in sectors whose economic activity is susceptible to disaster shocks (both positive and negative), and working part-time.

Our research findings also illustrate the difficulty in fully mitigating economic losses in regional communities in Australia, particularly where economic activity is concentrated in – and centred around – disaster sensitive industries like agriculture or tourism. For the Wide Bay-Burnett region, these difficulties will only be exacerbated by the projected population growth and climate change, which is expected to increase extreme weather events and the risk of further inundations in communities like Bundaberg.

For more information, please email mehmet.ulubasoglu@deakin.edu.au

Figures

Figure 1: Cyclone Oswald Path

Figure 2: Burnett River Catchment Area LGAs and Richmond River Catchment Area LGAs

Australian Government Department of Industry, Science, Energy and Resources | Business Cooperative Research Centres Program | DEAKIN BUSINESS SCHOOL Centre for Energy, the Environment and Natural Disasters

© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au

bushfire&natural HAZARDS CRC

FINDINGS

Appropriate management of disaster risk in a dynamic urban context requires performance criteria to be explicit in considering both direct and indirect impacts generated by the interdependent elements of urban system to which these criteria apply.

Urban Form and Disaster Risk Reduction:

Developing Performance Criteria for Urban Areas Exposed to Flooding

Saimum Kabir[1], Professor Alan March[1,2], Dr. Kathryn Davidson[1], Dr. Leonardo Nogueira de Moraes[1,2]

[1] The University of Melbourne, Victoria
[2] Bushfire and Natural Hazards CRC, Victoria

Australia's national policies have advocated a flexible performance-based approach to planning for disaster resilience. The Victoria Planning Provisions warrant performance-based planning mainly by Overlay controls. In an existing urbanized area, Flood Overlays come as a development-control measure, but they have no or limited implication on land use, land subdivision, dwelling density, distribution of open space etc. which have significant connection with risk avoidance and recovery process. In addition, Overlays are ineffective in reducing indirect impact of flooding. It also lacks performance criteria to assess urban form's capacity to mitigate the flood risk.

Introduction

Although existing spatial and urban resilience approaches have dealt with urban form indirectly, and, conversely, some studies in urban morphology have tried to grasp the complexity of urban-natural environments, an explicit morphological perspective on disaster risk reduction (DRR) is still lacking in academic research[1]. This study seeks to address this gap by identifying performance criteria at the morphological scale based on the substantive evidence of associations between urban form variables (Density, Street, Land use, Plot, Building, Open space) and DRR (response, recovery and mitigation). It is argued here that, an urban morphological approach provides an appropriate framework for examining urban form's performance in disaster risk reduction.

Methods

This study has been undertaken as a systematic literature review. The research question addressed by this study is: What particular role can urban form play in disaster risk reduction? Thompson Reuters Web of Science and Google Scholar bibliographic databases were used to identify the literature on urban form and environmental performance; urban form and disaster risk recovery, response and mitigation. When combined, the dataset included publications (articles, book chapters, conference proceedings, reports) from a variety of disciplines (Engineering, Urban Planning, Environmental Study, Geoscience Study, Disaster Science, etc.). The studies were then reviewed to determine if they actually covered the intended search. They were excluded if the studies (a) failed to address the research question and (b) were not based on empirical data.

Results

There are substantial indications that urban form has bearing on disaster risk reduction. Fig1 (i)-(v), show the implication of various urban form variables on flood risk assessment. However, in several cases evidence on the relationship between urban form elements is contentious, ambiguous and even contradictory. This contradiction seems to lay on contextual variations, and the selection of control variables during analysis. Inconsistency is also observed in consideration of multi-scalar implications of urban form on disaster risk reduction.

Discussion

The alliance between urban morphological elements and disaster risk reduction are discussed below:

- The association between density and DRR is controversial. High-density development within a pre-existing vulnerable location may expose more people and property to flood hazards, increasing disaster risk. Conversely, when coupled with land use diversity, high net density offers more room for avoidance of sensitive areas and can influence attributes such as social capital and place attachment which facilitates recovery.
- Street patterns, permeability and drainage feature were identified as associated with disaster response and recovery both at the macro and micro scales. At the macro scale, gridded networks, with small blocks, are found more desirable for improving emergency service accessibility and for facilitating rapid evacuation, while at the micro scale, the incorporation of various street design features such as vegetated swales, wayfinding systems, and a network of small and medium assembly areas may enhance the ability of rapid recovery.
- Open spaces have the potential to act as an agent of recovery, to provide essential life support, as a primary place for rescue and shelters; and a mode for mitigation.
- Various aspects of plot(subdivision, impervious coverage) and building (form, footprint, setback, roof type, material and technology) have bearing on disaster risk reduction. Studies also showed that urban wide transformations in this micro scale aspects can have positive effects on the macro scale.

In reducing disaster risks, various urban form measures may reinforce or conflict with one another. Different trade-offs may occur due to conflicts in purposes and priorities, and varying requirements depending on the type of disaster and the stage of risk management. Trade-offs may also occur within spatial scales. Any intervention in urban form should be pursued in an integrated manner in order to maximize synergies and minimize trade-offs between potentially competing strategies for risk reduction and urban development.

1. Forgaci, C. and Van Timmeren, A., 2014. Urban form and fitness: Towards a space-morphological approach to general urban resilience. In ISDRC 2014: 20th Annual International Sustainable Development Research Conference" Resilience–The New Research Frontier", Trondheim, Norway, 18-20 June.

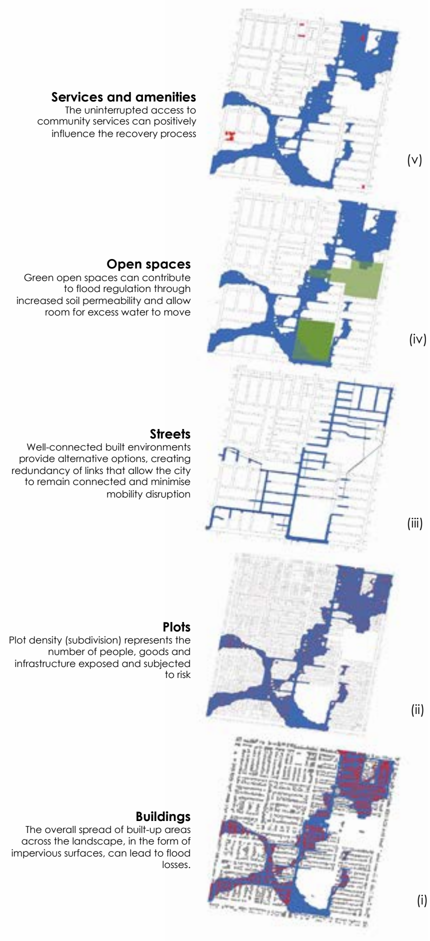


Figure1: Implication of Urban form on flood risk assessment

Australian Government
Department of Industry, Science, Energy and Resources
Business Cooperative Research Centres Program
The University of Melbourne

© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au

FINDINGS

A pragmatic approach to valuing research on disaster risk reduction

The Value of BNHCRC Research

John Handmer[1,2,3], Adriana Keating[1,2,3], Ken Strahan[1,4]

[1] Bushfire and Natural Hazards CRC, Victoria
[2] The Risk Laboratory
[3] RMIT University
[4] Strahan Research

Funders of research on fire and emergency management increasingly want to ensure that research dollars will generate value for the emergency management sector and contribute to risk reduction. Researchers are often asked to justify their funding requests as well as their expenditure. This paper sets out two approaches developed to value the disaster risk management research funded by the BNHCRC.

Introduction

The key objective of this work is to estimate values of research for communicating with: a) Treasury, where economic impacts across society in the form of e.g. benefit-cost ratio, cost effectiveness, or return on investment are important; b) agency funders, who are interested in financial impact for their agencies and focus on the return on their contribution; and c) dedicated research funding organisations who want to understand and promote the value of the research they fund, for Australian society broadly.

Methods

There is no specific framework for assessing the value of research in the wildfire – or more generally the disasters – context. However, we have identified a number of pathways for BNHCRC research to have positive impact and therefore value. Drawing on the models reviewed (Strahan et al 2020), and applying a broad view of public value, we have identified four main pathways to value for hazards related research:

- Project level impacts – mostly direct impacts on agency policy or practice;
- Training and capacity building;
- Knowledge generation;
- Broader social and economic impacts.

We have taken two approaches to estimating monetized value. Approach one is to estimate the total value of each pathway; approach two is to ascribe value for each of the four pathways by individual BNHCRC projects.

Discussion

Conventionally, research value for emergency management related research in Australia has been conceptualised in terms of value for specific fire and emergency service agencies, or in some cases for the whole formal fire and emergency management sector. We have broadened the potential worth by considering a variety of pathways to value. These were drawn from the relevant literature on the value of public research. They expand the potential value of research and highlight the range of strategic areas that publicly funded research enhances.

1. The first approach values each of the four identified pathways using methods that are easily reproduced and compatible with the available data.
2. The second approach identifies CRC project impacts by pathways, and then rates each impact using a dimensionless ratio scale. Drawing on the case studies, a sample of impacts will be valued in dollar terms and this will allow the monetisation of all impacts.

Some factors, such as the estimated effect of CRC research on loss reduction and discount rates, are likely to have major impacts on the final value and these should be tested for sensitivity.

For more information, please email john.handmer@rmit.edu.au

Figure 1

Figure1: Steps in assessing the dollar value of BNHCRC research

Strahan, K, Keating, A, Handmer, J (2020) "Models and frameworks for assessing the value of disaster research" Progress in Disaster Science https://doi.org/10.1016/j.pdisas.2020.100094

Australian Government Department of Industry, Science, Energy and Resources | Business Cooperative Research Centres Program

© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au

Education and Communications

FINDINGS

More than 90% of people who drive through floodwater experience no adverse consequences

Flood Risk Communication

Mel Taylor[1,2], Matalena Tofa[1,2], Katharine Haynes[1,3]

[1] Bushfire and Natural Hazards CRC, Victoria
[2] Macquarie University, New South Wales
[3] University of Wollongong, New South Wales

This project focused on gaining a better understanding of people's behaviour in and around floodwater. Specifically, the two behaviours associated with the greatest number of fatalities in Australia; driving into floodwater and recreating in floodwater. Findings from this research are being used to identify and quantify challenges for flood risk communication and develop guidelines for those communicating with the public.

Introduction

Flooding is a significant cause of death, accounting for the second highest number of fatalities due to natural hazards in Australia after heatwaves. Our research investigating vehicle-related flood fatalities in Australia found that at least 96 people died in incidents between 2001and 2017, with older males (aged 50–59 and 70–79) being the highest-risk group.

This 3-year research project comprised several studies. These included investigation of factors associated with driving into floodwater with the general public and State Emergency Services (SES), interviews to understand how experts and lay public differ in their conceptualisation of flood and flood risk, consolidation and exploration of vehicle-related flood fatality data, and evaluation of public flood risk communication and the public's recall of flood campaigns and messages. In addition, experimental research has been undertaken to develop and validate a tool to assess expertise in the risk assessment of floodwater.

Stakeholder summaries of these studies are available in a series of Research into Practice Briefs.

Methods

This poster presents keys findings from just one research study - an online public survey of driving and recreating in floodwater. Data were collected from a proportionally representative sample of the adult Australian population, balanced by state and gender.

The survey investigated experiences of driving into, and entering, floodwater. This included collecting details of a specific recent incident of driving into floodwater. The survey also investigated recall of flood risk campaigns and messaging.

Results

A total of 2184 people were surveyed. Some key findings are listed below.

- 26% of respondents had entered floodwater on land
- 19% had engaged in activities in flooded rivers
- 55% had driven (or been driven) through floodwater in the last 5 years
- 40% reported they could recall an official flood campaign
- 6.4% could recall the core 'if it's flooded, forget it' message.

Of those who drove through floodwater:

- 61% drove through water estimated to be 15-45cm deep
- 91% drove through with no adverse consequences
- 0.7% needed rescuing by emergency services

Discussion

Our study findings have many implications for flood risk communication. The fact that more than half the public drive through floodwater and 90% incur no adverse consequences means that flood communication asserting risks and danger will not align with lived experience and is likely to be rejected.

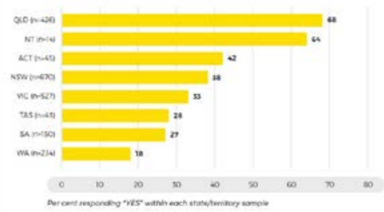
Recall of flood risk messaging is generally poor, although better in some states where both the risks can be greater (due to remoteness and lack of alternative routes) and campaigns have been strongly promoted in recent times.

For more information, please email mel.taylor@mq.edu.au

Outputs from this project are available at https://www.bnhcrc.com.au/research/floodrisk communication

Examples of public flood campaigns aimed at preventing people driving into floodwater

- 40% reported they could recall an official campaign aimed at preventing people driving or playing in floodwater.
- 6.4% recalled the message 'if it's flooded forget it'



Public recall of flood campaigns: national survey (n=2109)

Research into Practice Briefs – generated from research activities

Australian Government
Department of Industry, Science, Energy and Resources
Business Cooperative Research Centres Program
MACQUARIE University
UNIVERSITY OF WOLLONGONG AUSTRALIA

© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au

FINDINGS

Red headers on bushfire evacuation messages help encourage community members to follow emergency instructions

Adding Colour and Icons to Emergency Warning Messages

Associate Professor Dominique Greer[1], Dr Paula Dootson[1], Dr Sophie Miller[1] & Professor Vivienne Tippett[2]

[1] QUT Business School, QUT, Queensland
[2] School of Clinical Sciences, Faculty of Health, QUT, Queensland

Current Australian emergency warning messages that have been refined to match evidence-based practice already encourage community members' readiness to act on emergency instructions. What happens when we add colour and/or icons to emergency warning messages?

Introduction

Since 2014, emergency service agencies across Australia have adopted a range of evidence-based practice when constructing emergency warning messages.

As the written elements of warning messages are working well to encourage readiness to act (Greer et al., 2019), this research examines the effect of adding colour and/or icons to official warning messages.

This research complements the increasing industry interest in developing a National Multi-Hazard Warning System that can promote clear understanding of warnings and appropriate protective action across Australian jurisdictions.

Methods

A total of 2,482 Australians across all states/territories participated in a survey.

Participants first read one of 16 mock emergency warnings (see Figure 1) about either a bushfire or a riverine flood that were variously presented without icons, with icons, in greyscale and colour (see Figure 2).

Participants then answered a series of questions about their demographic characteristics, message comprehension and effectiveness, threat appraisal and coping appraisal.

Data were analysed using two-way between-groups ANOVA.

Results

Adding colours and/or icons to the Evacuate Now (Bushfire) message creates small improvements:

- Adding a red header to the message improved the comprehensibility and effectiveness of the message
- The event described in the message is considered more likely when either a coloured icon or no colour/icon is used.
- Adding a red header to the message improved how confident participants felt in their ability to complete the action.

While these improvements are small from a statistical standpoint, the effect small changes can have at a population level are likely impactful, especially when message improvements can save lives, properties and reduce harm.

The other three messages showed no improvement (or loss) in message comprehension, effectiveness, threat appraisal, or coping appraisal as a result of adding colours and/or icons. Colours and/or icons might be useful, however, to aid the interpretation of less well-worded emergency warning messages if they reduce uncertainty.

For more information, please email dominique.greer@qut.edu.au

Figure 1. Mock emergency warning (1 of 16)

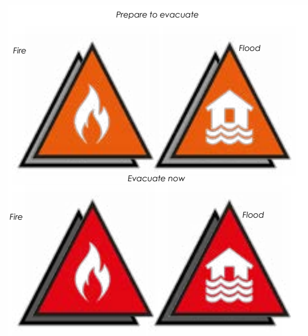


Figure2: Example icons in colour and greyscale

Australian Government
Department of Industry, Science, Energy and Resources
Business Cooperative Research Centres Program

© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au

bushfire&natural HAZARDSCRC

Comprehensive School Safety: A participatory approach to school bushfire emergency management planning.

Matthew Henry
Central Queensland University, School of Human Health and Social Sciences, QLD
Bushfire and Natural Hazards CRC, VIC
Supervisors : Professor Ken Purnell & Dr. Briony Towers

A participatory approach to school bushfire emergency management planning.
Although schools have an emergency management plan for bushfire to keep students, staff and the broader school community safe, are these plans effective during a bushfire event?
This research will examine the degree of involvement of the principal, students, staff, parents and community stakeholders in school bushfire planning, how concerned each group are about bushfire risk and whether the school community believe they could be more involved in school bushfire planning. The project will use a participatory action research (PAR) methodology to work collaboratively with the school principal, teachers, students, parents and members of the school community to investigate effective participatory approaches to school bushfire planning.

The UN-level Comprehensive School Safety (CSS) framework (UNESCO/UNICEF, 2014) provides a detailed and coordinated approach to reducing all hazard risks to the education sector. The CSS provides a guiding framework that can be customised to the Victorian school setting to facilitate the development of a participatory approach to school bushfire emergency management planning.

Research questions
1.Are current school bushfire emergency management planning policies and practices sufficient to be effective during a bushfire event?
2. Does the development of a participatory approach to school bushfire emergency management planning have the capacity to improve planning effectiveness?

Research Aims
1.Examine current school policies and practice related to school bushfire emergency management planning.
2.Investigate opportunities for the implementation of a participatory approach to effective school bushfire emergency management planning.

The research will involve:
- A Participatory Capacity and Vulnerability Analysis (PCVA) Focus group interviews with students
- Transect walk with students/school staff
- Risk and resource hazard mapping exercises
- Semi structured interviews with the school principal teaching staff, parents/carers, community stakeholders

A participatory approach to school bushfire emergency management planning, and the adoption of a school safety framework specifically designed for the Victorian school setting, has the potential to enable school communities to better prepare for, mitigate, respond to and recover from the impacts of bushfire.

• (Source, GADRRRES, 2014)

Australian Government Department of Industry, Science, Energy and Resources
Business Cooperative Research Centres Program
CQUniversity AUSTRALIA

© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au

FINDINGS

Easily achievable **fire-fitness** strategies **normalise preparedness** to become a **routine** part of daily life, narrowing the **awareness-action gap**.

Advancing public health in the context of natural hazards: normalising preparedness within a framework of adapted Protection Motivation Theory.

Rachel Westcott[1,2]

[1] Bushfire and Natural Hazards CRC, Victoria
[2] Engine Room Solutions Pty Ltd, South Australia

This project proposes public health policy and processes to assist people to negotiate natural hazards in an increasingly hostile, climate change induced environment. This is achieved by normalising preparedness – to make "fire-fitness" routine and everyday. With data gathered from a diverse regional community in South Australia this predominantly qualitative research adapted Protection Motivation Theory (PMT) and used Thematic Analysis (TA) to identify strategies which favour beneficial outcomes for individuals, communities and their immediate social microclimates. Locally bespoke and societal-wide applications are recommended to help narrow the awareness-action gap, promote public safety and well-being and identify topics requiring further research.

Introduction

The *awareness-preparedness gap* – i.e. the mismatch between people's *awareness* and *readiness* to manage a hazard threat and treat risk - is widely acknowledged as persistently too large. While the magnitude of the gap remains, human morbidity and mortality in bushfire (and other) natural hazards will not be significantly reduced; people will continue to make poor decisions, thereby perpetuating the cycle of negative outcomes and ramifications emergency responders routinely encounter.

Previous studies have contributed to addressing this problem, but none have identified the need to establish a preceding culture of normalised preparedness, which this author has named "fire-fitness" (trademark pending).

Methods

Data collection took place in a bushfire at-risk regional area in South Australia from June to August 2015. Two demographically diverse groups - animal owners and Emergency responders participated in eight focus groups (n=72) and 32 individual interviews. A pilot survey (n=37) of livestock and cropland primary producers completed the data collection phase.

Results and Discussion

Findings were grouped into six main categories of strategies and proactive, potentially life-saving public health and safety policies with each aiming to make preparedness as routine as buying the groceries or fuelling a car.

Proposed categories are:

- A new type of workplace leave: Catastrophic Day/Extreme Fire Weather Leave
- Financial incentives
- Effective use of the social microclimate - synchronous, synergistic delivery of information
- Acknowledging and rewarding best practice fire-fitness
- Adaptive rewards – that an action is gainful - and dynamic risk assessment
- Cropland fires: use of firebreaks, crop types and crop placement and planting around assets

Each of these strategies contributes to cultivating a culture of preparedness over the short, medium and long terms. Importantly, a fire-fitness program for any given group must be locally relevant and bespoke.

Future use of this research

The recommendations from this research are readily achievable and need only some visionary advocacy to instigate and trial. None require regulatory or legislative action to implement. These strategies are *not* intended to replace preparedness campaigns. Rather, they are designed to change the preparedness environment by establishing a *preceding* culture of fire-fitness as a routine social norm – to develop a prescient suite of lifestyle adaptations to confront and manage the 'new reality' of extreme weather events.

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

For more information, please email:
rachel@engineroomsolutions.com.au

The complete project can be accessed at:
https://researchdirect.westernsydney.edu.au/islandora/object/uws%3A49051

Figures

Figure 1: Research rationale – broad summary of key elements. The word "human" is used wholistically. Adverse environmental and animal impacts which inevitably affect humans are assumed inclusions.

Figure 2: A new type of workplace leave, financial incentives and synchronicity in the social microclimate are some fire-fitness strategies to normalise preparedness.

Australian Government
Department of Industry, Science, Energy and Resources
Business Cooperative Research Centres Program
ENGINE ROOM SOLUTIONS
Accelerating Excellence
Scan me
WESTERN SYDNEY UNIVERSITY

© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au

bushfire&natural HAZARDS CRC

FINDINGS

Personality traits and sociocultural environment predict floodwater driving

Nurturing to avoid nature: The influence of personality traits and cultural worldview on floodwater driving

Shauntelle Benjamin, Dr Amy Lykins, Dr Melissa Parsons
University of New England, New South Wales

While we are beginning to understand the demographics of who is most likely to drive through floodwaters, we know less about individual-level characteristics that influence this decision. Our study aimed to find whether personality factors can influence this behavior. We found that agreeableness, extraversion and neuroticism, as well as cultural worldviews can predict whether an individual would drive through floodwaters. Overall, perception of peer pressure appears to be a powerful indicator of floodwater driving.

Introduction

Floodwater driving as a behaviour continues to increase, despite pleas to the public to avoid it. While there is a growing body of research investigating the demographics on who engages in floodwater driving and why they may do so, our study aimed to examine whether personality traits (which are expected to remain relatively stable across lifespan) on an individual level may be interfering with attempts to alter group behaviour.

Methods

Participants (N=250) were asked to complete an online survey, including the International Personality Item Pool and Cultural Cognition Scale, in order to assess their psychological characteristics. Following this, they were asked to engage with a Situational Judgement Test: a series of three written vignettes designed to explore their reaction to risk and rank their likely responses to each of three driving conditions—the first in which they arrive at a flooded road and decide in isolation, the second where a car arrives behind them (to assess for social pressure) and the third in which the car overtakes them and they choose whether to follow.

Results

A multinomial logistic regression showed that in the first two conditions, individuals high in agreeableness would be significantly more likely to attempt to cross. Additionally, in the second condition, those high in neuroticism would be more likely to attempt a crossing than ignore the person behind them, while those who reported high extraversion would continue to assess for themselves. The third condition suggested that personality traits did not have any significant impact on driver behaviour, rather the decision to drive through was based on group culture signifiers: which are related to hierarchism and egalitarianism.
From a cluster perspective, absent of any explicit social nudging (Condition 1), early latent class analysis reveals two groups or classes of individuals: Individuals in Class 1 (Figures 1) are more likely to attempt a crossing immediately. They are characterised by higher neuroticism, and responded that making the decision increased their anxiety more significantly than those in Class 2 (Figure 2). Class 2 individuals were characterised by higher levels of extraversion, agreeableness and conscientiousness, and as such would be more likely to hesitate to consider the behaviour.

Discussion

While we knew that social factors were involved in floodwater driving behaviour, we didn't necessarily know the extent to which it was affecting behaviour, or the number of levels at which it has that effect. Future research could confirm and implement these results in a number of ways:

- Due to the number of participants, the present study did not use a clinically recommended measure of personality. Further research would be well served to do so with samples geared toward agreeableness and extraversion and specific assessment for social anxiety.
- As neuroticism is often conceptualised as the experience of intense moods (which can be symptoms of anxiety or depression), it is possible that treatment for social anxiety may reduce the intensity of the anxiety experienced by decision-making. Further research focused solely on neuroticism could be beneficial to understand the differences in these responses.
- Current research has leaned toward addressing generic signage to reduce floodwater behaviour. More specific signage designed to capture the thought processes of different personality traits may see more success.
- It may be beneficial to see whether providing psychoeducation or more intense treatment to individuals experiencing peer pressure in the context of personality traits would make a significant difference to behaviour.

Figures

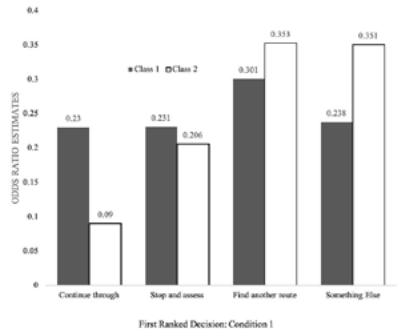


Figure1: Primary Decision made in Condition 1

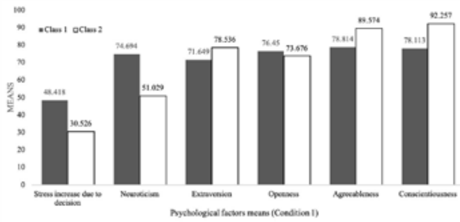


Figure 2: Psychological factor means

For more information, please email
Shauntelle Benjamin sbenjam3@myune.edu.au
Dr Amy Lykins alykins@une.edu.au
Dr Melissa Parsons mparsons@une.edu.au

Australian Government Department of Industry, Science, Energy and Resources | Business Cooperative Research Centres Program

une University of New England

© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au

FINDINGS

Understanding the need for, availability of, and interpretation of information by the public during large scale hazard events.

Katherine Akers [1,2]

[1] Bushfire and Natural Hazards CRC, Victoria
[2] Massey University, New Zealand

In partnership with Fire and Emergency New Zealand, QuakeCoRE, GNS Science and the ECLIPSE supervolcano project, this PhD project is looking at the challenges facing specific communities and populations in accessing and understanding emergency information during large scale hazard events.

Introduction

The project will be assessing the relationship that people have with natural hazards in their region by conducting a range of risk perception surveys.

Methods

Co-production methods will be assessed for risk mitigation and preparedness implementation. A mixed-methods approach will be used, with data collected from a range of communities located in the Taupō Volcanic Zone to identify the factors that influence audience needs, availability and interpretation of emergency information. Guidelines can then be developed for emergency managers and other providers for the improved communication with the diverse range of audiences involved in a natural hazard response.

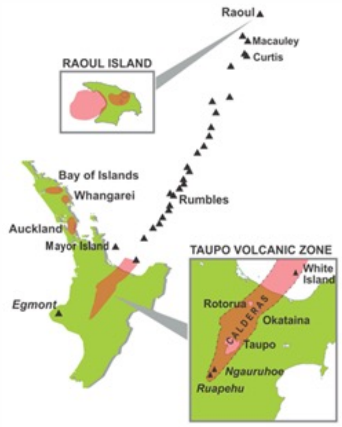
The socio-cultural context in which the public needs, has access to, and interprets information about natural hazards differs radically. This has implications for the effective communication of information during large scale hazard events. This audience heterogeneity presents challenges for the communication of critical information. Improved understanding of the audiences, and regular work across the spectrum of community sectors, is essential to enable effective readiness and resilience.
This project positions community at its heart and focuses on lessons from recent disasters and on research into the production of consistent and coherent public messages to instill credibility, public trust and confidence.

Research Questions

- What common communication principles can be identified for effective communication across diverse audiences during large scale hazard events?
- How does information contribute to community resilience?
- What are the features and attributes of trusted information sources and channels?
- What aspects influence whether all members of the public receive and understand hazard warning information during large scale hazard events?
- What's already in the emergency managers' toolbox of hazard communication and processes for disseminating warnings, and how effective has messaging been?

This project will investigate whether the co-production of risk mitigation solutions – through participatory outreach approaches with schools and the wider community – can enable those sectors of the public to become change agents to effectively interpret, manage and mitigate the threats associated with large-scale hazard events.

For more information, please email k.akers@massey.ac.nz



The project study area: Taupo Volcanic Zone in New Zealand's central North Island.
Image credit: GNS Science

Australian Government Department of Industry, Science, Energy and Resources | Business Cooperative Research Centres Program

MASSEY UNIVERSITY TE KUNENGA KI PŪREHUROA UNIVERSITY OF NEW ZEALAND

ECLIPSE

© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au

bushfire&natural HAZARDSCRC

"What is essential is to realize that children learn independently, not in bunches; that they learn out of interest and curiosity, not to please or appease the adults in power; and that they ought to be in control of their own learning, deciding for themselves what they want to learn and how they want to learn it."

~ John Holt (1967), How Children Learn

Through Children's Eyes: Disaster Risk Reduction Education for Children, with Children and by Children

Mayeda Rashid[1,2], JC Gaillard[3], Kevin Ronan[1,2], Quamrul Alam[2], Briony Towers[1,4]

[1] Bushfire and Natural Hazards CRC, Victoria
[2] Central Queensland University, Australia
[3] University of Auckland, New Zealand
[4] RMIT University, Australia

Introduction

Over the last decade, a number of studies have investigated the benefits of disaster risk reduction (DRR) education programs for children. Although these studies suggest positive outcomes, they are primarily based on the evaluations of adult researchers, such as those undertaken by Non-Government Organisations (NGOs), and many of them have significant methodological limitations. This PhD aimed to overcome these challenges by conducting rigorous research on DRR education in Bangladesh through the eyes of children. This involved children serving as co-researchers alongside the PhD researcher.

Methods

The power inequalities between children and adult researchers are inevitable for obvious reasons, namely the age differential, the lack of experience of children in research, and above all, the existing accountability mechanism in academia. In an attempt to effectively minimise the power differential, the study has incorporated child-friendly methods and techniques which are built on children's competencies and interests. Most importantly, in recognition of children's right "to be provided the opportunity to be heard" (UNICR, 1989) and co-researchers' right to communication of research findings, a complete chapter has written by the child co-researchers (which is also the largest chapter in this thesis). The children have also contributed another substantial section in the conclusion chapter.

Results and Implications

The The PhD project makes a significant contribution to our theoretical understanding of DRR education from children perspectives. It provides evidence to support improvements in policy and practice. The recommendations in the thesis made by the child co-researchers can be used as guiding principles in the design and implementation of CC-DRR-focused participatory education programs. Thus government organisations, NGOs, emergency management agencies, schools, communities and, in particular and ultimately, children will benefit as a consequence of this study.

Most importantly, by bringing children on board as co-researchers, the study provides a framework for empowering children's participation in disaster research. Thus the research also contributes in designing child participatory research methods. Finally, the thesis is also expected to encourage future researchers to empower children as co-researchers and foster their genuine participation in research.

For more information, please email mayeda.rashid@cqu.edu.au

Tables and figures

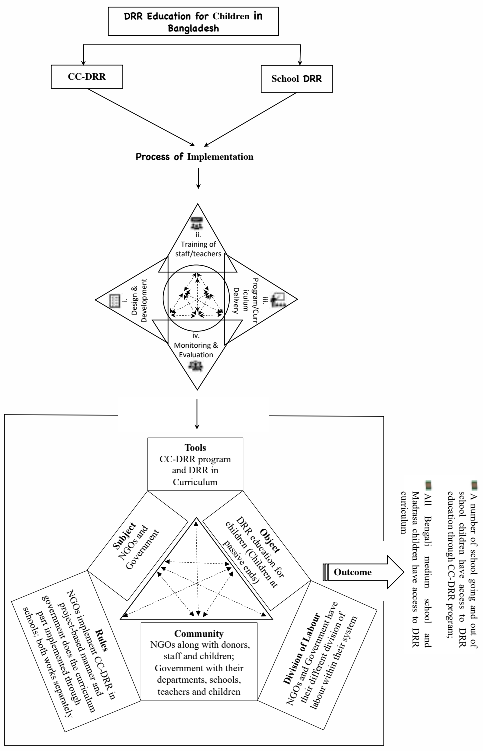


Figure1: Activity framework of DRR Education for children in Bangladesh (adapted from Engeström, 1987)

Australian Government Department of Industry, Science, Energy and Resources | Business Cooperative Research Centres Program | CQUniversity Australia | The University of Auckland New Zealand | RMIT University

© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au

Extreme Weather

bushfire&natural HAZARDSCRC

FINDINGS

A better understanding of the built environment can **improve forecasts of wind impact** on residential buildings.

Impact-based forecasting for the coastal zone: East Coast Lows

Harald Richter[1,3], Craig Arthur[2,3], David Wilke[1,3], Beth Ebert[1,3], Mark Dunford[2,3], Martin Wehner[2,3]

[1] Bureau of Meteorology, Victoria
[2] Geoscience Australia, Australian Capital Territory
[3] Bushfire and Natural Hazards CRC, Victoria

Preliminary evidence shows that a prototype residential wind impact forecast, based on the 10-m wind gust from an NWP model and available vulnerability and exposure data, outperforms a wind-based implementation of warning criteria currently used by the Bureau of Meteorology.

Introduction

This project presents a pilot study predicting the **impact of extreme wind** on residential buildings in Australia. The aim is to improve mitigating actions by a range of stakeholders, including emergency services. As part of the project we developed and verified prototype **wind impact forecasts** for the **April 2015 East Coast Low (ECL)**. This event brought significant damage to parts of NSW near Newcastle including the loss of three lives in the town of Dungog.

Methods

Figure1: Impact forecast workflow

We tested four **wind impact forecasts** based on differing measures of the wind strength from the BARRA-SY reanalysis. These are the event maxima of the surface mean wind, the surface wind gusts, the 900hPa wind and the max. gust within 40 km of a point.

The impact is determined via Figure 1, using residential building exposure data from the **National Exposure Information System (NEXIS)** and idealised heuristic vulnerability curves.

The forecast is expressed as a mean structural loss ratio which we convert to a mean damage state for each SA1 area in three categories: nil, minor and major (Figure 2).

To verify the forecast performance we use Rapid Damage Assessment (RDA) data from the **NSW Emergency Information Coordination Unit (EICU).**

The EICU data records the damage to a building in 5 categories; 1: 'no damage', 2: 'minor', 3: 'major', 4: 'severe' and 5: 'destroyed'.

To compare to the forecasts, observations are filtered to remove damage not due to wind, averaged over SA1 areas, then converted to 3 categories by combining states 2&3 (minor) and 4&5 (major) in the EICU data, shown in figure 2.

We also define a 3-category **reference forecast** which derives the damage state using wind gust warning criteria: nil < 90 km/h; minor: ≥ 90 km/h (**damaging**); major: ≥ 120 km/h (**destructive**). The reference forecast (also shown in figure 2) uses no exposure or vulnerability information.

Results

For predicting wind impact, the **surface wind gust** performed better than the other measures of wind strength. It has an accuracy of 61% which, after optimisation of the damage category thresholds, improves to 66%. Both **outperform the reference forecast** which has an accuracy of only 35%, illustrating that vulnerability and exposure data can add value. The results for the calibrated and reference forecast are compared with observations in Table 1 and Figure 3.

Discussion

The gust impact forecast shows promise at identifying residential areas most impacted by wind. More detailed damage data is needed to improve confidence in performance and further develop the forecasts. We suggest that future **damage reports collect information related to the causative hazard and damage magnitude** to assist quantitative impact forecast development.

For more information, please email harald.richter@bom.gov.au

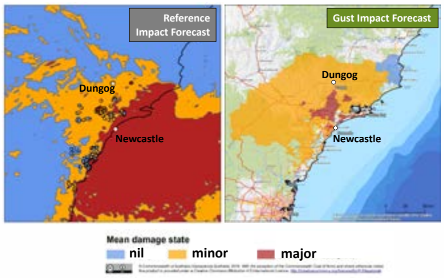


Figure 2: Impact forecasts for the April 2015 ECL. Left; the reference impact forecast based on the event maximum wind gust from BARRA-SY with re-categorised EICU observations overlayed, right; the corresponding SA1 residential gust impact forecast.

Reference (Forecast × Observed)

Forecast \ Observed	nil	minor	major
nil	2	0	0
minor	20	27	2
major	11	20	0

Gust Impact (Forecast × Observed)

Forecast \ Observed	nil	minor	major
nil	11	3	0
minor	21	43	2
major	1	1	0

Table 1: Contingency tables for the reference and calibrated gust impact forecast/observation pairs. The reference forecast has a significant over-forecast bias with 20 SA1 areas forecast in the major damage state but observed with minor damage, shown in red.

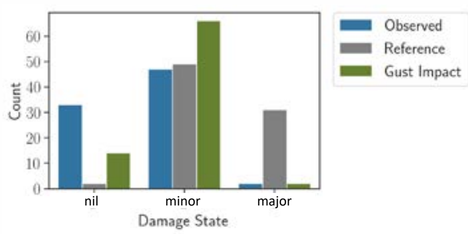


Figure 3: A histogram showing the three-category distribution of observed damage categories, predicted damage categories based on calibrated gusts and the reference impact forecast based on BoM warning criteria.

Australian Government
Department of Industry, Science, Energy and Resources
Business Cooperative Research Centres Program

Australian Government
Bureau of Meteorology
Geoscience Australia

© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au

FINDINGS

High-resolution simulations provide valuable insight into the meteorology of the Tathra bushfire.

Improved predictions of severe weather: The meteorology of the Tathra bushfire

David Wilke[1,2], Jeff Kepert[1,2], Kevin Tory[1,2], Paul Fox-Hughes[1,2]

[1] Bushfire and Natural Hazards CRC, Victoria
[2] Bureau of Meteorology, Victoria

Very high-resolution simulations reveal the extreme conditions that drove the Tathra bushfire: a result of complex interactions between mountain waves, organised convection and the passage of a frontal system.

Introduction

On the 18th March 2018, a fire started at **Reedy Swamp** within the Bega Valley Shire on the New South Wales South Coast. Aided by the passage of a strong cold front, the fire burned into the town of **Tathra** during the mid-afternoon, leading to the evacuation of the township and the **destruction of 70 homes** and other structures.

Methods

We compare observations with **very high-resolution** numerical weather simulations. While forecast models typically run at 1.5km resolution or coarser, we run research simulations to **400m** and **100m** (figure 1).

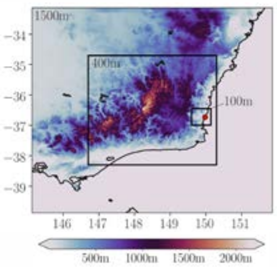


Figure 1: The three highest-resolution domains and orography. The red circle is Tathra.

Results

At high resolution, fine-scale details help to explain the observed conditions (figure 2):

Mountain waves (figure 3) likely contributed to the strong wind event around the time the fire started and may have influenced the severity of peak fire weather in the afternoon.

Boundary layer rolls (figure 4) were responsible for strong gradients in windspeed and vertical velocity, with their movement generating highly variable conditions at a point, as observed at Bega (figure 2), and across the fireground. The rolls likely contributed to the **mass spotting** and **enhanced lee slope fire behaviour** observed near Vimy ridge; crucial for the fires jump of the Bega River and subsequent attack on Tathra.

The **frontal passage was complex,** with the cool change pushing through Merimbula around 16:30 AEDT, only for hot and gusty conditions to redevelop 20 minutes later (figure 2). The 100m simulation shows this was likely a result of interactions between **boundary layer rolls** and the developing change, which may have taken a full 2 hours to push over the fireground. As a result conditions during this period at times **oscillated unpredictably between extremes**.

Discussion

This study illustrates the utility of high-resolution simulations in understanding, and predicting, **high impact weather.** It also highlights the significant spatio-temporal variation often present in **dangerous fire weather** conditions, especially near the coast or topography, and the importance of capturing this variation in forecasts and warnings to better **predict** and **respond** to **extreme fires**.

For more information, please email david.wilke@bom.gov.au

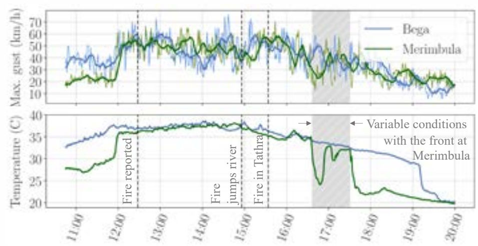


Figure 2: One-minute observations at **Bega** and **Merimbula**, the nearest weather stations to the fire. Time is in AEDT on March 18th, 2018.

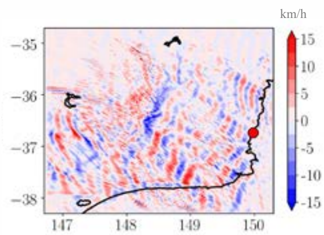


Figure 3: The 400m simulation vertical velocity at 3.5km above sea level at 11:45 AEDT, shortly before the fire was reported. The red circle is Tathra. Note the banded **trapped lee waves** of **ascending** and **descending** air.

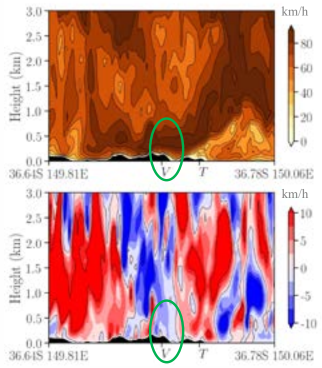


Figure 4: Vertical cross-sections through the path of the fire of the 100m simulation windspeed (top) and vertical velocity (bottom) as a **boundary layer roll** impacts at 14:10 AEDT. Vimy ridge (*V*) and Tathra (*T*) are marked. Note the **descending** strong winds on the lee slope (circled), and the significant pockets of **ascending** air. Model windspeed near Vimy ridge is in **excess of 90 km/h**.

Australian Government Department of Industry, Science, Energy and Resources | Business Cooperative Research Centres Program

Australian Government Bureau of Meteorology

© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au

bushfire&natural HAZARDSCRC

FINDINGS

Our new method for calculating **bushfire ember transport** is **accurate** and **very fast.**

Improved Predictions of Severe Weather: Ember Transport

Jeff Kepert[1,2], Will Thurston[3], and Kevin Tory[1,2]

[1] Bushfire and Natural Hazards CRC, Victoria
[2] Bureau of Meteorology, Victoria
[3] Met Office, Exeter, U.K.

This project has explored several aspects of severe weather, including fire, severe thunderstorms and tropical cyclones. This component aims to develop a computationally efficient way of predicting long-range ember transport within bushfire plumes.

Introduction

Embers accelerate fire spread and make it less predictable. They contribute to fires breaking control lines and are a major factor in house loss.

This poster describes a new, rapid method for predicting how far bushfire embers will travel.

Ingredients

The plume model
We use the bulk equations for plume rise, similar to but more sophisticated than the Briggs model used in our pyrocumulonimbus firepower threshold work. These tell us the plume structure, rise and updraft strength, depending on the fire strength, environmental winds and stability.

Plume turbulence
The flow in plumes is naturally unsteady (turbulent), and these fluctuations increase the maximum transport distance. Two quantities matter – the strength, and the spatial scale, of the fluctuations. We have developed statistical models for both, based on over 40 simulations of plumes in a large-eddy model.

Ember shedding from the plume
At each step along the plume, the probability that an ember falls is proportional to the probability that the total updraft (mean + turbulence) is less than the ember fall velocity, divided by the spatial scale of the turbulence. We integrate this quantity along the plume to get the fall-out distribution

Ember fallout
Once embers fall out of the plume, they are advected by the winds below as they fall.

Results

The figures to the right compare the ember landing patterns simulated at very high resolution, using a large-eddy model and explicit ember transport, by Thurston et al (2017), to those with the new method. Good agreement is apparent, except that the parameterization presently overpredicts ember density at long range, especially for the high fall velocity case.

Thurston et al.'s simulations each required **thousands of CPU hours** on a supercomputer. The new method takes **less than a second** on a desktop PC.

Next steps

We need to complete our validation of the method against Thurston et al.'s simulations, improve the long-range performance, and extend the method to work when the wind direction changes with height.

Then, we will implement it in a fire spread model, and examine how it performs in some chosen fire events.

Finally, we will document the method so that it is useable by others.

Thurston, W., Kepert, J. D., Tory, K. J. and Fawcett, R. J. B., 2017: The contribution of turbulent plume dynamics to long-range spotting. *Int. J. Wildland Fire*, **26**, 317–330, doi:10.1071/WF16142

For more information, please email Jeff.Kepert@bom.gov.au

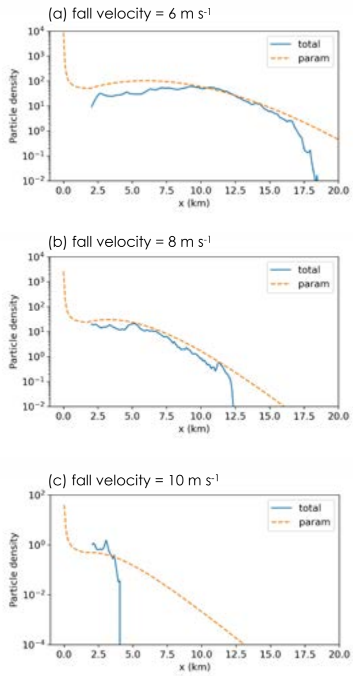


Figure1: Results from the ember transport parameterization. All cases are for a 250-m radius fire with heat flux 100 kW m^{-2}, in a turbulent boundary layer with gradient wind speed 15 m s^{-1}. The blue curves show the data from Thurston et al (2017), and the orange dashed curves are the parameterization. Data are plotted against downwind distance, and are the total number of embers, summed across the wind direction. Ember fall velocity is (a) 6 m s^{-1}. (b) 8 m s^{-1} and (c) 10 m s^{-1}.

Australian Government
Department of Industry, Science, Energy and Resources
Business Cooperative Research Centres Program

Australian Government
Bureau of Meteorology

© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au

bushfire&natural HAZARDSCRC

FINDINGS

"The PFT provided very useful guidance to forecasters briefing emergency services." *

Real-time trial of the Pyrocumulonimbus Firepower Threshold: A prediction tool for deep moist pyroconvection

Kevin Tory and Jeff Kepert[1,2]

[1] Bushfire and Natural Hazards CRC, Victoria
[2] Bureau of Meteorology

Following the success of the real-time trial of a pyrocumulonimbus firepower threshold (PFT) forecasting diagnostic during the 2019/2020 southern Australian fire season, there has been overwhelming support from fire-weather forecasters and fire-behaviour analysts to improve usability for the next fire season. Planned improvements include: increasing the output frequency, optimizing display features and improving access to forecast products. Additional fine-tuning and adjustments to the suite of products are also planned.

Introduction

The PFT was designed to help predict deep, moist pyroconvection (MPC) including fire-generated thunderstorms. It provides a theoretical estimate of the minimum firepower required to generate deep MPC in the fire plume. The PFT flag is designed to identify the specific range of conditions that support both large and intense fires and moist plume development, necessary for deep MPC. It is essentially the PFT divided by a modified fire danger index. Examples are provided in Fig. 1. Forecast plots of these fields were provided to fire-weather forecasters and fire-behaviour analysts twice-daily for six regions around Australia, at six-hourly intervals.

Performance

The PFT and PFT flag provided very useful guidance for almost all deep MPC cases including most fire-generated thunderstorms. It became apparent during the trial that favourable conditions can vary greatly in space and time, especially when associated with relatively small-scale meteorological features such as wind-change lines. High spatial and temporal resolution forecasts were produced manually for high-risk events, when possible, and found to provide a substantial increase in forecast value.

Product development feedback

Users expressed interest in a number of product developments to improve ease of use, including: additional labelling to more easily relate the timing of PFT features as they approach fire locations (e.g., local time, fire-district boundaries, prominent topography); more accessible forecast products; and forecast data that can be incorporated into existing display systems. Additional feedback identified areas to improve the accuracy of the PFT and PFT flag.

Utilization Project

The utilization project aims to implement, as much as possible, the feedback development ideas raised by users. This will include:

- Substantial improvements in computing efficiency to enable more forecast domains to be run, including the routine running of high-resolution forecasts from operational numerical weather prediction models.
- Improved labelling to more easily identify threat location and timing
- Password-protected web access to forecast products
- Tuning to eliminate false triggering of the PFT flag during cold-outbreaks (e.g., Fig. 2).
- Incorporation of buoyancy losses from entrainment in the cloudy part of the plume.

Additional improvements will be added in consultation with end-users as the project progresses.

For more information, please email kevin.tory@bom.gov.au

Figures

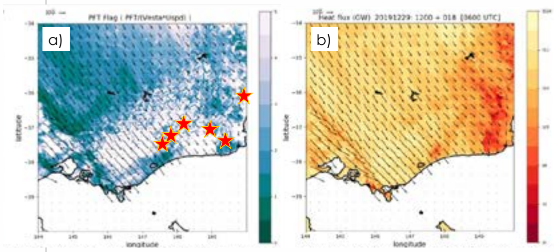


Figure 1: The most active day of the season, 30 December 2019 saw seven confirmed fire-generated thunderstorms on six fires (starred) and many more fires produced deep moist pyroconvection. a) PFT flag b) PFT. Darker shading indicates increasing favourability.

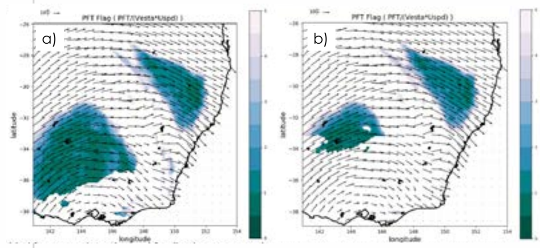


Figure2: PFT flag 6-hour forecasts, 0600 UTC 6 September 2019. (a) Original PFT flag, (b) PFT flag adjusted to reduce triggering over green vegetation during cold outbreaks. Two distinct patches are evident in both panels. The patch to the northeast correctly warned of the potential for deep MPC (e.g., Bees Nest fire), whereas the patch to the southwest was triggered during a cold outbreak. In (a) this includes regions with green vegetation, and in (b) the adjusted PFT flag removes the green-vegetation region.

* *Bureau of Meteorology specialist fire-weather forecaster*

Australian Government Department of Industry, Science, Energy and Resources | Business Cooperative Research Centres Program

Australian Government Bureau of Meteorology

© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au

bushfire&natural HAZARDSCRC

GOAL

Effective flash flood forecasts and warnings to improve risk awareness and encourage protective action

Improving Flash Flood Response Outcomes Through Emergency Warnings and Improved Regional Forecasting Techniques

PhD Candidate: Kim Robinson[1] **Supervisors:** Stuart Corney[1] | Paul-Fox Hughes[2] | Gabi Mocatta[3] | Chris White[4] **Research Advisors:** James Bennett[5] | Chris Irvine[6] | Fiona Ling[7] | Luke Roberts[6] | Carlos Velasco-Forero[2]

[1]Institute of Marine and Antarctic Studies, University of Tasmania | [2]Bureau of Meteorology | [3]Discipline of Geography and Spatial Sciences, University of Tasmania | [4]Department of Civil and Environmental Engineering, University of Strathclyde | [5]CSIRO Land and Water | [6]Tasmanian State Emergency Service | [7]WMAwater

Our research will review effective warnings and risk communication and consider the impacts of advances in technology. From here we'll assess the gaps between the data needed to inform this communication and what forecasting systems provide. This will allow us to make a contribution to the improvement of regional flash flood forecasting techniques.

Introduction

Short duration high intensity rainfall events result in a diverse range of flash flooding impacts both within and between catchments. Forecasting provides advance notice of these impacts. Effective warnings disseminate this forecast information in a manner that engages and informs their target audience, enabling emergency responders and transient, urban and rural populations alike to understand the potential impacts and take informed protective action.

What do we need from our forecasting system?

Warning-dissemination technology is advancing, and our ability to disseminate messages, images and complex multimedia to large audiences in near real-time is rapidly improving.

Modelling techniques are also advancing. Weather radar coupled to numerical weather predication models produces ensembles of nowcast rainfall. Hydrologic modelling techniques can provide statistically reliable probabilistic forecasts, and regional hydraulic models can produce animations of flood behaviour.

Smartphone applications and personal weather stations allow new data sources to feed back into forecasting systems and enhance the potential benefits of two-way communication.

This means we should be able to produce more effective forecast and warning systems. However, understanding how this data and technology is best used to ultimately result in more effective protective action is not straightforward.

A Tasmanian case study

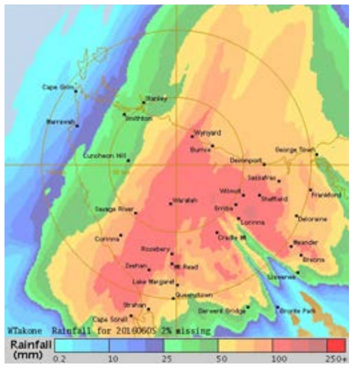
Our case study will be based in Tasmania, where, over the past 5 years, flash floods have cost lives and inflicted millions of dollars worth of damage (Figures 1 and 2). The state has varied topography, two operational weather radars and a dense hydrographic network. Weather systems are driven by multiple climate drivers and a state-wide hydrologic and hydraulic model is being developed.

For more information, please email kim.robinson@utas.edu.au

Figures

(ABC: Edith Bevan)

Figure 1: In May 2018 residents awoke to cars floating down the street in Hobart due to flash flooding on the Hobart Rivulet. Insurance claims in the region totalled close to $100 million[1].



(Bureau of Meteorology)

Figure 2: In June 2016 Tasmania experienced extensive floods, 3 lives were lost and damage estimates exceed $180 million[2]. One farm at Circular Head lost 200 cows in freak flash floods associated with the event[3]

References

[1]Cooper, E. (2019, May 19). *Tasmania's $100m floods still affecting homes and businesses one year on*. Australian Broadcasting Corporation.

[2]Rockliff, J. (2017, June 5). *Anniversary of June 2016 floods a time for reflection* (Issue June). Tasmanian Government.

[3]Dolan, C. (2017, June 3). *Looking back at the June 2016 floods that devastated Tasmania*. The Examiner.

Australian Government Department of Industry, Science, Energy and Resources | Business Cooperative Research Centres Program

University of Strathclyde | Australian Government Bureau of Meteorology | University of Tasmania | IMAS

© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au

Fire Predictive Services

bushfire&natural HAZARDSCRC

FINDINGS

Coupled modelling can provide the next level of value for fire danger forecasting, if it can be developed to be faster than real time, by enough to matter.

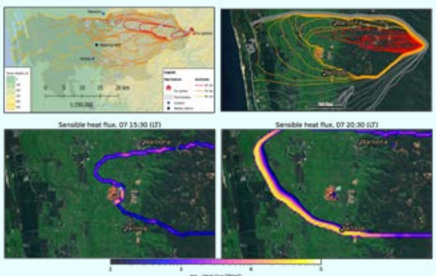
ACCESS-Fire: a case study

Jesse Greenslade[1,2], Mika Peace[1,2], Jeffrey D Kepert[1,2], Harvey Ye[1,2]

[1] Bureau of Meteorology
[2] Bushfire and Natural Hazards CRC

This work examines fire spread and related weather phenomena in a large-scale high-intensity fire over complex topography using a coupled atmosphere and fire spread model ACCESS-Fire. The simulated fire occurred in 2016, igniting ~20 km east of Waroona WA, and behaviour diverged from forecast fire spread metrics. This is due to the fire generating its own weather systems revealed here by coupled modelling.

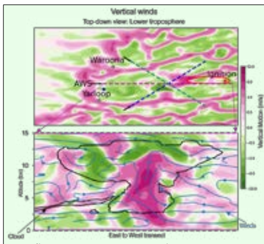
PyroCB near Waroona, 2016



Introduction

ACCESS is the Australian Community Climate and Earth-System Simulator - Australia's premier numerical weather prediction model. Coupled to a fire model by Melbourne and Monash Universities and BoM it allows pyrogenic heat and moisture to feed back into the simulated atmosphere.

The top left panel shows fire spread over three days, while the top right panel shows modelled spread for much of the first day (red), and the last nine hours of the second day (orange). Simulated spread does not include suppression efforts that occurred between Waroona and Yarloop. Ignition points (and spotting) are prescribed in the model. The bottom two panels show heat output at two different times. Notably both spread and intensity are qualitatively similar for these two days.

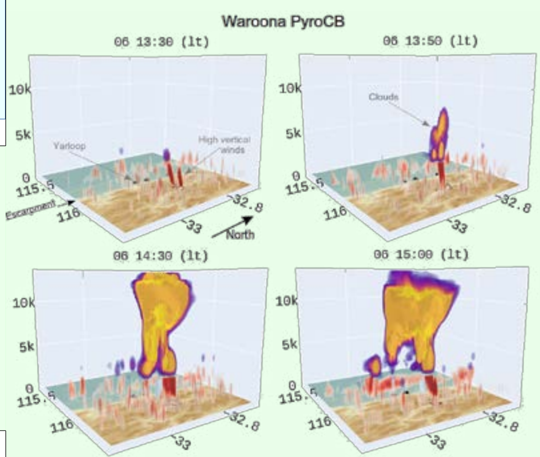


Pyrocumulonimbus (PyroCB)

The coupled model captured the formation of the PyroCB shown top-right. These often cause strong surface winds and lightning, both of which lead to unexpected fire spread. Strong winds lead to spotting when burning embers are transported in the elevated updrafts and turbulence. Waroona PyroCB or lightning were the most likely cause of downwind spotting on the first day of the fire.

The figure to the right shows PyroCB seen near Waroona, along with the formation seen in ACCESS-Fire output. The output is shown on 3D model levels up to 13.5km altitude above ground level, over topography with the escarpment labelled in the top left panel. The cloud formation follows high energy output at a time when the fire front expands rapidly westwards. This matches what was seen in the field.

The figure here shows a slice through the same PyroCB, highlighting the vertical motion (updrafts in pink and downdrafts in green). The updraft generated by the fire front can be seen to extend up to almost 13 km. The scale of this PyroCB is almost 40 km from east to west – lightning generated fires could easily occur distant from the front.



Modelled PyroCB formation: clouds form due to massive heat output as the fire spreads. Updrafts are shown in red in the lower 2 km of atmosphere.

Discussion

Coupled modelling can clearly capture complex phenomena such as PCB and downslope fire spread. This is a step towards improved understanding and forecasting of these life threatening events.

- Fire spread is accurate but requires realistic estimation of potential downwind spotting.
- PyroCB Formation and impacts could add value to danger warnings for fire suppression crews.
- Complex topography can lead to complex weather phenomena, which are difficult to accurately forecast using traditional fire danger indices.
- We can now run these simulations in better than real time, allowing, with the necessary infrastructure, for the possibility of operational use

For more information, please email jesse.greenslade@bom.gov.au

Australian Government
Department of Industry, Science, Energy and Resources
Business Cooperative Research Centres Program

Australian Government
Bureau of Meteorology

© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au

FINDINGS

Dynamic wind reduction factors have **considerable effects** on forest fires where **variable canopy heights** play important roles.

Dynamic wind reduction factor in predicting fire rate of spread

Mahmood Rashid[1], James Hilton[2], Duncan Sutherland[3], Khalid Moinuddin[1]

[1] Victoria University, Melbourne, Victoria, Australia
[2] Data61, CSIRO
[3] UNSW Canberra, ACT, Australia

The behaviour of fire is primarily governed by the wind flow and fuel types on the affected area. For the forest fire, tree canopies play an important role by reducing the wind velocity when it passes through the forest. The objective of this research is to apply a dynamic wind reduction factor (WRF) in an operational model to predict the fire rate of spread (RoS).

Introduction

Wind reduction factor is dynamic in nature, i.e., it changes with the wind velocity and fuel structures. For simplicity, fire behaviour analysts use a *rule-of-thumb* to estimate the WRF for a specific fuel type for operational fire prediction models e.g., in Spark [1], an operational fire simulation model developed by Data61 of CSIRO, the value of WRF is 3 for Eucalyptus forests. For a dynamic fire, passing through canopies, the relationship between the wind speed and RoS appears more complicated than can be described by a constant value as illustrated by Moon et al. [2], Sutherland et al. [3]. Although research on complicated fire canopy interactions is ongoing, we have made a significant progress in enhancing RoS prediction in an operational model.

Methods

In our study, we are using Harman-Finnigan model [4] model to calculate dynamic WRF. The Harman-Finnigan model for flow in and above a uniformly distributed tree canopy is a three layers model:

- Subcanopy - the Inoue Model [5] for subcanopy flow is used within the canopy
- Shear layer - across the top of the canopy and immediately above the canopy - the Raupach Model [6] is used, and
- Displaced Log-Layer - above the canopy.

In our model WRF is calculated as:

$$wrf = \frac{U_{10}}{u_z}$$

where, U_{10} is open wind speed at 10 m above the ground and u_z is the sub-canopy wind velocity at various heights.

Towards calculating WRF, we prepare raster maps of leaf area index (LAI) and vegetation height data respectively obtained from [7] and [8] to feed in Spark (e.g., Figure 1 (a) and (b) are the prepared raster maps of the area of 2009 Kilmore Fire, VIC).

Results

We tested our model with synthetic leaf area density (LAD) data to calculate WRF and apply that to Spark. The outcome of Spark's two variant (i) base spark and (ii) spark with our model applying WRF are presented in Figure 2 (a) and (b).

Further, we run our model on eight actual bushfire cases (e.g., Lithgow 2013, Kilmore 2009, Forcett 2013, Wangary 2005 and others) to assess capability of our model. Figure 3 (a) and (b) present the outcomes of the 2009 Kilmore fire where 3(a) represents the fire without applying WRF and 3(b) represents fire after applying dynamic WRF. Black lines represent the final perimeter of the actual fire.

Discussion

In our results, the effects of dynamic WRF is evident, which is producing better predictions relative to the results with constant WRF. However, we observed some inconsistency in RoS in a few cases and our initial assumption is, this might happen because of very low resolution (*1km x 1km*) of the vegetation height data in comparison to Spark's high resolution (*30m x 30m*). We aim to investigate further to find the root-cause.

References

1. C. Miller, J. Hilton, A. Sullivan, M. Prakash, Spark - a bushfire spread prediction tool, Environmental Software Systems, 2015
2. K. Moon, T. Duff, K. Tolhurst, Sub-canopy forest winds: understanding wind profiles for fire behaviour simulation, Fire Safety Journal, 2016
3. D. Sutherland, J. Philip, A. Ooi, K. Moinuddin, Large eddy simulation of flow over stream-wise heterogeneous canopies: Quadrant analysis, Australasian Fluid Mechanics Conference, 2018.
4. I. Harman, J. Finnigan, A simple unified theory for flow in the canopy and roughness sublayer, Boundary-Layer, 2007
5. E. Inoue, On the turbulent structure of air flow within, Journal of the Meteorological Society of Japan, 1963
6. M. R. Raupach, Drag and drag partition on rough surfaces, Boundary-Layer Meteorology, 1992
7. TERN and ANU - Landscape Data Visualiser, https://maps.tern.org.au/#/, 2019
8. M. Simard, N. Pinto, J. B. Fisher, A. Baccini, Mapping forest canopy height globally with spaceborne lidar, Journal of Geographical Research, 2011.

For more information, please email khalid.Moinuddin@vu.edu.au

Tables and figures

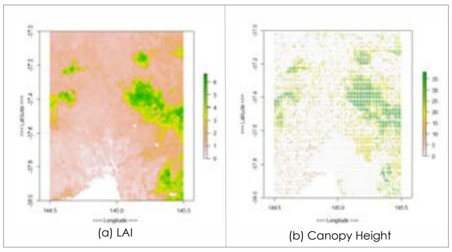


Figure 1: The raster maps of 2009 Kilmore fire incident area in Victoria. (a) the LAI raster map obtained from landscape data [7] and (b) the canopy height raster map obtained from Vegetation Height for Australia [8].

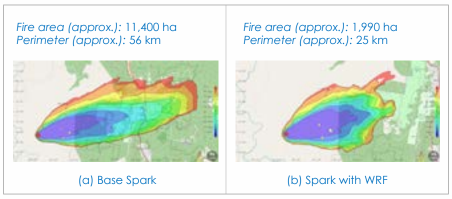


Figure 2: Effect of WRF on RoS on a random point fire. (a) the outcomes of Spark's base implementation; (b) the outcome of Spark after implementing our model with a calculated WRF obtained from a LAD value of 0.20.

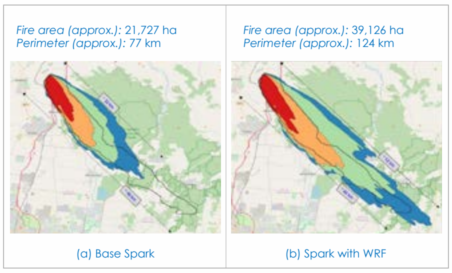


Figure 3: Kilmore Fire, VIC, 2009. towards finding and and applying WRF. (a) LAD is worked out from LAI raster data shown in Figure 1(a) using a uniform canopy height of 10 metres; (b) LAD is worked out from LAI raster data using actual height raster data shown in Figure 1(a) and (b) respectively. The black dotted line represents the recorded fire perimeter.

Australian Government
Department of Industry, Science, Energy and Resources
Business Cooperative Research Centres Program
bushfire&natural HAZARDSCRC
VICTORIA UNIVERSITY MELBOURNE AUSTRALIA

© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au

FINDINGS

bushfire&natural HAZARDSCRC

Real time wildfire detection trial using Himawari-8

Fire Surveillance and hazard mapping

Dr. Chermelle Engel[1,2], Prof. Simon Jones[1,2], Assoc. Prof. Karin Reinke[1,2]

[1] Bushfire and Natural Hazards CRC, Victoria
[2] RMIT University, Victoria

A real-time active fire hotspot detection algorithm was developed and trialed, with the active fire hotspots delivered in real-time to the NSW RFS. The trial demonstrated the timeliness and accuracy of the RMIT active fire hotspot method by comparison to MODIS overpasses and indicated possible areas for future research.

Introduction

Detecting active fires is critical for the protection of lives and property. While many tools exist for detecting active fires in the Australian landscape, new techniques providing enhanced temporal coverage and real time capability are needed. One option being explored is remotely sensed data from the Himawari-8 geostationary satellite. Himawari-8 provides remotely sensed observations over Australia every 10-minutes. In 2018, the RMIT team designed an algorithm to detect active fires in Australia using historical Himawari-8 data. This previous work created the desire for a similarly designed real-time algorithm.

Methods

A real-time RMIT Himawari-8 active fire algorithm was created and run over the whole of New South Wales and Victoria from 15th March 2019 to 23rd March 2020. Himawari-8 data was received in real-time from the Japan Meteorological Agency via the Bureau of Meteorology. Himawari-8 reflectance (0.64 µm, channel 3) , mid-infrared (3.9 µm, channel 7) and thermal infrared (10.7 µm, channel 13) were stratified according to Interim Biogeographical Regionalisation of Australia (IBRA) sub-regions and statistically compared with historical Himawari-8 data at the same time of day from the 4-weeks prior. Hotspots were determined using real-time data and delivered to the NSW RFS in real-time.

Results

Active-fire hotspots were to delivered to NSW RFS within two minutes of Himawari-8 data being received for processing. RMIT/Himwari-8 hotspots were compared against Fire Information for Resource Managements (FIRMS) MYD14 hotspots (table 1). RMIT/Himawari-8 hotspots had commission errors of 8% during the day (11% during the night). Omission errors were 51% during the day (37% during the night).

Discussion

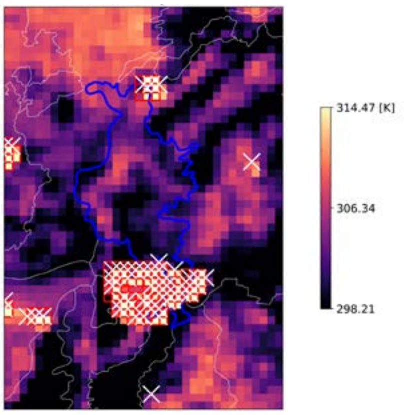
This trial has demonstrated that RMIT/Himwari-8 NSW/VIC hotspots could be delivered in real-time to NSW RFS. Advanced discussions are underway to upscale this to all of Australia.

The MODIS Terra /Aqua satellite system has higher resolving power than the Himawari-8 satellite, and the difference in IFOV will impact on fire detection statistics. The omission errors of 51% (day) and 37% (night) probably result from fires below the resolving power of the Himawari-8 satellite. The 8% (day) and 11% (night) commission error may also reflect differences in the algorithms and/or the transient nature of fires. Our team is currently investigating ways to improve the RMIT/Himawari-8 algorithm and further investigate comparisons with the MYD14 collection.

Our team is also working on innovative ways to interrogate the reliability of RMIT/Himawari-8 hotspots outside the MYD14 overpasses times.

For more information, please email chermelle.engel@rmit.edu.au

Tables and figures



Above: Example Himawari-8 data (3.9 µm, channel 7) centered on NSW North Coast IBRA region NNC02 (outlined in thick blue line; other IBRA regions shown with thin white lines) for 4 UTC on 7th September 2019. Overlaid are RMIT/Himawari-8 (red squares) and MYD14(white crosses) active fire hotspots.

Description	MYD14 (DAY)	MYD14 (NIGHT)
Number of RMIT/Himawari-8 hotspots in the MYD14 reconstructed swath	6398	5132
Number of RMIT/Himawari-8 hotspots detected within 1 pixel of a MYD14 hotspot	5881	4546
Commission error for RMIT/Himawari-8 hotspots	8%	11%
Number of MYD14 hotspots (collated on the Himawari-8 grid)	14247	7496
Number of MYD14 hotspots (collated on the Himawari-8 grid) detected within 1 pixel of a RMIT hotspot	7003	4751
Omission error for RMIT/Himawari-8 hotspots	51%	37%

Table 1: MYD14 hotspots over NSW/VIC compared with RMIT/Himawari-8 hotspots from 15 Mar 2019 to 10 Jan 2020. MYD14 archival quality data was used for 15 Mar 2019 to 30 Sep 2019, and near real-time quality data for 01 Oct 2019 to 10 Jan 2020. MYD14 hotspots with pixel size less than 1.7km were kept and assigned to the nearest Himawari-8 pixel. Areas were defined using the MYD14 hotspots that fell on specific date/times. Hotspots that fell in the area (within +-10 minutes) were considered co-incident. Matches were defined as hotspots in one dataset that had at least one in the opposing dataset within +/- 1 pixel. Statistics were split into daytime and nighttime sets.

Australian Government Department of Industry, Science, Energy and Resources
Business Cooperative Research Centres Program
Australian Government Bureau of Meteorology
Japan Meteorological Agency
Australian Government Geoscience Australia
State Government Victoria Department of Environment, Land, Water & Planning
NCI
RMIT UNIVERSITY

© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au

FINDINGS

The study explores the live fuel moisture – soil moisture relationship at a national scale and suggests an approach to predict live fuel moisture content.

Predicting live fuel moisture content using soil moisture

Vinodkumar[1,2], Imtiaz Dharssi[1,2], Marta Yebra[1,3] , Paul Fox-Hughes[1,4]

[1] Bushfire and Natural Hazards CRC, Victoria
[2] Bureau of Meteorology, Melbourne, Victoria
[3] Australian National University, Canberra, ACT
[4] Bureau of Meteorology, Hobart, Tasmania

Introduction

- Live fuel moisture content (LFMC) critically affects fire ignition and fire propagation.
- Soil Moisture (SM) is found to be a key factor that influences LFMC.
- Both LFMC and SM have recently become available at continental scale through BNHCRC projects.
- LFMC is derived from satellite data and SM is provided by the JULES based Australian Soil Moisture Information (JASMIN). Both datasets are available from the Australian Flammability Monitoring System (AFMS, http://anuwald.science/afms).
- We conducted a preliminary investigation of the suitability of SM as a predictor for LFMC:
  - What is the strength of the SM-LFMC relationship over the Australian landscape?
  - Can a simple model be developed to predict LFMC using SM estimates?

Methods

- The modelling strategy assumes that the LFMC departures from its annual cycle can be predicted using SM departures from its own annual cycle.
- Therefore, at each grid point, annual cycle models were constructed for both LFMC and SM, and residuals from these models were used in the prediction model.
- 0-35cm SM from JASMIN ($SMC_{0\text{-}35cm}$) is used to develop the LFMC predictive model.
- Annual cycle models for $SMC_{0\text{-}35cm}$ and LFMC are based on trigonometric functions.
- Ordinary least-squares regression model with residual $SMC_{0\text{-}35cm}$ as the independent variable was developed for each grid point to predict daily changes in LFMC.

Results

- Figure 1 presents lag-correlation analysis conducted between LFMC and SM over selected 60 locations corresponding to the CosmOz, OzFlux, and OzNet SM networks combined.
- Average (over all sites) maximum lag-correlations observed for grasslands, woodlands, forests and croplands between LFMC and $SMC_{0\text{-}35cm}$ are 0.71, 0.69, 0.47 and 0.5, respectively, with corresponding average lag 14.28, 64.54, 218.91 and 16.85 days.
- A lag of 14 days for all sites returned a reasonable skill (site average R^2 = 0.64).
- The model was extended for the whole country with a constant lag of 14 days at all grid points (at 5 km resolution).
- Figure 2 depicts the correlation and normalized root mean squared difference (NRMSD)obtained from comparing the model and original (AFMS) LFMC products.
- Figure 3 shows the comparison of original and predicted LFMC over locations where a fire is detected (using MODIS FRP data). For the AFMS dataset, the mean±standard deviation of LFMC over grassland, cropland, woody savannas, and evergreen broadleaf forests locations are 40.7±30.2, 78.4±36.1, 53.9±14.1, and 101.5±20.3, respectively. The corresponding scores from the predictive model are 46.2±28.9, 82.4±30.9, 58.5±13.3, and 102.3±17.6, respectively.

Discussion

- The results indicate that SM is a leading indicator of LFMC.
- This has significant operational implications as daily variations in LFMC can be predicted using SM information from JASMIN on a national scale.
- JASMIN is currently a research prototype but can be extended to run both at real-time and in forecast mode, providing SM forecasts for up to 10 days. Thus, from the above results, a 24 day-day lead-time forecast for LFMC is possible from a 10-day SM forecast.

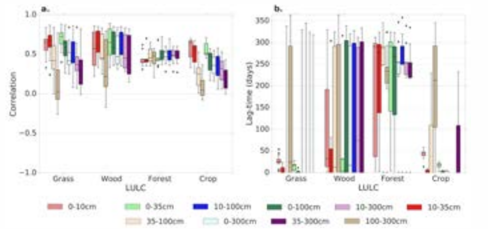


Figure 1. Box and whisker plot representing a) Lag-correlation and b) lag in days between LFMC and SM from various JASMIN native and derived layers. The scores are computed for 60 sites from the CosmOz, OzFlux, and OzNet SM networks combined. The grouping is done based on the land cover type of the observing site. The outliers are marked as diamonds.

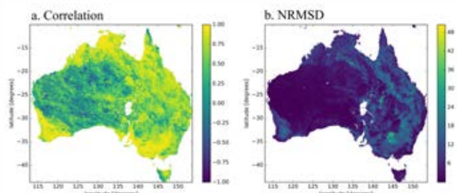


Figure 2. Validation of the LFMC predictive model: a) Pearson's product-moment correlation, and b) normalized RMSD. The validation time period is 2010-2019.

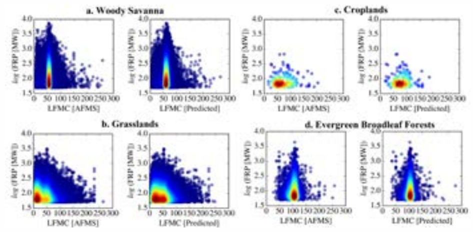


Figure 3. Scatter plot of original AFMS LFMC and predicted LFMC against the MODIS FRP. The colours depict the probability density estimated using Gaussian kernel density estimation method. The light blue colours indicate least dense locations on the plot and the dark red indicate the densest locations. The data span from 2010-2016.

End-user statement: Stuart Matthews, NSW RFS

Predicting the moisture status of live fuels is an important gap in modelling fire risk over periods of weeks to seasons. Current methods rely on persistence of observed values or subjective expert assessment of the response of fuels to forecast rainfall anomalies. Being able to link fuel moisture to predicted soil moisture has the potential to improve the skill and repeatability of fire danger predictions

Australian Government Department of Industry, Science, Energy and Resources | Business Cooperative Research Centres Program | Australian Government Bureau of Meteorology | Australian National University

For more information, please email vinod.kumar@bom.gov.au

© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au

bushfire&natural HAZARDSCRC

FINDINGS

Two-dimensional fire simulators have been extended to model vorticity-driven lateral spread and incorporate spotting processes.

Incorporating firebrands and spot fires into vorticity-driven wildfire behaviour models

J.E. Hilton[1,2], N. Garg[2], J.J. Sharples[1,3]

[1] Bushfire and Natural Hazards CRC, Victoria
[2] CSIRO Data61, Clayton South, Victoria
[3] UNSW Canberra, Australian Capital Territory

Complex modes of fire behaviour resulting from fire-atmosphere coupling are a significant challenge for operational wildfire spread simulations. While three-dimensional fully coupled fire-atmosphere models are able to account for many types of fire behaviour, their computational demands are prohibitive in an operational context. We investigated extending computationally efficient two-dimensional fire spread simulations to model coupled effects resulting from wind flow over a ridge that can result in a number of non-intuitive modes of fire behaviour, such as vorticity-driven lateral spread (VLS). Furthermore we developed extensions of these two-dimensional models to incorporate three-dimensional firebrand transport and showed that enhanced downwind spot fire formation can result under certain VLS conditions.

Introduction

Fire spread simulators play an essential part in wildfire risk assessment and management, but their effectiveness is limited in a number of ways. In particular, when the spread of a wildfire is dominated by dynamic modes of fire propagation, which arise due to fire-atmosphere interaction. VLS is a mode of dynamic fire behaviour that has been shown to be critical in the development of extreme wildfires. VLS is characterised by rapid lateral propagation of a fire across the top of lee-facing slopes, but its influence on extreme wildfire development can be mostly attributed to the secondary generation of firebrands, massive ember attack and spot fire coalescence downwind of the lateral spread zones. Modelling these important aspects of fire behaviour are currently beyond the capability of operational fire spread simulators.

Methods

Hilton et al. (2018) detailed a two-dimensional fire spread model that uses a potential flow formulation to partially account for local fire-atmosphere interactions. This model has been implemented as part of the Spark fire simulation framework, which is based on the level-set method. Sharples & Hilton (2020) extended the model to simulate vorticity-driven effects. Here the model is extended further to incorporate firebrand generation and spot fire formation.

Firebrands were incorporated into the simulation using a Lagrangian particle model implemented in the Spark framework. The motion of each firebrand was given by:

$$m\frac{\partial \boldsymbol{v}}{\partial t} = \frac{1}{2} c_D \rho A \|\boldsymbol{u} - \boldsymbol{v}\| (\boldsymbol{u} - \boldsymbol{v}) \boldsymbol{g}'$$

where m is the mass of the firebrand, $\boldsymbol{v}$ is the firebrand velocity vector, ρ is the air density (kg m^{-3}), c_D the coefficient of drag for the firebrand and A (m^2) is the cross-sectional area of the firebrand perpendicular to the flow. The reduced gravity vector $\boldsymbol{g}'$ accounts for buoyancy effects and is given by $\boldsymbol{g}' = (0,0,(b-1)g)$, where g = 9:8 m s^{-2} and b is a dimensionless buoyancy parameter.

Results

In the absence of definitive research to inform the choice of parameter value, the buoyancy parameter was treated as a free parameter. To account for cooling effects within the plume, we assumed a simple exponential cooling model, where the buoyancy parameter reduces over time according to $b = b_0 \exp(-kt)$, where k is a decay parameter.

Simulations of fire spread in the lee of a ridge are shown in Fig. 1. The domain was a ridge 1 km high with a slope of 20° on the windward side and 35° on the lee slope. The ignition was initiated as a line 300 m in length and 50 m in width perpendicular to the ridge at a distance of 950 m from the ridge line. The simulation resolution was 10 m and the simulation was run for a period of 2 hours. The fire rate-of-spread was estimated using the Rothermel model with a fuel moisture content of 8%, a fuel load of 13.024 tonnes $acre^{-1}$ and a surface-to-volume ratio of 1159 ft^{-1}. Simulations took approximately 10 seconds on a K6000 GPU without firebrands and 110 seconds when firebrands were used.

The wind direction was set to be perpendicular to the ridge with a speed of 10m s^{-1} on the windward slope and re-circulation over the leeward slope was prescribed by setting the wind speed to -1m s^{-1} on the lee slope. This imposed wind field was then modified by the pyrogenic potential model to account for vertical vorticity effects in the ground plane.

Discussion

The combined VLS and firebrand models appear to qualitatively replicate the fire behaviour shown in real fires, despite the range of simplifications used for the models. There are a number of assumptions and unknowns in the model which require calibration and further research. These include the firebrand rate of production and the plume decay constants b_0 and k. However, simulations using these models could provide information on counter-intuitive modes of fire behaviour for management and risk assessment. Future studies will investigate the applicability of the models to more complex scenarios and compare the results of the model to real-world data.

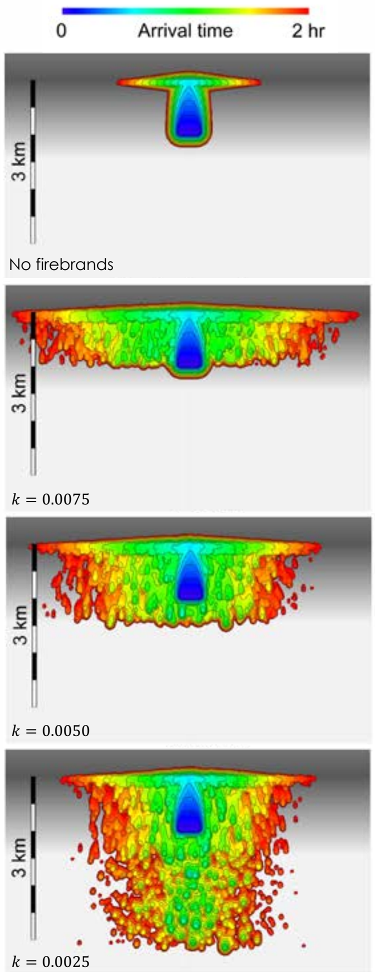


Figure1: Dynamic fire spread simulator demonstrating capability to emulate VLS and spotting behaviour. Each panel shows the results for a different decay parameter, as indicated. The elevation is shown in grayscale and the colour scale represents the fire arrival time at each point. Ten-minute isochrones are overlaid as solid black lines.

Australian Government
Department of Industry, Science, Energy and Resources
Business
Cooperative Research Centres Program

For more information, please email j.sharples@unsw.edu.au

References:
Hilton et al. (2018) *Environmental Modelling and Software*, 107.
Rothermel (1972) Research Paper INT-115.
Sharples & Hilton (2020) *Frontiers in Mechanical Engineering*, 5.

SPOTFIRE PROJECT
UNSW Canberra
DATA 61
CSIRO

© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au

FINDINGS

The validity of using dynamic heating regimes and VHFlux apparatus as a standardised method has been demonstrated.

Flammability of live plants, do we need a new testing approach?

Tim Miller[1], Alex I. Filkov[2,3], Trent D. Penman[3]

[1] Department of Environment, Land, Water and Planning, Victoria
[2] Bushfire and Natural Hazards CRC, Victoria
[3] University of Melbourne, Victoria

The aim of this study was to determine the impact of different heating regimes on flammability of live vegetation and to propose a new testing method.

Introduction

Understanding live vegetation fuel properties and how they behave when exposed to radiant heat and flame allows us to better predict fire behaviour during wildfire events. Current methodologies of testing flammability of live vegetation are limited in their ability to provide accurate quantification due to their reliance on static heat flux exposure, which does not accurately replicate how live plants experience radiative heat flux during a wildfire in their natural environment. This study aims to determine a more effective, replicable and accurate method of testing flammability.

Methods

Two heating regimes were tested for this study – a static heat flux to reflect current methods and a dynamic (increasing) heat flux to more accurately replicate real conditions of an approaching fire front. Piloted-ignition and unpiloted-ignition were also tested for both of these heating regimes. A Variable Heat Flux (VHFlux) Apparatus developed by The University of Melbourne was used to test flammability of *Acacia floribunda*, *Cassinia arcuata*, *Pinus radiata* and bark from *Eucalyptus obliqua* samples (Figure 1). Time (s) to pyrolysis (production of volatile products), smouldering, flaming ignition, complete consumption and radiant exposure (the radiant energy received by a sample over a time of heating) were used as ignitability measures.

Results

It was observed that time (Figure 2) and radiant exposure required to reach flaming ignition were higher under a dynamic heating regime. During static heating regime experiments, it was noticed that ignition would occur in multiple stages. More than 70% of samples reached flaming ignition in piloted experiments, whereas less than 40% reached flaming ignition in unpiloted experiments. The exception was Bark which had 100% ignition success in both ignition types.

Discussion

Our study has proposed a new standardised methodology for testing ignitibility of live plant species, with potential for extending further to flammability metrics. The validity of using dynamic heating regimes as a standardised method has been demonstrated, with clear differences observed between heating regimes for time and radiant exposure required for ignition and other ignitibility measures. The influences observed on ignitibility due to the pilot ignitor and species characteristics were heavily outweighed by the influence of the heating regime.

The VHFlux apparatus allows for flammability testing of live plant samples using dynamic heating regimes where parameters can be controlled to create repeatable and accurate testing in a controlled environment. This far exceeds the suitability of current methodologies.

Adoption of this methodology is recommended to ensure more realistic data on flammability of individual plant species and plant communities. This will ultimately lead to better informed, more accurate, and dynamic wildfire behaviour modelling.

For more information, please email alexander.filkov@unimelb.edu.au

Figures

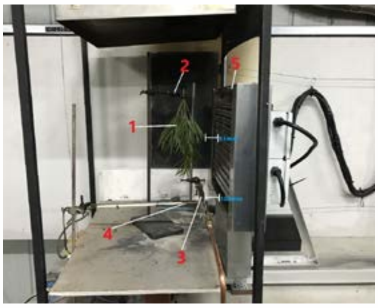


Figure1: Experimental design: 1) sample, 2) clamp, 3) pilot igniter, 4) spark igniter, 5) radiative panel.

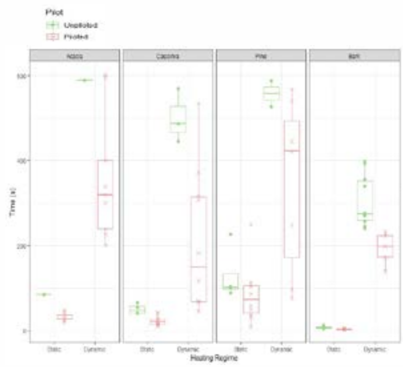


Figure2: Time (s) to flaming ignition comparing static and dynamic heating regimes (x-axis) in both unpiloted (green) and piloted (red) experiments.

Australian Government
Department of Industry, Science, Energy and Resources

Business
Cooperative Research Centres Program

THE UNIVERSITY OF MELBOURNE

© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au

bushfire&natural HAZARDSCRC

FINDINGS

- ❖ At different slope angles and driving wind velocities, different operational quasi-steady Rate of Spread *(RoS)* of fire roughly lies between dynamic maximum, minimum and averaged *RoS* values
- ❖ Within the slope angle considered in this study, a second order polynomial relationship exists between quasi-steady Rate of Spread *(RoS) of fire* and slope angle, pyrolysis width and slope angle and fire intensity and slope angle.
- ❖ As the upslope angle and wind velocity increases the plume inclines more towards the ground and when the fire runs uphill, the flame length is found to be higher

Physics based simulations of grassfire propagation on sloped terrains; upslopes and down slopes

Jasmine Innocent[1,3], Duncan Sutherland[2,3], Nazmul Khan[1,3] , Khalid Moinuddin[1,3]

[1]Institute of Sustainable Industries and Liveable Cities, Victoria University, Melbourne, Australia
[2]School of Science, University of New South Wales, Canberra, ACT, 2610, Australia
[3]Bushfire and Natural Hazards CRC East Melbourne, Victoria, 3002, Australia

What effect does the slope have on fire Rate of Spread (RoS) and how does that compare with operational models? What effect does the driving wind velocity has on the RoS, head fire, flame parameters, as the slope angle varies?

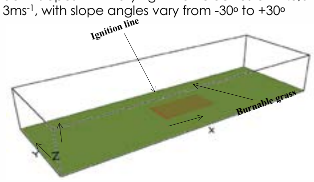
INTRODUCTION AND HIGHLIGHTS

- Rate of spread of fire *(RoS)* and fire behaviour depends on various topographical, weather and fuel factors. Topographical feature such as slope can increase or decrease *RoS* depending on whether the slope is upward or downward.
- A physics-based Fire Dynamics Simulation(FDS) model is used to conduct a set of field-scale simulations with varying wind velocities and slope angles.
- Rate of spread (*RoS*), head fire width, fire intensity, flame parameters are analyzed and compared with widely used empirical models.
- This study aims to provide insight into grassfire behavior which may then be used to improve operational models, improve prediction of real wild fires, and subsequently mitigate the risks of wildfire impact.

MODEL SETUP

The simulation domain size is 360m(L) x 120m(W) x60 m(H). The burnable plot is 80 m (L)x 40 m(W) x 60m(H). Slope is implemented in the simulations by changing the magnitude of components of gravitational force in the x and z directions. Grid size for burnable plot is chosen as 0.25x0.25x0.25m. Fuel and thermo- physical parameters are selected following Moinuddin et al [3].

Simulations are conducted for both upslopes and downslopes with varying wind velocities of 12.5,6 and 3ms^{-1}, with slope angles vary from -30º to +30º



RESULTS AND DISCUSSION

From the contour plots in Figure 1, it is observed that as the slope angle increases, the firefront becomes wider and reaches the end of the burnable grass plot much earlier. Pyrolysis width increases as the firefront progresses from the ignition line, then it plateaus (i.e. reaches a quasi-steady state) and finally decreases as shown in Figure 2 (a). Quasi-steady pyrolysis width values with lower wind velocities cases are found to be lower than that with higher wind velocities, for both upslope and downslope cases (Figure 2b).

The results show that within the slope angles considered in this study, a second order polynomial relationship exists between the quasi-steady *RoS* and the slope angle, pyrolysis width and slope angle and fire intensity and slope angle, for the upslope and downslope cases for U_{10}= 12.5,6 and 3ms^{-1}.

The dynamic averaged *RoS* values are found to be closer to quasi-steady *RoS* values, for all three velocity cases (Figure 3 for 6ms^{-1}cases). Comparing the numerical results, for a given slope angle, quasi-steady *RoS* values with lower wind velocity cases are found to be lower, however, the difference narrows between 3 and 6 ms^{-1} cases as the slope angle increases.

From the plots in Figure 4, with higher upslope angles the plume would be prone to flame attachment. When the fire runs uphill, the flame length is found to be higher when the flame is attached. It is also found that the flame height varies between 1.5 to 2.5m, which is less than value considered by fire behaviour analysts as 4m.

References:

[1] McArthur, A.G., *Weather and grassland fire behaviour*. 1966: Forestry and Timber Bureau, Department of national Development, Commonwealth
[2] *AS 3959 : Construction of Buildings in Bushfire-prone Areas : Standards Australia : Sydney*. 3rd Edition 2009
[3] Moinuddin, K.A.M., D. Sutherland, and R. Mell, *Simulation study of grass fire using a physics-based model: striving towards numerical rigour and the effect of grass height on the rate-of-spread*. International Journal of Wildland Fire, 2018. 27(12): p. 800-814.

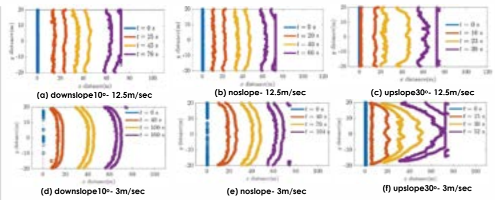


Figure1: Progression of isochrones- wind velocities 12.5 and 3 ms^{-1}

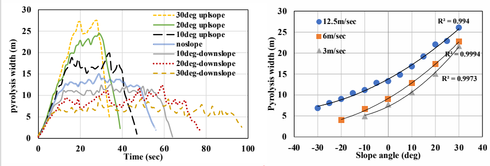


Figure2: (a) Pyrolysis width vs time at velocity 12.5 ms^{-1} (b) Quasi-steady Pyrolysis width vs slope angle

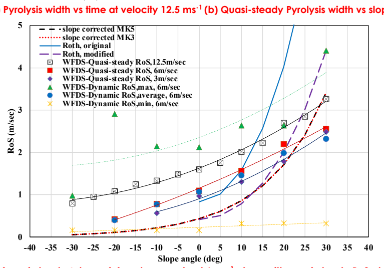


Figure 3: RoS (quasi-steady &dynamic) vs slope angle at 6 ms^{-1},along with quasi-steady RoS at 12.5&3 ms^{-1}

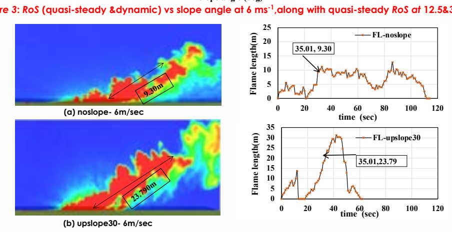


Figure 4: Graphic representation of plumes emanating from grass plot at 0ºand +30º slope when the flame is attached and instantaneous flame length when flame is attached -wind velocity 6 ms^{-1}

Australian Government
Department of Industry, Science, Energy and Resources

Business Cooperative Research Centres Program

VICTORIA UNIVERSITY MELBOURNE AUSTRALIA

© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au

FINDINGS

Forests of the **Tasmanian *E. delegatensis*** subspecies are more **resilient** to a **single high-severity fire** than the mainland Australian subspecies.

Recovery strategies of *Eucalyptus delegatensis* subsp. *tasmaniensis* after the 2016 fires in Central Tasmania

Dario Rodriguez-Cubillo[1,2]

[1] School of Natural Sciences, University of Tasmania
[2] Bushfire and Natural Hazards CRC, Victoria

This study has found that forests of the Tasmanian *E. delegatensis* subspecies are more resilient (able to return to pre-disturbance conditions) to a single high-severity fire than the obligate-seeder subspecies in the Australian mainland.

Introduction

In January 2016, lightning storms in Tasmania started hundreds of natural fires. The extremely dry conditions and the adverse weather allowed the fires to enter large areas of mature forests of *Eucalyptus delegatensis* subsp. *tasmaniensis*, endemic to the island. The objective of this research is to investigate the effects of fire severity and logging history on the mortality and recovery of this species, and to compare these post-fire recovery responses to the mainland Australian subspecies, the obligate-seeder *Eucalyptus delegatensis* subsp. *delegatensis*. This study enables consideration of the vulnerabilities of the Tasmanian subspecies to fire disturbances and logging in a warmer climate.

Methods

We collected post-fire survival and regeneration data of *Eucalyptus delegatensis* subsp. *tasmaniensis* forests in summer 2018 in the Central Plateau of Tasmania. We established 82 transects (0.1 ha each), in long-unburnt forests and forests burnt by the 2016 fires, to assess the effects of fire on *E. delegatensis* trees. In each transect, we measured the diameter of *E. delegatensis* trees, assessed the status of the tree (live undamaged, epicormic resprouting, basal resprouting or dead) and classified the transect by its fire severity: unburnt, low-severity (fire scarring on the stem and/or lower canopy burnt) and high-severity (full canopy burnt). We used model selection to analyse tree survival, vegetative regeneration and seedling recruitment depending on understorey type, fire severity, logging intensity and tree size (diameter).

Results

Fire severity affected tree survival: 36% of trees were alive in high-severity transects versus 84% in unburnt transects. The main fire-recovery strategy was epicormic resprouting, with < 1% of all trees recovering only through basal resprouting.
Fire severity had an impact on epicormic resprouting, with 99%, 70% and 4% of live stems after the fire resprouting, respectively, in high-severity, low-severity and unburnt transects (Figure 1). Tree size influenced tree survival: trees < 20-cm diameter suffered the most fire-induced mortality (Figure 2). Seedling recruitment was uncommon and, when seedlings were present, their densities were low: median = 400 and maximum = $4 \cdot 10^4$ seedlings · ha^{-1}.

Discussion

This study highlights that mature forests of *E. delegatensis* in Tasmania are more resilient to a single high-severity fire than their mainland counterparts, as they can recover more quickly through epicormic resprouting. However, logging reduces this resilience for several decades because it makes the regrowth (< 20-cm diameter) more susceptive to fire kill.
It is difficult to predict how the Tasmanian *E. delegatensis* subspecies will respond to an increased frequency of high-severity fires associated with a projected drier climate. This fire risk could be mitigated by maintaining multi-aged forest structures. Silvicultural approaches based on variable retention and uneven-aged treatments can be used to retain biodiversity, increase natural regeneration from in-situ resources and secure ecosystem function.

Tables and figures

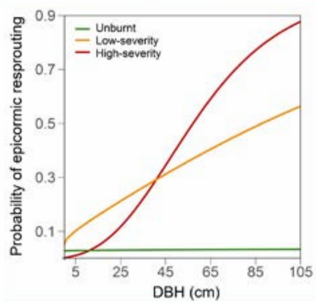


Figure 1. Probability of epicormic resprouting according to fire severity and tree diameter.

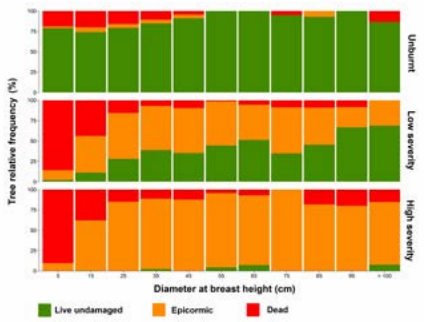


Figure 2. Status of *E. delegatensis* trees by fire severity and diameter. "Live undamaged" are undamaged, live trees. "Epicormic" are stems with live epicormic resprouts. "Dead" are trees where the main stem is dead, and there are neither live basal nor live epicormic resprouts. Trees are binned in 10-cm diameter classes, with the midpoint of the class shown on the x-axis (diameters > 100 cm are binned into one class).

Australian Government Department of Industry, Science, Energy and Resources | Business Cooperative Research Centres Program | University of Tasmania

For more information, please email dario.rodriguez@utas.edu.au

© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au

FINDINGS

GLOBAL MODELS CAN PRODUCE RELIABLE SMOKE EMISSION ESTIMATES FROM *EUCALYPTUS* FOREST FIRES

Characterising smoke emissions from the 2013 *Eucalyptus* forest fire in Southern Australia

M. N. Ndalila[1], G. J. Williamson[1] and D. M. J. S. Bowman[1]
[1] School of Natural Sciences, University of Tasmania

Introduction

Episodic wildfires in Australian temperate forests have produced significant smoke emissions but have received less attention than the North American conifer forests and the Australian tropical savanna fires.

We use the Forcett-Dunalley fire as a case study to understand smoke emissions dynamics from temperate *Eucalyptus* ecosystems and compare a basic emissions model with a global model GFED.

Methods

- Map spatial patterns of carbon dioxide (CO_2) and particulate matter ($PM_{2.5}$) emission using basic model (FS) that incorporates fine scale fuel attributes.
- Investigate the reliability of GFED by comparing with the basic model.
- Conduct a sensitivity analysis to determine the effect of variability in fire severity on emissions estimation.

Results

- From the basic (FS) inventory, total CO_2 emission was 1.125 ± 0.232 Tg (or 56 t ha^{-1}) while $PM_{2.5}$ emission was 0.022 ± 0.006 Tg (or 1.1 t ha^{-1}).
- Both inventories produced comparable estimates for CO_2 (difference of 27%), but $PM_{2.5}$ estimates were a factor of three (or difference of 70%) lower for GFED.

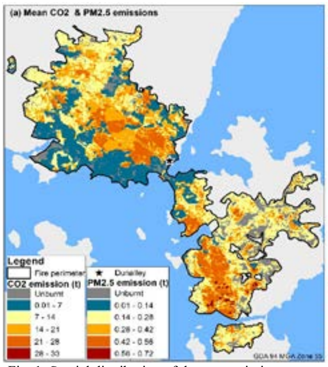


Fig. 1: Spatial distribution of the two emissions types (in tonnes) from the fire using the basic model.

- The spatial distribution based on GFED was poor compared to basic model (Figs. 1, 2).
- Fire severity contributed to an emissions variability of 34-38%.

Discussion

We highlight GFED's reliability within the limits of emissions uncertainties in *Eucalyptus* ecosystems because of comparable:

- Burnt area estimates with FS inventory.
- Total CO_2 emissions with FS inventory.
- Temporal evolution of both CO_2 and $PM_{2.5}$ emissions (Fig. 3).

To further improve emissions estimation, we recommend the following:

- More detailed field assessments of coarse wood fuels (CWD) and fuel consumption.
- An upward revision of emissions factors for $PM_{2.5}$ within GFED.

Figures

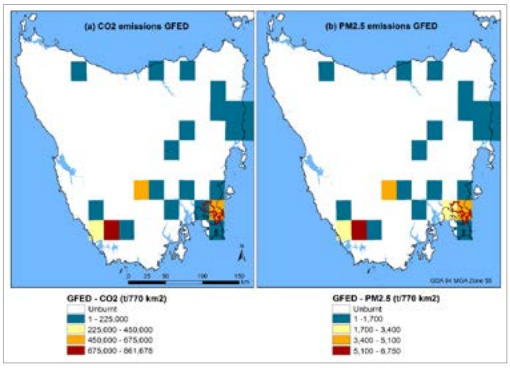


Fig. 2: Spatial distribution of the two emission types (in tonnes) from several fires in mainland Tasmania, including the Forcett-Dunalley fire.

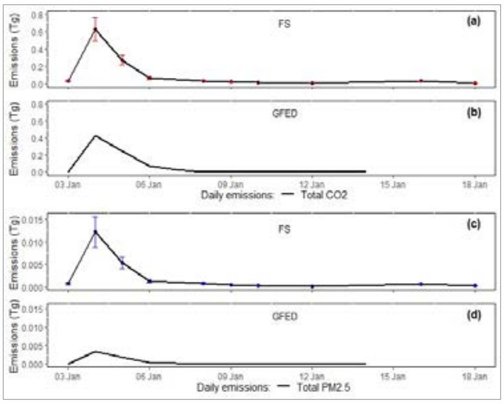


Fig. 3: Daily variability of the two emission types from the Forcett-Dunalley fire between the fine scale (FS) and GFED inventories.

For more information, please email: mercy.ndalila@utas.edu.au

Australian Government Department of Industry, Science, Energy and Resources | Business Cooperative Research Centres Program | UNIVERSITY of TASMANIA | Tasmania Fire Service

© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au

bushfire&natural HAZARDSCRC

FINDINGS

Spot fires and topography interact to enhance fire rate of spread.

Effect of spot fires and topography on fire rate of spread: Combustion tunnel experiments

Michael Storey[1], Owen Price[1], Miguel Almeida[2], Carlos Ribeiro[2], Ross Bradstock[1], Jason Sharples[3]

[1] Centre for Environmental Risk Management of Bushfires, Uni. Of Wollongong

[2] Association for the Development of Industrial Aerodynamics, Coimbra, Portugal

[3] School of Physical, Environmental and Mathematical Sciences, UNSW Canberra

Understanding the role of spot fires in the overall spread of a bushfire is vital if more accurate bushfire behaviour models are to be produced. To improve our understanding, we conducted a series of experiments at the Forest Fire Research Laboratory of the Association for the Development of Industrial Aerodynamics in Lousã, Portugal.

Introduction

Ignition of unburnt fuels by firebrands during bushfires creates spot fires: separate new fires ahead of the main fire line. These spot fires interact with the main fire and influence the overall or combined (i.e. main fire + spot fires) rate of spread in some way. We conducted experiments in a combustion wind tunnel to explore how spot fires influence rate of spread, and whether the effect differs between a flat fuel bed and a fuel bed with a hill present.

Methods

We conducted 30 experiments on a 3 m wide by 4 m long fuel bed in a combustion wind tunnel. For all experiments we ignited a fire line and had a 1.5 m/s wind pushing the fire through the fuel (pine needles). For some experiments we then manually ignited 1 or 2 small "spot fires" ahead of this fire line, while for the remaining experiments there were no spot fires ignited. For half of the experiments the fuel bed had a model hill installed and the other half of the experiments just had a flat fuel bed. We recorded the experiments and measured spread time and rate of spread at 3 different distance intervals (Figure 1).

Results

All our flat fuel bed experiments had similar rates of spread regardless of the number of spot fires ignited (i.e. spot fires had no significant effect on rate of spread). But for the experiments with the model hill, rate of spread was substantially different between spot fire levels, with the strength of the effect differing between measurement intervals. When a hill was present, zero spot fire experiments had the slowest spread, while one or two spot fire experiments had the fastest spread (depending on interval). See figure 1 for some results in seconds.

Discussion

The results suggest rate of spread can be significantly influenced by an interaction between spot fires and topography: spotting may increase rate of spread of bushfires in hilly areas but have only a minor effect on rate of spread in flat areas. Our results appeared to be mainly due to spot fires spreading back up the lee side of the hill (under influence of a lee slope eddy) to merge with and extend the main fire (top photo). This effect is important to explore further (e.g. with bushfire observations) as it could be incorporated into bushfire spread models to produce more accurate rate of spread predictions.

For more information, please email mas828@uowmail.edu.au

Tables and figures

Above: Rate of spread experiment with a line fire spreading up a model hill towards two manually ignited spot fires on the lee side of the hill.

Above: Final stages of a rate of spread experiment with a line fire conducted on a flat fuel bed

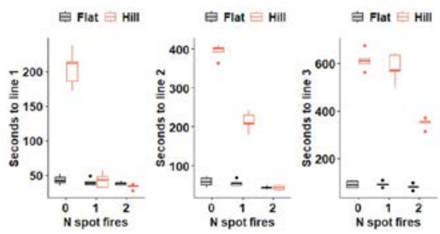


Figure1: Boxplots representing the time taken (seconds) for the main fire to cross three spread measurement intervals (line 1 225 cm, line 2 275 cm, line 3 350 cm downwind of the ignition line). If spot fires were separate, they were not included in the rate of spread measurement, but once the spot fires merged with the main fire, this was considered as the new main fire.

Australian Government Department of Industry, Science, Energy and Resources

Business Cooperative Research Centres Program

UNIVERSITY OF WOLLONGONG AUSTRALIA

© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au

FINDINGS

bushfire&natural HAZARDSCRC

The influence of soil moisture on litter fuel moisture content (FMC) depends on the soil condition and the arrangement of the litter layer. Wetter soil can contribute to higher litter FMC. Subsurface litter, which is in contact with the topsoil, is more sensitive to the influence of soil moisture than surface litter. The influence of soil moisture on litter FMC is through its influence on local air humidity.

Coupling Litter and Soil Moisture Dynamics for Surface Fine Fuel Moisture Content Forecasting-Field Experiment

Li Zhao[1,2], Marta Yebra[1,2,3] , Albert I.J.M. van Dijk [1,2], Geoff Cary[1,2]

[1] Fenner School of Environment & Society, College of Science, Australian National University, ACT

[2] Bushfire and Natural Hazards Cooperative Research Centre, Melbourne, Australia

[3] Research School of Aerospace, Mechanical and Environmental Engineering, College of Engineering & Computer Science, Australian National University, ACT

Introduction

- Fuel moisture content (FMC) of surface fine fuel (or forest litter fuel) is a critical factor determining fire ignition and spread.
- Several models have been developed to forecast litter FMC
  - Empirical regression functions against incorporating weather variables
  - Physics-based models with water and energy conservation equations.
- Soil moisture has been shown to influence FMC but few models explicitly consider it

Objective

Evaluate how soil moisture content affects litter FMC forecasts by coupling soil moisture in a physics-based model (Matthews, 2006).

Methodology

A series of controlled factorial field experiments have been carried out in the *Eucalyptus* woodland in the Australian National Botanic Gardens to better understand and quantify the processes involved in litter and soil moisture dynamics.

Experiment Design

- 1 ×1 m control and treatment plots were selected at both a dry and a wet site for the experiment (Fig. 1).
- In each site there are two parallel experiments (Fig. 1) including:
  - A control plot where there is direct contact between soil and litter;
  - A treatment plot where a water-proof material was placed as a barrier between soil and litter to prevent the influence of soil moisture.
- Fuel sticks, a soil moisture sensor and RH/T sensors were installed at different heights to measure variables in different layers. A Microclimatic weather station was installed to measure local weather variables.
- Data has been collected since September 2019.

Preliminary Results

- **Dry Site**

Litter with the water-proof material has a relatively lower RH than the other treatment in both surface and subsurface litter; the maximum surface and subsurface FMC difference between two treatments was no more than 3% during the long drying period (Fig.2).

- **Wet Site**

Litter with the water-proof material has a much lower RH than the other treatment in the subsurface litter; the maximum FMC difference between two treatments is around 5% in the surface litter and 10% in the subsurface litter (Fig.3).

Conclusions and Future Work

- The influence of soil moisture is limited at the dry site but is apparent at the wet site.
- The influence of soil moisture on FMC is through the influence on local air relative humidity as the evaporation of soil moisture increases the air humidity of the fuel.
- The ongoing work is analysing and quantifying the influence of soil moisture on litter FMC.

End user statement:

"Predictions of fuel moisture are vital for many aspects of fire management. This important project will help improve predictions as well as aiding adoption of new soil moisture models."

Stuart Matthews, NSW Rural Fire Service

For more information, please email li.zhao@anu.edu.au

Figures

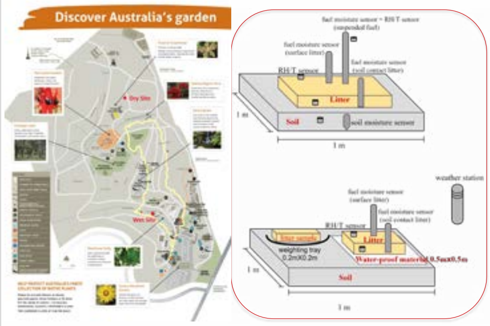


Fig. 1. The two experiment sites on the visitor map (left), and the parallel experiments and instruments at each site (right).

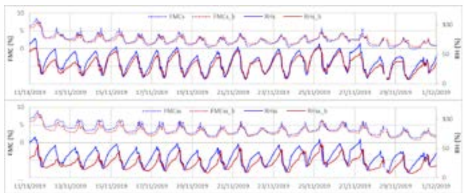


Fig. 2. Time series of FMC and RH at the dry site. FMC_s, RH_s and FMC_{ss}, RH_{ss} represent FMC and RH in surface and subsurface litter, respectively, for the treatment without the barrier. FMC_{s_b}, RH_{s_b} and FMC_{ss_b}, RH_{ss_b} represent FMC and RH in surface and subsurface litter, respectively, for the treatment with the barrier.

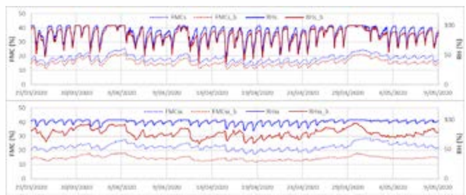


Fig. 3. Time series of FMC and RH at the wet site. Symbols refer to Fig. 2.

Australian Government Department of Industry, Science, Energy and Resources | Business Cooperative Research Centres Program | Australian National University

Main Reference

[1] Matthews, S., 2006. A process-based model of fine fuel moisture. International Journal of Wildland Fire, 15(2), pp.155-168.

© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au

FINDINGS

Validation of firebrand model in fire dynamic simulator with tree burning experimental data, and quantifying firebrand landing and heat flux on structures.

Physics-based simulation of firebrand and heat flux on structures in the context of AS3959

Amila Wickramasinghe[2], Nazmul Khan[2], Khalid Moinuddin[1,2]

[1] Bushfire and Natural Hazards CRC, Victoria
[2] ISILC, Victoria University, Victoria

Is it feasible to model firebrand and heat load on structures in the wildland-urban interface (WUI) using a physics-based model?

Introduction

Quantifying the firebrand and heat flux on structures is essential to determine the wildfire risks and prepare plans to mitigate the hazard. We endeavour to use a physics-based model, Fire Dynamic Simulator (FDS) to map firebrand and heat flux to determine the vulnerability of structures in the wildland-urban interface(WUI).

- We have validated FDS' tree burning and firebrand transporting sub-models against the experiment conducted in no wind condition at the National Institute of Standards and Technology (NIST).
- Subsequently, the input number, direction, and velocities of firebrands of validation were used to quantify firebrand and heat flux on a designed house in different wind velocities.

Modelling

Tree burning:

Firebrand data of the Douglas fir tree burning experiment were analyzed and divided into 30 mass classes to use as inputs to the model. The domain size is taken as 8 m×8 m×10 m to capture the complete flame and to include devices to replicate all the firebrand collection pans. The height (2.6 m) and the girth (1.5 m) of the cone shape model tree were chosen the same as the original tree. Thermo-physical parameters of the vegetation were taken from Moinuddin et al[1]. Fig. 1 illustrates tree burning and firebrand distribution at different times of the simulation. The grid convergence was appraised in terms of mass loss rate (MLR) and grid convergence index (GCI). An inverse analysis was carried out inputting multiplications (4, 5, 6, etc.) of the experimental firebrand collection (70) and different firebrand initial velocities to map the mass distribution of the simulation and the experiment.

Firebrand landing and heat flux on a structure:
The structure is designed with proper architectural features using Pyrosim software. Wind fields of U_{10}=3 m/s, 6 m/s and, 12.5 m/s are added with synthetic eddy method (SEM) [2] to the simulation. The buoyancy for firebrand transporting is generated by a burning tree. Firebrands' initial velocity and input number were taken from the validation of Douglas fir tree burning.

Results and Discussion

Peaks aligned MLR and HRR results of tree burning simulations are presented for 100 mm, 75 mm, 50 mm and, 37.5 mm grid sizes in Fig. 2(a) and (b). With decreasing grid size, results gradually converged and 50 mm is taken as the reasonably grid size. The GCI of 75 mm/50 mm is about 4%. The FDS' particle model was examined for these grid sizes and found the firebrand mass distribution difference was -6% to +5% for 100 mm – 37.5 mm grids compared to the 50 mm grid. Fig. 2(c) is the MLR comparison of the experiment and the simulation with an 8.5% difference of total mass loss. The firebrand mass distribution contour map is shown in Fig 2. (d) where the tree base is on (0,0) coordinates. Results show that firebrands should eject with 70 cm/s vertical and 210 cm/s horizontal velocities to reach collection pans. The experimental firebrand collection is about 18±4 g and inputting 5 times of this collection could obtain 18.9 g of firebrand mass in simulation while successfully validating the FDS' tree burning and firebrand transporting sub-models.

Fig. 3 is the firebrand mass distribution contour map around the tree and the house. Increasing wind velocity shows landing firebrands more towards the house. However, firebrands did not land on the house because of the low height of the tree and low fire-induced buoyancy. According to Fig. 4, radiative heat flux is higher at the ground level of the house close to the fire. Lowest heat flux is at the door corner and the magnitude of heat flux is decreasing with increasing the distance between the fire and each strategic location of the house. Most of the time lower wind velocity shows higher radiative heat flux at the ground level while medium wind velocity shows higher heat flux at the top level of the house.

Conclusion and future studies

- The physics-based model FDS has been validated against the measurements from a single tree burning and firebrand distribution experiment conducted by NIST.
- Firebrand and heat flux will be examined further in the future by simulating a cluster of taller trees (100 m wide) to quantify the heat flux and firebrand hazard on structures.
- Outcomes are expected to add to the prevailing AS3959 standard for the better counter the wildfire risk and improve the standards of building construction in bushfire-prone areas.

References

[1]. Moinuddin, K. and D. Sutherland, *Modelling of tree fires and fires transitioning from the forest floor to the canopy with a physics-based model*. Mathematics and Computers in Simulation, 2019.

[2]. Jarrin, N., et al., *A synthetic-eddy-method for generating inflow conditions for large-eddy simulations*. International Journal of Heat and Fluid Flow, 2006. **27**(4): p. 585-593.

For more information, please email
p.wickramasinghe@live.vu.edu.au

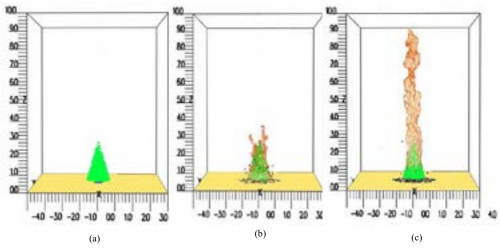


Fig. 1. Graphical representation of Douglas fir tree burning and firebrand distribution at (a) zero second (b) 14 seconds and, (c) 35 seconds.

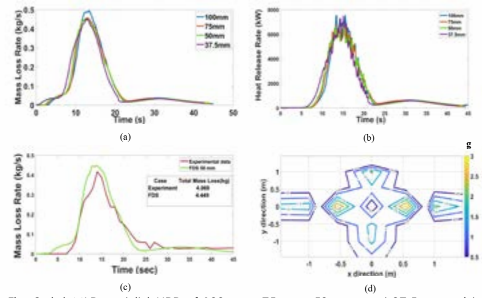


Fig. 2. (a) MLR and (b) HRR of 100 mm, 75 mm, 50 mm and 37.5 mm grid sizes. The MLR comparison of experiment and 50 mm grid is shown in (c). The contour map of firebrand mass distribution is presented in (d).

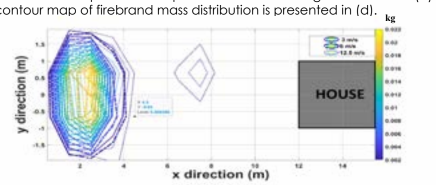


Fig. 3. The domain size is 40 m ×10 m×10 m and the contour map illustrates firebrands landing is increasing with the increase of wind velocity. The tree base is at (2, 0) coordinate.

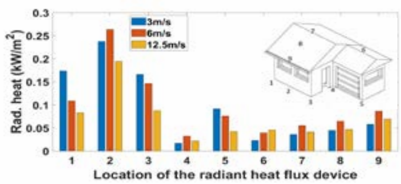


Fig. 4. Radiative heat flux on the house at 3 m/s, 6 m/s and, 12.5 m/s wind velocities. Each strategic location such as wall corners, door corners, gutter, and rooftops is numbered from 1 to 9.

Australian Government
Department of Industry, Science, Energy and Resources
Business Cooperative Research Centres Program

© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au

Future Workforce

bushfire&natural HAZARDSCRC

FINDINGS

The difference between a future where **emergency volunteering** struggles or flourishes rests on **leadership**, **resourcing**, **risk tolerance**, **cultural change**, and **shared learning**.

Emergency volunteering 2030: a sector-wide snapshot

Blythe McLennan[1,2]

[1] Bushfire and Natural Hazards CRC, Victoria
[2] RMIT University, Victoria

This report provides an important snapshot of how the unfolding future of emergency volunteering in Australia is viewed at the present point in time. It shares the synthesised findings from a wide-ranging Environmental Scan that captured diverse stakeholder views of the current and emerging landscapes of emergency volunteering.

Introduction

The Environmental Scan was conducted as part of a futures study that aims to support the development of greater foresight capability in the emergency management sector with respect to the design of emergency volunteering models, infrastructure, and systems. The subject of the study is any and all volunteering that supports communities before, during and after a disaster or emergency, regardless of its duration or its organisational affiliation, or lack thereof. It includes volunteering across preparedness, response, relief and recovery.

Methods

Data was collected via semi-structured interviews and qualitative questionnaires with 183 people that have deep knowledge of emergency volunteering across seven representative groups: 1) Response Organisations – Volunteerism, 2) Response Volunteers, 3) Response Organisations – Community Engagement, 4) Recovery Organisations, 5) Community Sector, 6) Local Government, and 7) Volunteering Peak Bodies.

Results

The research identified 31 key trends impacting on emergency volunteering within and beyond the sector. It developed a collective picture of current understandings of the projected future for emergency management under current trajectories, and of a preferred future (Fig. 1). It identified seven key 'big picture' issues that most need to be tackled to bring about a preferred future for emergency volunteering (Table 1), and five underlying enablers without which progress towards that future is likely to be modest at best.

Discussion

The emergency management sector needs to start grappling with the larger and more systemic issues in the emergency volunteering landscape, and do it head on.

Currently too much is being asked of formal emergency management volunteers through systems and processes that are well-designed to fit the needs of organisations, but less so when it comes to the needs of today's volunteers. Meanwhile, the workforce beyond established emergency management organisations is not being effectively enabled.

While positive shifts are already underway in the sector, progress is likely to be modest at best unless important enabling conditions are built:

- strong change leadership at all levels;
- appropriate, inclusive, and proactive resourcing;
- a more constructive balance between the need to manage risk and the need to change (greater risk tolerance);
- cultural change to become more inclusive, open and innovative;
- Learning that is a) widely and deeply shared, and b) retained over time.

For more information, please email blythe.mclennan@rmit.edu.au

Tables and figures

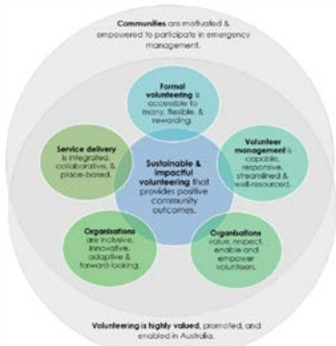


Figure 1: Collective image of a preferred future

What are the 'big picture' issues that need to be tackled?

1. **Formal volunteering** - making formal volunteering easier, more accessible and rewarding to as many people as possible.
2. **Volunteer management** - building greater capacity to manage and lead volunteers well.
3. **Organisations** - valuing volunteers more widely and deeply in emergency management organisations.
4. **Organisations** - building the resilience of all volunteer-involving organisations that contribute to emergency management.
5. **Service delivery** - enabling and designing more integrated, collaborative, and place-based services.
6. **Communities** – making greater space for community connection and participation, while also managing risks.
7. **Volunteering** – advocating the value of volunteering more effectively to communities and governments.

Table1: Seven issues that most need to be tackled

Australian Government
Department of Industry, Science, Energy and Resources

Business Cooperative Research Centres Program

RMIT UNIVERSITY

Download a copy of the report from the project webpage.

© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au

FINDINGS

bushfire&natural HAZARDS CRC

The drive to use research to inform practice is growing. This research has developed a self-assessment tool and guidelines to help agencies maximize their investment in research.

Closing the research-practice gap

Christine Owen[1, 3],

Noreen Krusel [2]

Loriana Bethune [1]

[1] Bushfire and Natural Hazards CRC, Victoria

[2] Australasian Fire and Emergency Services Authorities Council (AFAC), Melbourne

[3] University of Tasmania.

The University of Tasmania (UTAS) in partnership with the Bushfire and Natural Hazards CRC and the Australasian Fire and Emergency Services Authorities Council (AFAC) have developed the research utilisation matrix and guidelines to assist agencies to utilise research to support evidence-informed practice .

Introduction

One of the challenges facing the emergency management sector is the gap between research and practice. Despite the considerable investment in publicly funded and commissioned disaster research, the application of research findings to operational practice often lags, if implemented at all. This project has identified activities involved in the research utilisation process to support agencies to gain maximum benefit from their investment in research.

Methods

Initial survey results were discussed with members of the AFAC Knowledge Innovation Research Utilisation Network (KIRUN) and in collaboration with them a research utilisation maturity matrix has been designed as a self-assessment tool. Indicators associated with the tool were then used in a later survey to test a model of research utilization that could predict levels of implementation.

Results

The survey was completed by 190 respondents from 29 fire and emergency services agencies across Australia and New Zealand. The survey included (in part) indicators of two models of research utilisation: the science-push/demand pull model and a more relational model of knowledge building called the socially-interactive organisation model. The socially interactive organisation model was a better fit for indicators of effective research implementation. Figure 1 shows a model to conceptualise how these elements may work together to support research utilisation.

Discussion

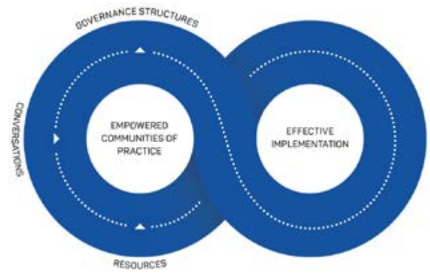
Conversations and communities of practice within agencies are the first step in building effective implementation activities.

The research utilisation maturity matrix is designed to aid reflection, inform development and promote change. It can be used by individuals, in teams, or across a whole agency at a strategic level. The matrix provides a mechanism for supporting structured and ongoing discussions about the level of utilisation maturity in the organisation.

The matrix can be used in a number of ways and at different stages in the development of research-informed practice. Its uses include:

- benchmarking current research utilisation capability
- identifying differences in perceptions, and building consensus across different roles, functions and teams about research utilisation
- helping units and agencies to identify their own areas of strength and areas for improvement, and tracking these over time
- demonstrating characteristics of an organisation and/ or team with a more developed approach to research utilization
- encouraging peer support – matching those with something to share to those with something to learn.

A model of research utilisation



Enabler	Description
People	The degree to which people in the unit or agency are expected to have or supported in obtaining the skills necessary to find, appraise and use research. The degree to which utilisation is authorised as part of core activity, embedded within job roles.
Culture	The underlying beliefs, values and behaviours of the unit/agency that inhibit or support research utilisation. This includes how receptive (or resistant) the culture is to adopting and promoting research utilisation in its everyday practice and decision making, and the extent to which research utilisation is viewed by personnel as central to the development and improvement of future policy and practice.
Communic-ation and Engagement	The degree to which engaging in utilising research is an individual or collective affair. Is it driven by passionate individuals alone or are there engaged communities of practice where people discuss, share insights? Are these found within the unit or agency and/or between agencies; potentially introducing utilisation insights from other sectors?
Resources and professional develop-ment	The degree of investment in resources to develop and improve the capability of all personnel to understand and enable research utilisation. This includes the extent of sufficient learning opportunities provided for personnel to develop their skills, knowledge and experience of research and utilisation.
Policies, procedures and doctrine	The presence or absence of appropriate policies, procedures and doctrine so that research is used to inform practice. The processes by which policies may link utilising research to the agency's core business.
Structures	The presence or absence of appropriate mechanisms to capture and facilitate research utilisation, to monitor its implementation and to disseminate and promote it throughout the organisation and the wider sector.
Governance	The processes in place to monitor, implement and report on research utilisation including quality assurance for continuous improvement.
Products	What happens to the products emerging from research. The degree to which these are taken up across the agency or simply sit on the shelf.

Download the Guidelines at
https://www.afac.com.au/docs/default-source/ru/afac-rumm-guidelines.pdf?sfvrsn=2

Australian Government Department of Industry, Science, Energy and Resources | Business Cooperative Research Centres Program | afac | UNIVERSITY of TASMANIA | Disaster Resilience Research Group

© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au

bushfire&natural HAZARDSCRC

Emergency managers sometimes need to **think outside the box**. We created a technique called **Stretch-Thinking Loops** to solve this problem. Using this technique, groups improved their options analysis by 86%.

Divergent Thinking and Brain Plasticity

Ben Brooks[1,2], Steve Curnin[1,2]

[1] Bushfire and Natural Hazards CRC, Victoria
[2] University of Tasmania.

The research aim has been to determine the value of developing alternate human skills to support people to think differently – particularly when there is no standard approach available for the incident. The types of incidents where this occurs are typically of a large scale, cross jurisdictional boundaries, are sometimes multi-hazard, and create complex social, economic, natural and built environment effects.

Introduction

In recent times one of the most significant changes in capability has been for emergency services to embrace human factors. Contributing to this, our previous research agenda has explored cognition in the context of decision making, developing training and aide memoires to support personnel in areas such as the management of cognitive biases and maintenance of situational awareness. The research supporting this work identified other problems around developing options analysis and predicting consequences for out-of-scale events. This has led our end users to ask how we can prepare our future leaders for the new norm? For human factors to adapt and remain relevant in this changing environment, the simple answer is we need to build new human capabilities.

Methods

Before commencing the discussion exercises all 86 participants completed a standardised testing regime called the Abbreviated Torrance Test for Adults (ATTA). We then conducted a training intervention to evaluate if the Stretch-Thinking Loops improved the results of an options analysis.

Results

Average creativity levels for the cohort were lower than the average for the reference sample use for the Abbreviated Torrance Test for Adults. 63% of participants in private organisations were assessed at average or above average levels of creativity. 57% of participants from public organisations were assessed as having below average levels of creativity. Between the first and second discussion exercise the creativity of the options analysis improved 86%.

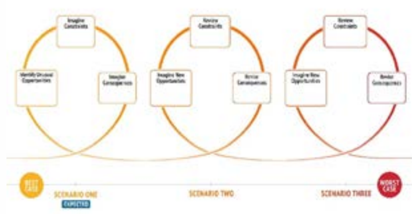
Discussion

We need to consider creativity as a valuable non-technical skill of similar importance to other non-technical skills like situational awareness, leadership and communication. A prudent approach would be to develop or enhance a creative capability earlier in a person's emergency management career. This has two benefits. Firstly, it may arrest a decline in natural levels of creativity. Subsequently, it provides more time to develop creativity before the individual finds themselves in a senior role that requires this skill at a high level.

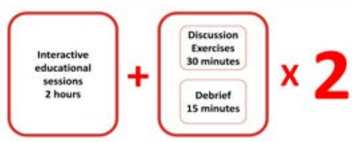
This requires a small shift in the paradigm we use to train and understand non-technical skills, and potentially some additional training resources at different levels of progression through public and private training packages.

Importantly, creativity is just one aspect of brain plasticity explored in this project and more research is needed to assess other functional plasticities for their potential value in enhancing EM capability.

Tables and figures



Stretch-Thinking Loops



Design of the Training Intervention

	DISCEX 1	DISCEX 2	Difference
Group 1	5	11	+6
Group 2	6	9	+3
Group 3	5	9	+4
Group 4	5	12	+7
Group 5	6	13	+7
Group 6	6	10	+4
Group 7	14	27	+13

Summary Divergent Thinking Scores

For more information, please email Benjamin.brooks@utas.edu.au or steven.Curnin@utas.edu.au

Australian Government Department of Industry, Science, Energy and Resources | Business Cooperative Research Centres Program | UNIVERSITY of TASMANIA | AMC Australian Maritime College | Disaster Resilience Research Group

© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au

FINDINGS

Inclusion is the key that unlocks diversity potential; a vital capability for organisations and communities managing natural hazard risk.

Diversity and inclusion: building strength and capability

Celeste Young[1]Roger Jones[1], Bruce Rasmussen[1], Neelam Maharaj[1] and Fiona MacDonald[1]
In collaboration with the end user research project team

[1] Victoria University

Natural hazard risks communities and emergency management organisations (EMOs) are multifaceted and continuously changing. In this dynamic environment, diversity provides the range of perspectives, skills and capabilities to support decision making. Inclusion ensures that this diversity is effective and enhances core functions and outcomes.

Introduction

'Diversity and inclusion: building strength and capability' was a three-year project funded by the Bushfire and Natural Hazards Cooperative Research Centre from 2017–2020. Its core aim was to develop a framework to support more effective management and measurement of diversity and inclusion (D&I) in EMOs.

Methods

The project was undertaken by Victoria University in collaboration with D&I practitioners in EMOs. The team applied a transdisciplinary approach using an established end user-based methodology (Working from the inside out). This methodology uses context-specific, systemic assessments and embeds research into decision making systems. Co-design, knowledge sharing and reflection are central to this process. The study had four areas of inquiry: economic benefits, community and organisational capability, and D&I risk.

Results

This research has been used to develop an evidence-based decision-making framework to support better management and measurement of D&I. The framework has four components: strategic change, continuous improvement (programmatic), inclusive growth, and management of social and human risk. It provides the basis for integrating D&I into organisational systems using a risk-focused approach that develops capability and skills (see Figure 2).

Key findings

Key findings from this study include the following:

- Inclusion plays a pivotal role in the management of human and social risk associated with natural hazards.
- How people are included needs to be determined from their perspective and not imposed. Statements of Inclusion can be useful for this process.
- Management of D&I has been largely implicit and tends to be less formally acknowledged, rewarded or valued than conventional skills and capabilities.
- You can't do everything at once. Staged and focused approaches to implementation achieve better outcomes.
- Measurement protocols are developing, primarily around diversity. The effectiveness of inclusion measurements are limited and require further development.
- Economic benefits were found, however a lack of data and suitable economic models limit calculating return on investment of community benefits and D&I programs more widely.
- Although diverse communities have specific capabilities and skills important for building resilience and inclusion, there are gaps that limit their ability to engage effectively in response and resilience-building activities.
- D&I capability and skills need to be developed as part of strategic workforce management and integrated into organisational strategic, transformational change and risk management frameworks.

Figures

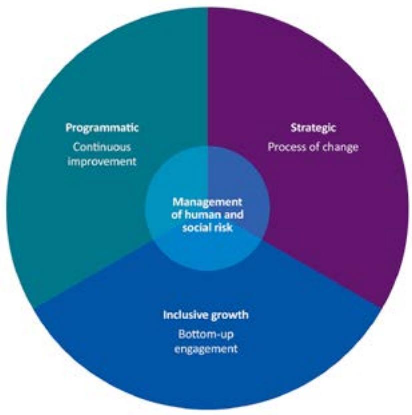


Figure 1: Diversity and inclusion framework components

Figure 2: Key activities that support embedding D&I risk into existing systems

For more information, please email celeste young@vu.edu.au

Australian Government Department of Industry, Science, Energy and Resources
Business Cooperative Research Centres Program
VICTORIA UNIVERSITY
ISILC INSTITUTE FOR SUSTAINABLE INDUSTRIES AND LIVEABLE CITIES

© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au

FINDINGS

bushfire&natural HAZARDSCRC

Managing expectations and satisfying psychological needs are critical to the recruitment and retention of emergency services volunteers.

For more information, please email **Patrick.Dunlop@curtin.edu.au.**

Enabling sustainable emergency volunteering

Associate Professor Patrick Dunlop[1], Professor Marylène Gagné[1], Associate Professor Aleksandra Luksyte[2], Dr Darja Kragt[3], Dr Djurre Holtrop[1], & Hawa Muhammad Farid[3].

[1] Future of Work Institute, Curtin University, [2] UWA Business School, University of Western Australia, [3] School of Psychological Science, University of Western Australia.

This project investigated the **recruitment**, **wellbeing**, **diversity**, and **retention** practices of State Emergency Service (SES) volunteers in Western Australia (WA). We conducted 70 volunteer interviews and two state-wide surveys with over 600 volunteers. This is a snapshot of the current and critical findings that will inform stakeholders and emergency services organisations on the practices that will help improve the recruitment and retention of emergency services volunteers.

RECRUITMENT: How do you recruit SES volunteers effectively?

- A key finding from the 70 volunteer interviews conducted was that managing expectations is critical to the effective recruitment and retention of emergency services volunteers.
- 109 quotes and 40 pictures representing SES volunteers in various roles were tested as potential recruitment messages that map into accurate and attractive expectations.
- The recruitment messages were tested with **112 current SES volunteers** and **453 community members** (i.e., potential volunteers).
- Overall, **61 quotes** and **28 pictures** were rated as being;
  - *Most attractive by both current and potential volunteers, and*
  - *Most accurate in representing SES volunteering experiences by current volunteers.*
- A **Recruitment Messaging Toolkit** was then created and launched at the 2019 Western Australian Fire and Emergency Services (WAFES) conference to help volunteer leaders find recruitment messages that are able to **set realistic expectations**, using tailored messages, **based on what the individual units can offer.**

Other volunteers are my family now!

Access the Recruitment Messaging Toolkit here:

WELLBEING: What makes SES volunteers happy?

Between September 2019 and February 2020, a Cultural Assessment Tool (CAT) survey was conducted to obtain information on the current state of volunteering in WA. The survey sample of 226 volunteers (43% women, Mean age = 46.9 years) were asked questions on different aspects of volunteering (e.g., volunteer needs, wellbeing, unit culture, leader support).

Based on the survey findings, the key areas of strength are listed below:

Volunteers are thriving through their learning experiences.	Volunteers feel valued and respected for their individual differences.	Unit leaders' behaviours are regarded very positively during and outside of call-outs.	Volunteers have strong social support from their team members who are non-leaders.

However, some key opportunities to improve include:

Improving how energetic volunteers feel about their roles through social connectedness.	Giving volunteers more task autonomy.	Improving psychological safety, and feelings of competence and autonomy for women and volunteers who are non-leaders.	Including volunteers in the units' decision-making processes.

For recommendations, strategies for improvement, and a comparison of the findings between the CAT 2018-19 and 2019-20 surveys, access the full report from the link below or from the QR code given here:
bit.ly/ESEV2020

DIVERSITY: Do volunteers of different nationalities thrive differently?

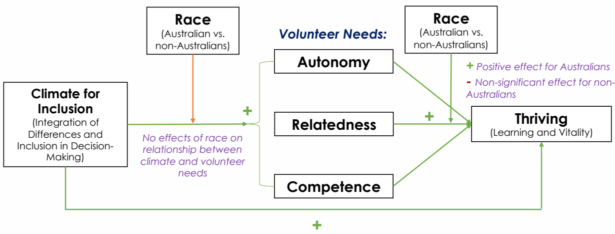


Figure 1: The interacting effects of an inclusive climate, psychological needs, and race on volunteers' thriving.

Key Findings:

Irrespective of race, integrating individual differences and inclusion in decision-making is critical for satisfying the needs of all volunteers, which results in better thriving (i.e., volunteers feeling like they are energised and continuously learning).

For Australian volunteers, an inclusive climate was particularly important for thriving due to an increased sense of relatedness with other volunteers.

QUITTING: Why have volunteers considered leaving the SES?

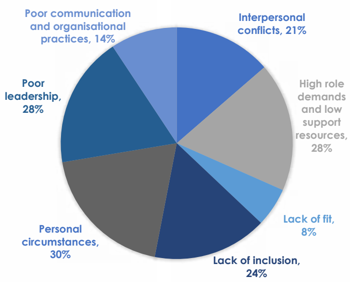


Figure 2: Reasons why SES volunteers have considered leaving the service.

- This study investigated the responses of 254 volunteers (38.9% female, Mean age = 47.1 years) on the **reasons why they have considered leaving SES in the past.**
- These reasons are summarised in Figure 2.
- It is important to note that the reasons were provided by volunteers who were still serving as a volunteer.
- Several practices can be implemented in order to address these reasons. These include:
  - *Providing flexible work arrangements that assist volunteers with their work commitments,*
  - *Giving volunteers more autonomy in their roles,*
  - *Encouraging volunteers for feedback on what organisational practices are unnecessary, and*
  - *Motivating leaders to be supportive in addressing volunteers' lack of fit and inclusion within their groups.*

Australian Government Department of Industry, Science, Energy and Resources | Business Cooperative Research Centres Program

THE UNIVERSITY OF WESTERN AUSTRALIA

Curtin University FUTURE OF WORK INSTITUTE

© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au

bushfire&natural HAZARDSCRC

FINDINGS

Non-technical skills such as situation awareness, decision making, communication, coordination, and cooperation have been identified as core non-technical skills that are essential for emergency management. We have developed simple practical tools through a human-centred design method that places end-users at the centre of the development process. The tools have now seen extensive utilization across emergency management organisations.

Managing Non-Technical Skills in Teams

Chris Bearman[1,2] and Peter Hayes[1,2]

[1] Bushfire and Natural Hazards CRC, Victoria
[2] CQUniversity, Appleton Institute

KEY INDUSTRY TOOLS

- Team Process Checklist (TPC)
- Key Task Cognitive Aid for State & Regional Control Centres
- Emergency Management Breakdown Aide Memoire (EMBAM)
- Emergency Management Non-Technical Skills Checklist (EMNoTS)

The tools are freely available from the BNH CRC website.

USE OF THE TOOLS

The tools are checklist based and can be used flexibly in a number of different ways:

- As an aide memoire.
- To set teamwork expectations and create a shared language.
- To ensure the team is functioning effectively.
- To identify problems.
- To conduct debriefs and after-action reviews.

END USER STATEMENTS

Heather Stuart *NSW SES*

The project is providing practical techniques and strategies to help people function in more complex EM environments now and into the future.

Jeremy Smith, *Tasmanian Fire Service*

These types of tools that support incident management and fire operations, or indeed any other hazard, are invaluable.

Neil Cooper *ACT Parks and Wildlife*

Those tools are bloody fantastic.

HUMAN-CENTRED DESIGN (HCD)

The tools were developed in close conjunction with our end-user partners using a HCD process. In a HCD process:

- Products are designed to suit the characteristics of intended users rather than requiring users to adapt to the product.
- End-users are at the centre of the process helping to shape the products so they meet their needs.
- Activity is characterized by an iterative cycle that involves: development, evaluation in-situ and re-development.

SELECTED RESEARCH PUBLICATIONS

- Hayes, P., Bearman, C., Thomason, M., & Bremner, P. (2020). Staying on task: a tool to help regional and state coordination centres. *Australian Journal of Emergency Management, 35*, 38-44.
- Brooks, B., Curnin, S., Bearman, C., & Owen, C. (2018) Human error during the multilevel responses to three Australian bushfire disasters. *Journal of Contingencies and Crisis Management*, 26 (4), 440-452.
- Bearman, C., Rainbird, S., Brooks, B., Owen, C., & Curnin, S. (2018). A literature review of methods for providing enhanced operational oversight of teams in emergency management. *International Journal of Emergency Management, 14* (3). 254–274.
- Grunwald, J. & Bearman, C. (2017). Identifying and resolving coordinated decision making breakdowns at the regional coordination level of wildfire management. *International Journal of Emergency Management*, 13 (1), 68-86.

For more information about the project please see our website at the BNH CRC or contact the project leader at c.bearman@cqu.edu.au

Tasmanian Fire Service State Coordination Centre. Photo credit: Chris Bearman.

UTILIZATION

Use in Action

- Tools are being used to actively manage emergencies in Australia.
- Tools are being used by observers to evaluate teamwork and decision making.
- Tools are being used to structure response plans.

International Use

- Selected tools have been translated into Spanish for use throughout Spain.

Changing Policies

- Agencies are changing their policies to facilitate use of the tools.

Inclusion in Key Resources

- Tools have been included in AFAC resources, such as the Coaching & Mentoring Guide.

Training

- Workshops on how to use the tools have been held with end-users in New South Wales, Tasmania, Victoria and South Australia.

Potential integration of these tools

- Discussions are being held with AFAC about how to better integrate tools into EMPS and Public Safety Training Units.

Australian Government Department of Industry, Science, Energy and Resources | Business Cooperative Research Centres Program | CQUniversity AUSTRALIA CELEBRATING 25 YEARS

© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au

UTILISATION

Workforce 2030: A utilisation project from the Enabling Sustainable Emergency Volunteering research stream

Enabling sustainable emergency volunteering

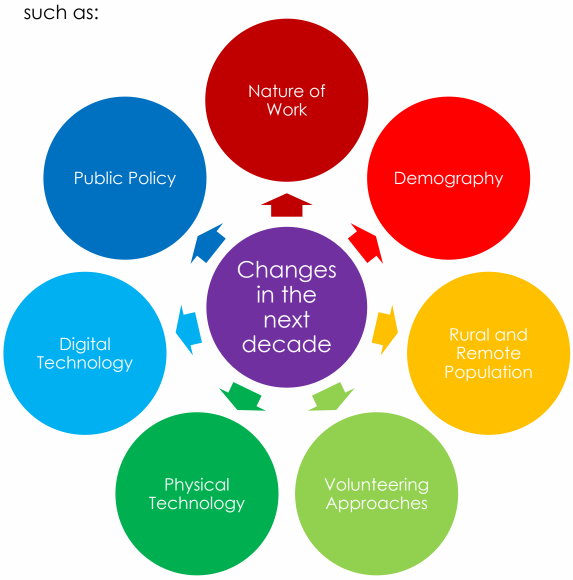
Dr Blythe McLennan[1], Assoc/Prof Patrick Dunlop[2], Jane Chong[2], Prof. Marylène Gagné[2], Dr Darja Kragt[3], Hawa Muhammad Farid[2], Prof. Mark Griffin[2], Assoc/Prof. Alex Luksyte[4], Loriana Bethune[5]

[1]School of Global, Urban, and Social Studies, RMIT University; [2]Future of Work Institute, Curtin University; [3]School of Psychological Science, University of Western Australia; [4]Business School, University of Western Australia; [5]Utilisation and DELWP Program Manager, BNHCRC

In the backdrop of significant environmental, economic, and technological changes, this project aims to provoke action in the sector by bringing together a range of CRC workforce related research and the Future of Work Institute at Curtin University to develop a report that provides a picture of the state of current research on emerging workforce challenges and opportunities likely to face emergency service organisations in the coming decade, and a series of tools that will enable the sector to confront this uncertain future. The project comprises three phases, with the large project team contributing expertise in 8 focal areas.

Phase 1 – The Changing Landscape in the 2021-2030 Decade

The project will commence by making sense of the changing landscape (external environment) that emergency management organisations operate in and which will shape workforce capability required over the next decade. The exact scope and content will be determined in discussion with the Steering Committee, however it will consider factors such as:



Phase 2 – The Eight Focal Research Areas Implication for Volunteers and Paid Workers

1. Recruitment and Selection Practice
What are the new roles? What talent is required? How do we attract it?

2. Socialisation and Training
As workers and volunteers' expectations change, how can new members be better inducted and trained?

3. Work Re-Design
As technology changes, how can we design better work to ensure human-system interaction is optimised?

4. Diversity and Inclusiveness
As Australia's demography changes, how to we ensure members from all communities feel welcome both as members and customers of the services?

5. Managing Mental Health
How do we ensure volunteer and workers' mental health is sustained while in the service?

6. Leadership
How do we instil leader skills that are adaptive to changing demographics, work roles, expectations, and performance requirements?

7. Change Management
How can we improve change management in the service?

8. Managing an Ageing Workforce
How do we engage an older workforce and create opportunities for younger workers and volunteers?

Expected Outputs

Scoping Document

Vision 2030 Report

Workforce 2030 Stories

Infographics

Animations and Vignettes

End User Engagement

At the time of printing, the team was recruiting a Steering Committee from member s of the AFAC Workforce Management Group and Volunteer Management Technical Group.

To engage with us, please contact:
blythe.mclennan@rmit.edu.au or
patrick.dunlop@curtin.edu.au

© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au

FINDINGS

Only 1 in 5 first responders seek and **receive adequate help** for a mental health condtion.

Service use and help-seeking experiences of Australian first responders with mental health conditions

Wavne Rikkers, David Lawrence

The University of Western Australia

First responders are at high risk of mental health conditions. Moreover, unacceptably low numbers of personnel either seek or receive adequate help for these conditions. Organisation-provided services have a low take-up rate and are perceived as of low usefulness.

Introduction

Early and appropriate treatment is paramount in preventing and treating mental health conditions in first responders. This study aimed to identify associations between mental health help-seeking behaviour and the demographic, employment characteristics, and mental health of Australian first responders.

Methods

Data from Answering the Call, the Australian national survey of the mental health and wellbeing of police and emergency services, was analysed to determine mental health help-seeking associations, as well as to measure patterns of service use. This encompassed 14,868 employees across 33 organisations in the ambulance, fire and rescue, police, and state emergency services sectors.

Results

Over half of employees needing help for a mental health issue neither sought nor received help, and only one fifth actually received adequate levels of help. This experience was common across all sectors. First responders with severe mental distress who delayed seeking help reported that they needed a lot more help than they received. Poor mental health help-seeking behavior and experiences were associated with high levels of post-traumatic stress disorder (PTSD) and psychological distress. For organization-provided services and programs, usage levels and perceptions of usefulness were low across all emergency services sectors.

Discussion

Findings support the importance of early intervention and help-seeking amongst first responders with emergency mental health conditions.

- Personnel across all emergency services sectors exhibited sub-optimal help-seeking behaviours and experiences. This means the causes may go beyond the organisational structures, policies, and programs of any individual sector and are likely to be systemic.
- Those needing help the most, were the least likely to seek it. Mental health literacy levels need to be improved so that people can identify symptoms of emerging mental health problems, and understand the importance of early help-seeking.
- Low take-up of wellbeing services and programs provided by organisations indicates a need for widespread review and improvement. While other barriers to seeking help may also be at play (e.g., concerns about confidentiality), the low levels of perceived usefulness of these services means they are not seen as effective or worthwhile.

For more information, please email wavne.rikkers@uwa.edu.au

Tables and figures

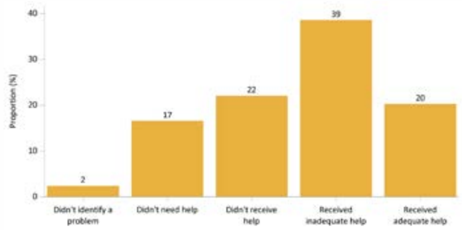


Figure 1: Perceived need for help by first responders with PTSD

Perceived need for help by first responders by severity of PTSD

PTSD Severity		n	Did not have a problem	Did not need help	Did not seek or receive help	Sought help
Sub-threshold	(%)	1570	9.3	24.5	19.7	46.5
Mild	(%)	612	4.0	23.7	22.4	50.0
Moderate	(%)	369	2.2	16.9	21.7	59.2
Severe	(%)	407	0.2	5.9	22.0	71.9

Australian Government Department of Industry, Science, Energy and Resources

Business Cooperative Research Centres Program

AFTER THE fires

THE UNIVERSITY OF WESTERN AUSTRALIA

© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au

FINDINGS

Victoria is at the forefront of developing capability in night aerial firefighting. The challenges facing aerial night firefighting teams are under-researched despite the catastrophic effects that can occur when teamwork breaks down.

Teamwork in night Fire aviation

Christine Owen[1, 2],

[1] Bushfire and Natural Hazards CRC, Victoria

[2] University of Tasmania.

The University of Tasmania (UTAS) in partnership with the Department of Environment, Land Water and Planning, and the Bushfire and Natural Hazards CRC have been working to understand human factors in night aerial firefighting operations and to use this understanding to develop capability into the future.

Introduction

Night Fire Aviation is a technologically rich activity and requires skills in both firefighting and aviation in the night environment, which provides challenges for human performance. The project has investigated the teamwork and coordination challenges facing operators working in night fire aviation operations, where coordination is required across three helicopter crews and where crews come together from different organisational and cultural contexts.

Most of the research into human factors relating to night vision technologies occur within established teams such as the military or police. This research represents a significant contribution to better understand the communication and coordination challenges for night fire-suppression operations comprising multi-agency teams.

Methods

The research methods included a survey (10 respondents), interviews (14 respondents), and a qualitative sorting technique (12 respondents) to address three research questions.

- What are the experiences of operators in relation to established teamwork dimensions and which of these dimensions are the most important in a night fire aviation operational context?
- What are the team communication and organisational - related human factors challenges for operators undertaking night fire aviation operations and how do these manifest in practice?
- What strategies can be identified to support teamwork and coordination in the night fire aviation context?

Results

The findings suggest:

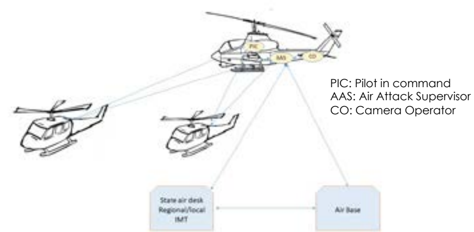
- There is a strong team orientation with the team being described as including all those engaged in flying as well as those in support. This includes Air Attack Supervisors (AAS's), pilots, Aircraft Officers – radio officers, the camera operator and those operators at the Air Base.
- The most important aspects of teamwork were consistently reported as mutual trust and adaptability.
- Adaptability is important given the changing external conditions and the hazard. A challenge for adaptability can be the ways in which tasking and geo-fence boundaries are established. There are also risks associated with motivations of commercial operators wanting to demonstrate the value of their contribution to the AAS
- Building shared mental models of the mission and the real and potential hazards is a coordinating mechanism that supports effective teamwork. There is also a need to ensure night AAS's consciously switch mental models from day attack mode as night fire presents different human factors challenges.
- Mutual performance monitoring occurs as personnel check all are up to speed with the operational tempo and not becoming task-saturated; and are not losing situational awareness due to fatigue.
- Back-up behaviour occurs through feedback and this could be more consistent and strengthened.

Future implications

A clear AAS night role specification and training program will assist in the selection, proficiency and currency of AAS's responsible for night fire operations. This would include clear guidance on the differences in the operating environment and firefighting strategies between day and night operations.

Both day and night aerial firebombing can be strengthened in developing support materials to familiarise pilots not experienced in fire aviation or Australian terminology. In addition, there is a need to review existing operations safety checks to institute a separation between operational feedback and quality assurance checks as part of the safety management system.

Team information flows



For more information, please email
Christine.Owen@utas.edu.au or
Nick.Ryan@delwp.vic.gov.au

Australian Government Department of Industry, Science, Energy and Resources | Business Cooperative Research Centres Program | EMV Emergency Management Victoria | University of Tasmania | Disaster Resilience Research Group

© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au

Indigenous Initiatives

bushfire&natural HAZARDSCRC

FINDINGS

Cultural or traditional burning requires taking **the long view** about how to live with each other and Country

Hazards, Culture and Indigenous Communities

Jessica Weir[1,2], Timothy Neale[1,3], Will Smith[1,3], Elle Daly[4], Dean Freeman[5], Tim McNaught[6], Amos Atkinson[7], Mick Bourke[7], Adam Leavesley[5], Aidan Galpin[8]
[1]Bushfire and Natural Hazards CRC, Victoria [2]Western Sydney University, New South Wales [3]Deakin University, Victoria [4]Rural Fire Service NSW [5]ACT Parks and Conservation Service [6]Office of Bushfire Risk Management WA [7]Dja Dja Wurrung Clans Aboriginal Corporation [8]Dept Environment & Water SA

Indigenous peoples' fire management captured national and international attention during the 2019-2020 bushfires. More than a burning technique, cultural or traditional burning is embedded in ways of knowing and doing attuned to the land and sustained relationships across generations with practical and purposeful understanding.

Introduction

Since 2016, we have worked collaboratively to understand how relationships between the natural hazard management sector and Aboriginal communities might be better supported in southern Australia. We have done so with qualitative methods that interpret the viewpoints of the different institutions and individuals involved.

Results

Aboriginal people bring to natural hazard management their own territories, their own governance processes and their own people. This is not just another cultural viewpoint; their self-determination and territorial rights are integral to the passage and generation of their knowledge, identity and ongoing existence as a people.

All Australian governments have a history of denying and disrupting these authorities – including through colonial policies of segregation and assimilation. Indigenous research collaborators have generously shared how such policies affect the governance of fire, Country and their own life stories today.

As partnerships with Aboriginal communities increase, the sector must identify and address where these histories remain evident in disparities in funding and authority, language and meaning, and how this informs what is considered 'normal' and appropriate.

Where collaborations are forming, this context means that: 1) Aboriginal communities are often reliant on agencies and their processes, and must develop relationships with non-indigenous practitioners, even if they do not wish to; and 2) Where collaborations are supported by the sector, these rely on the commitment of individuals, and are vulnerable to staff turnover, budgets, and the weight of meeting existing priorities.

Image: Dja Dja Wurrung and Yorta Yorta fire practitioner Mick Bourke

"Doesn't matter which way you think, we need to all start thinking in a way that respects each other and starts to learn from each other, and we can respond to these challenges ahead."
Oliver Costello, Firesticks Alliance

The long view

Unsurprisingly, this is a complex topic and involves initiatives not just in the natural hazard sector, but across governments and society. This is why taking *the long view* is so important. It is work that requires change in core institutions. It requires a more equitable sharing of power and authority. It also requires understanding that there are multiple viewpoints, and that Indigenous people need to be addressed as partners in the management of all Country. The foregrounding of Indigenous voices and leadership, on meaningful terms, across a suite of natural hazard practices and policy, is fundamental. We suggest this may include:

- Resourcing and support for Indigenous communities to conduct their own natural hazard management, including through greater authority over land
- Social learning for non-indigenous policymakers and practitioners to evolve agency culture, and foster more culturally safe workplaces
- Supported knowledge exchange and networking for both Indigenous and non-Indigenous practitioners
- Support for policy groups and networks for Indigenous people to have access to sector decision-making forums
- Appropriate regulatory, training and qualification regimes that enable Indigenous peoples' access to cultural fire
- Indigenous-led research to support evidenced based policy and practice
- Clear policy support for the sector to take partnership approaches to Indigenous communities, with all parties supported to be involved, and with respect for intra-Indigenous governance priorities
- Clear public sector reporting of agency performance in these activities

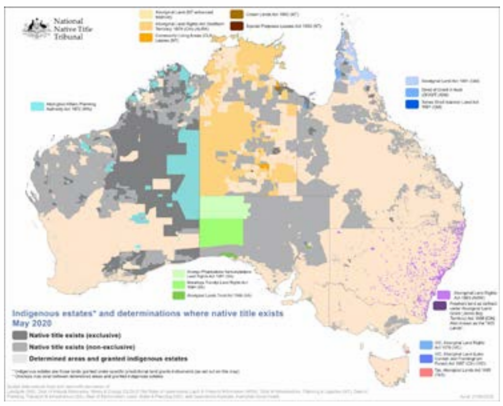
"By and large, people working in government are there to do a job, and they're there to do it by the book. You've got to find those driven people who will work with you to move things around and adapt the policies and procedures."
Amos Atkinson, Dja Dja Wurrung Clans Aboriginal Corporation

Image: Ngadju Elder Les Schultz, Ngadju Country

COUNTRY

Only traditional custodians can speak for Country, as handed down through law and custom, and practiced within networks of peoples and Countries. These intricate relational responsibilities have been abused by colonisation. Respect is needed to heal these intergenerational wounds.

The Indigenous Estate is only part of Country: all of Australia is Country



The Indigenous Estate reflects Australia's land tenure history. State, Territory and Federal governments are increasingly understanding Country means collaborating with First Nations across the entire continent and the sea. This is also in line with the principle of non-discrimination before the law, which was denied by *terra nullius*.

Australian Government Department of Industry, Science, Energy and Resources | Business Cooperative Research Centres Program | WESTERN SYDNEY UNIVERSITY | DEAKIN UNIVERSITY

For more information, please email j.weir@westernsydney.edu.au, and t.neale@deakin.edu.au, and see our HCIC project at www.bnhcrc.com.au

All images reproduced with permission

© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au

bushfire&natural HAZARDSCRC

FINDINGS

Government needs to make room for Bininj and other Indigenous Australians if they want "shared responsibility" in Emergency Management.

"Time to find those 'hidden' Bininj structures, they are not hidden and EM gotta connect with us!" : A pathway for effective community level decision-making for emergency response.

Bev Sithole[1], Otto Campion[2], Robert Bununggurr[2], Charlie Brian[2], Stephen Sutton[1] with ARPnet Team

[1] Charles Darwin University
[2] Aboriginal Research Practitioners Network 9ARPNet

With 'shared responsibility' EM agencies should ask: "how do you want us to work with you? But the reality is that 'at the coalface' few ever ask the question and even less are ready for the answer! This poster presents a model as an answer to this question from the community elders around Ramingining. They are clear on who and how they need to be connected to the current system of decision-making.

Up till now…

Without knowing about the existing structures and protocols for decision making in Aboriginal societies EM agencies have created structures based on their own culture (committees) which then lack local legitimacy. Committees are convenient for Balanda[1] but have created a negative dynamic in the community that has seen the following:

- Outside agencies failing to achieve real representation.
- The privileging of individuals by placing them in decision-making/leadership roles they have no cultural right to and don't want. This burdens these individuals, alienates them from their own people and undermines the primary objective; community resilience.
- Ignorance of community dynamics, interclan/family dynamics means that outside agencies persist with a model where they think an individual can represent, or access all.
- Outside agencies have ignored for too long the lack of alignment between their business and Bininj[2] business on country. We need to move the two towards each other.

- Agencies are unaware of the burden of meetings and the burnout resulting there from especially for individuals who sit on multiple committees.
- Bininj want to be strong actors in delivering Aboriginal safety.
- Communities vary and they will want different models. This notion has been said before and should be accepted.

What needs to happen from now….

- Government needs to make enough room for Bininj to participate. Making room means engaging with more Bininj, it also means setting aside resources to support their participation.
- This decision-making pathway/model;
  - Brings together the Bininj and Balanda systems for EM and identifies at least 5 Bininj who should be involved,
  - Gives guidance on the preferred spaces for meetings and working together and what is required to make this structure viable.
  - Associated with this pathway is the requirement for easy access to simple and effective messaging. The 3D model of Ramingining makes planning and visioning of EM more visual for country
  - Inclusion of people with skills in response is crucial to this new way.

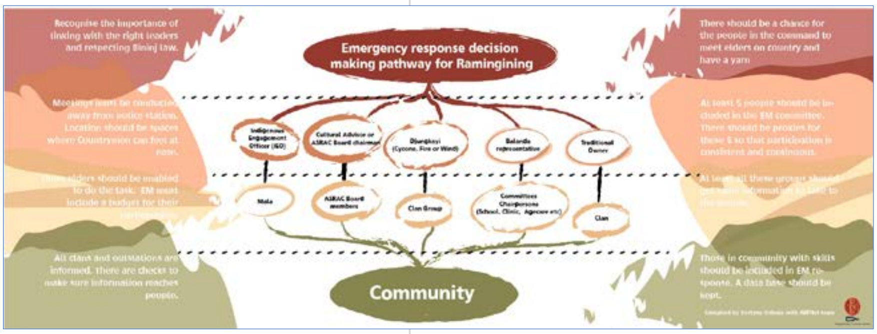


Figure1: A Model for Community Engagement between EM Agencies and Bininj, designed by Bininj

Notes:
1 Balanda = non-Aboriginal people
2. Bininj – Aboriginal people (central and western Arnhem Land)

For more information, please email bevlyne.sithole@cdu.edu.au

Australian Government Department of Industry, Science, Energy and Resources | Business Cooperative Research Centres Program

CHARLES DARWIN UNIVERSITY

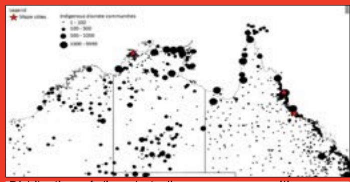
RIEL Research Institute for the Environment and Livelihoods

© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au

FINDINGS

bushfire&natural HAZARDSCRC

Long term support from Fire and Emergency Services Agencies is necessary to develop the relationships required to appropriately engage with Remote Indigenous Communities



Distribution of discrete Indigenous communities across northern Australia. (ABS 2016).

Scenario Planning for Remote Community Risk Management in northern Australia

Professor Jeremy Russell-Smith[1,2,3], Dr Kamaljit K Sangha[1,2] and Dr Andrew C Edwards[1,2]

[1] Bushfire and Natural Hazards CRC, East Melbourne Victoria Australia
[2] Darwin Centre for Bushfire Research, Charles Darwin University, Darwin NT Australia
[3] North Australian Indigenous Land and Sea Management Alliance, Casuarina NT Australia

This program involves collaborations between the Darwin Centre for Bushfire Research (DCBR) at Charles Darwin University (CDU), the North Australia Indigenous Land & Sea Management Alliance Ltd (NAILSMA), the Aboriginal Research Practitioners Network (ARPNet) at CDU, and regional stakeholders including Fire and Emergency Management agencies, conservation agencies and remote Indigenous communities in the NT, Kimberley and north Queensland.

Introduction

We developed a framework for **Fire & Emergency Services (FES) agencies** to engage with **Remote Indigenous Communities** to improve **FES** delivery.

The **FES** agencies recognise the need to improve the services provided remotely, but also recognise that some jurisdictions (particularly the NT) are not adequately resourced to achieve this.

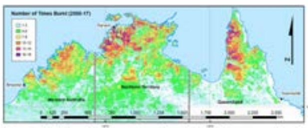
The classic model of volunteering does not suit **Remote**, significantly disadvantaged, **Indigenous Communities**. The expanding **Indigenous Ranger Groups** are a potential means to more appropriately engage with **Remote Indigenous Communities** to build emergency management (EM) capacity, community preparedness, resilience and response capability.

Methods

1. A suite of case studies, including interviews and workshops with 8 Indigenous Ranger Groups to ascertain their aspirations, willingness and capacity to engage in EM.

2. A full economic assessment to understand the full costs and benefits of effective EM in remote communities under various scenarios.

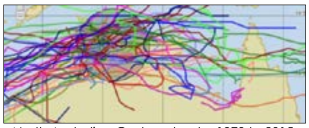
3. A full accounting of the costs of the most commonly occurring natural hazards and disasters in north Australia.



North Australian Fire frequency, 2000 to 2017 (Derived from north Australia fire information – www.firenorth.org.au).

Waanyi and Waanyi Garawa Rangers, Borroloola NT

Community members and researchers, Galiwinku Elcho Island, NT



North Australian Cyclone tracks, 1970 to 2015.

Results

A model for **effective engagement and partnership with remote Indigenous communities** can be guided through the following salient points:

- Long-term agency support is required from trained personnel with appropriate understanding of and consideration for the social, economic and cultural issues.
- The classic model of volunteering has limited applicability in remote Indigenous communities for various social, economic and cultural reasons.
- Support needs to build on foundations of mutual respect.
- A collaborative model of managing EM in remote communities must be developed in consultation with locals.
- Requires the implementation of a multi-sector approach, providing cost-effective mitigation and management of natural disasters.
- EM can be undertaken as part of activities addressing broader landscape and community management.
- Agencies need to provide patient support, regular, flexible and appropriate training, mentoring and resourcing assistance.
- Significant efficiencies can be gained through developing contracted, fee-for-service arrangements—especially where agencies have limited or no capacity to deliver required services themselves.

A detailed **assessment of the total costs** (monetary and non-monetary) associated with natural disasters in the NT:

- Average Annual Total Losses > $150 million (2010-2019): Monetary losses $53 million which are typically only considered for policy decision making.
- Non-monetary losses, estimated at $103 million/year (accounting mainly for bushfires and cyclones), constitute two-thirds of remaining loss - largely omitted in our current natural disaster-related assessments and policies.
- Minor, yet frequent, events such as floods, cost >$7 million/year, are not, but need to be considered in national disaster datasets—AUS-DIS and the Australian EM Knowledge Hub disaster events data (https://data.gov.au/dataset/ds-dga-26e2ebff-6cd5-4631-9653-18b56526e354/details?q=Disasters).
- Effective partnerships with remote communities, and cross-sectoral engagement, especially with the environmental sector, are essential for building resilience to natural disasters across northern Australia.

Above: Attendees at the Leadership Training Course for Indigenous Rangers from Remote Indigenous Communities

For more information, please email: Andrew.Edwards@cdu.edu.au

Australian Government Department of Industry, Science, Energy and Resources | Business Cooperative Research Centres Program | DCBR Darwin Centre for Bushfire Research | BUSHFIRES NT | DFES Department of Fire & Emergency Services | Queensland Fire and Emergency Services | Charles Darwin University

© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au

FINDINGS

Ongoing dispersal shapes intercultural collaboration with women caring for sentient and gendered Country.

Women Caring for Country on the Frontier

Katherine van Wezel[1,2]

[1] Bushfire and Natural Hazards CRC
[2] Research Institute for the Environment and Livelihoods, Charles Darwin University

In the southwest Gulf of Carpentaria, Waanyi and Garawa women have been at the forefront of establishing caring for Country programs on their lands. However, until recently they have seen relatively few employment opportunities to participate in these programs as rangers. This BNHCRC PhD project has provided an opportunity to work with the Waanyi-Garawa and Garawa rangers to support women in their struggle to care for Waanyi and Garawa Countries, and to develop a case study of intercultural collaboration within settler colonial Australia.

Introduction

Indigenous caring for Country programs are the leading employers of women within Australia's environmental management sector. However, gender is still left largely unconsidered in the planning and evaluation of intercultural caring for Country projects, and there is little critical consideration within settler policy discourse for the societal circumstances in which Indigenous women choose to participate in these partnerships*. This research therefore explores the question: *how does settler colonialism shape intercultural collaboration with women caring for Country in the Waanyi and Garawa case study?*

Methods

This is a participatory action research project, where Waanyi and Garawa women participated in the research as rangers, and I participated in their ranger programs as a research student based out of Robinson River community and Borroloola from 2015-2018. I have reflexively analyzed this experience, as well as unstructured interviews and group discussions, within a critical theoretical framework drawing on settler colonial and feminist studies. Under the guidance of women I have worked with, my thesis is narrated explicitly from my own perspective as a white researcher. Here I have positioned myself as a co-subject, already implicated in both settler colonialism and intercultural collaboration from the onset of the project.

Results

Key findings of this research include:

- Waanyi and Garawa Country continues to be sentient, gendered, and reciprocal to its peoples
- Waanyi and Garawa men and women understand damage to their Country as a direct result of their ongoing dispersal into surrounding townships and the subversion of their customary governance institutions
- Here women have different historical and contemporary experiences of dispersal to men, and hope to heal their Country by renewing its connection to its people as sovereign experts of their own Country
- Intercultural collaborations with Waanyi and Garawa women have the potential to undermine this aspiration by perpetuating settler colonial gender relations
- At the same time, Waanyi and Garawa men and women purposefully use intercultural collaborative action to decolonize these power structures situated within settler institutions and support women caring for Country.

Discussion

Recent BNHCRC funded research posits that it is useful to consider collaborations between settler institutions and Indigenous peoples as decolonizing experiments**. The number of Indigenous women employed in caring for Country programs and working in partnership with settler institutions is in Australia is steadily growing***. This case study provides insights into impediments and opportunities for decolonizing these intercultural collaborations.

*Davies, Walker, Maru, 2018. Warlpiri experiences highlight challenges and opportunities for gender equity in Indigenous conservation management in arid Australia. *Journal of Arid Environments,* 149: 40-52
**Neale, Carter, Nelson, Bourke, 2019. Walking together: a decolonising experiment in bushfire management on Dja Dja Wurrung country. *Cultural Geographies,* 26(3): 341-359
*** "Strong Women on Country: The Success of Women Caring for Country as Indigenous Rangers and on Indigenous Protected Areas", 2018. Country Needs People, PEW Charitable trust: https://www.countryneedspeople.org.au/strong_women_on_country

Image above: Ms. T. Green, Kathleen O'Keefe, Katherine van Wezel, Iris Hogan, Margaret Cutta, Katie Seccin, Maxine Wallace, and Clareece Coolwell planning fieldwork, courtesy of Harry MacDermott, Kaligan, May 2016

Image above: Joy and Katie Seccin burning their Country for the first time as part of their caring for Country program on the Ganalanga-Mindibirrina IPA, May 2017

Image above: Waanyi and Garawa custodians, rangers, and their collaborators discussed the dissemination of this research at their biannual Ganalanga-Mindibirrina IPA meeting. Wongalingi, May 2018

Australian Government Department of Industry, Science, Energy and Resources
Business Cooperative Research Centres Program
Charles Darwin University

For more information, please email katherinepetria.vanwezel@cdu.edu.au

© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au

Infrastructure and Impact

bushfire&natural HAZARDS CRC

FINDINGS

Certain house types can benefit from retrofitting for severe wind events

Benefit-Cost Analysis of Retrofitting Older Australian Houses for Windstorms

Korah Paracka[1], Martin Wehner[2], Hyeuk Ryu[2], John Ginger[1], David Henderson[1], Mark Edwards[2]

[1] Cyclone Testing Station, James Cook University, QLD
[2] Geoscience Australia, ACT

Detailed vulnerability modelling was used to determine benefit cost ratios of ten representative Australian house types

Introduction

Houses built prior to 1985 have not been designed according to contemporary engineering based design codes and can be significantly more vulnerable to wind damage compared to newer housing.

The efficacy of a range of retrofitting options for 10 representative Australian houses (an example shown in figure 1) were analysed using the VAWS wind vulnerability modelling software and benefit cost ratios were calculated based on the annual average loss over a 30 year period.

Methods

The development of the VAWS vulnerability modelling software has been a major part of this BNHCRC project. The program simulates structural, debris and water ingress damage of a house based on input data from wind tunnel studies and testing of structural elements. Using a Monte Carlo approach, a damage index as a function of wind speed can be calculated for a range of retrofitting scenarios, shown in figures 2 and 3 which show vulnerability functions for a metal roofed house and a tile roofed house.

Benefit-Cost ratios were calculated based on cost information from a professional quantity surveyor and the net benefit of retrofitting calculated based on the annual average loss derived from the damage index functions.

Results

The benefit cost ratios, shown in table 1 account for the probabilities of wind damage occurring through the annual average loss calculations for the different wind regions. As such, there is generally no benefit of retrofitting the representative house types in the non-cyclonic wind regions A. On the other hand, benefit cost ratios close to and exceeding 1.0 were determined for certain retrofitting scenarios in the cyclonic wind region C.

Additionally, it was found that tile roof houses greatly benefit from certain retrofitting scenarios. Mainly due to the reduction of water ingress damage at lower and more frequently occurring wind speeds.

Discussion

The current benefit cost analyses only account for cost related to the damage of the house. Accounting for costs related to the disruption of economic activity in the community and mental health impacts of the event on citizens and other intangible costs would improve the benefit to cost of retrofitting older houses. However, this level of analysis is outside the scope of the current BNHCRC Project.

Further reductions in costs can occur when there is increased demand in the market for retrofitting. For example, the average costs of a full roof upgrade (scenario 9.4) during the Queensland Household Resilience Program were significantly lower than those calculated by the quantity surveyor, yielding a B/C ratio of approx. 2 for a full roof upgrade on house type 9. Additional benefits that are not accounted for in this study are potential reductions in insurance premiums that may be offered to customers for implementing retrofitting measures.

For more information, please email korah.parackal@jcu.edu.au

Tables and figures

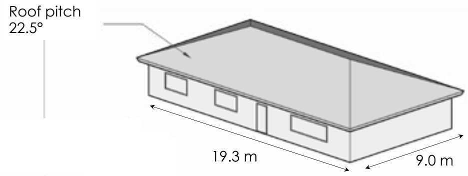


Figure 1 Overall dimensions of the hipped roof generic house types

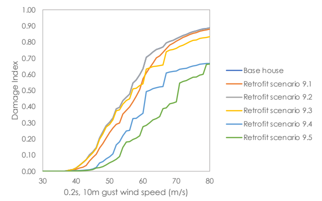


Figure 2 Vulnerability functions for house type 9 – brick veneer + metal roof cladding

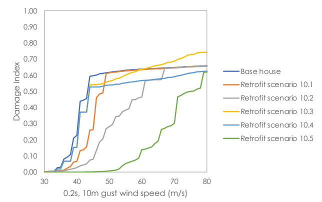


Figure 3: Vulnerability functions for house type 10 – brick veneer + tile roof cladding

Generic House Type	Retrofit Scenario	Retrofit Description	Benefit/Cost Ratio Region A	Benefit/Cost Ratio Region C
House Type 9	9.1	Window protection and door upgrade	0.00	0.94
-Brick Veneer	9.2	Roof sheeting upgrade	0.00	0.00
-Metal Sheet	9.3	Roof sheeting and batten connection upgrades	0.00	0.03
-Hip	9.4	Roof sheeting, batten connection and roof structure upgrade	0.00	0.56
	9.5	All upgrades 9.1 to 9.4	0.00	0.53
House Type 10	10.1	Window protection and door upgrade	0.06	9.03
-Brick Veneer	10.2	Additon of Sarking	0.02	4.75
-Tile	10.3	Addition of tile clips + batten connection upgrades	0.01	0.68
-Hip	10.4	Addition tile clips + batten connections and roof structure upgrade	0.01	0.58
	10.5	All upgrades 10.1 to 10.4	0.02	3.60

Table 1: Benefit cost ratios for a range of retrofitting scenarios for house types 9 and 10.

Australian Government Department of Industry, Science, Energy and Resources | Business Cooperative Research Centres Program | James Cook University Australia | Cyclone Testing Station | Australian Government Geoscience Australia

© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au

bushfire&natural HAZARDSCRC

FINDINGS

Remotely sensed data can improve flood forecasting capability in poorly gauged catchments

Improving flood forecast skill using remote sensing data

V. Pauwels[1], J. Walker[1], S. Grimaldi[1], A. Wright[1], Y. Li[1]

Department of Civil Engineering, Monash University, Clayton, VIC

Floods cause considerable socioeconomic damage worldwide. In the past 40 years the average annual cost of floods is estimated to be $377 million dollars. The Insurance Council of Australia have declared 823,560 Queensland homes to be unprepared for flooding. Water and emergency agencies use flood forecasting systems to limit the socio-economic exposure to floods.

Introduction

This project explored novel ways to combine remote sensing data and models to improve flood forecasting capability and skill. Flood forecast capability was improved by:

- Using remotely sensed soil moisture in a multi-objective calibration scheme for the hydrologic model,
- Using remote sensing-derived flood extent and waterline to calibrate the hydraulic model.

Methods

Hydrologic model: To assess flood forecast skill at internal sub-catchment locations, a traditional semi-distributed hydrologic model which is calibrated to the downstream flow gauges at Chinchilla and Lilydale respectively, is compared to a model which additionally calibrates internal sub-catchments to remotely sensed soil moisture observations.

Hydraulic model: The calibration framework aims at minimizing the discrepancies between modelled and remote sensing-derived flood extents and waterlines. Performance metrics that provide a quantitative evaluation of the accuracy of the modelled floodplain inundation dynamics were used. The 2011 and 2013 floods in the Clarence catchment were used as test cases.

Results

Hydrologic model: The results from Li et al. (2018) demonstrate that semi-distributed hydrologic models which use remotely sensed soil moisture observations are significantly more able to forecast streamflow at internal sub-catchment locations.

Hydraulic model: The remote sensing-based calibration framework determined a spatially distributed parameter set for both the flood events. Gauged data were used as an independent validation dataset and the remote sensing-derived spatially distributed parameters led to Nash Sutcliffe values consistently higher than 0.75.

Discussion

Hydrologic model: It is not uncommon for significant flooding to occur upstream of in-situ streamflow gauges. Further, installing additional gauges at these locations is not always feasible. The ability to use remotely sensed soil moisture to improve streamflow forecast skill at these locations had wide-reaching impacts.

Hydraulic model: The accuracy, timing, and spatial coverage of the remote sensing observations largely impacted the effectiveness of the calibration exercise. Further improvements to the framework are required when using remote sensing observations acquired after the flood peak in valley filling events. Further testing of the calibration framework on catchments with different hydrological and morphological features is strongly recommended.

For more information, please email Ashley.Wright@monash.edu

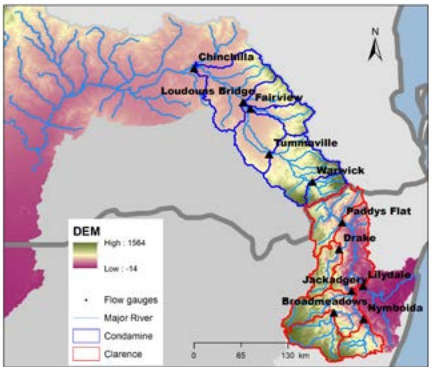


Figure 1: By using remotely sensed soil moisture streamflow simulation skill was improved at internal locations.

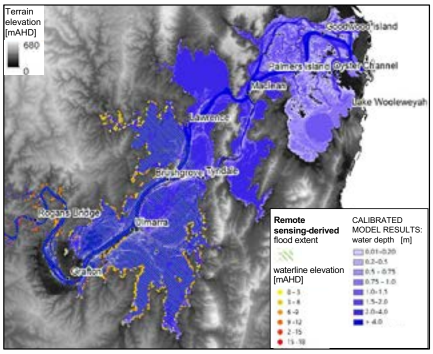


Figure 2: Clarence catchment, 2011 flood event – remote sensing-derived observations compared with model results.

References

Li, Y., Grimaldi, S., Pauwels, V. R., & Walker, J. P. (2018). Hydrologic model calibration using remotely sensed soil moisture and discharge measurements: The impact on predictions at gauged and ungauged locations. https://doi.org/10.1016/j.jhydrol.2018.01.013

Australian Government Department of Industry, Science, Energy and Resources | Business Cooperative Research Centres Program | MONASH University Engineering | Australian Government Bureau of Meteorology | Australian Government Geoscience Australia | SES NSW STATE EMERGENCY SERVICE

© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au

FINDINGS

bushfire&natural HAZARDSCRC

The structural integrity of reinforced concrete buildings to seismic actions can be enhanced by retrofitting works that combine the strengths of bracings and walls.

Retrofitting Strategy for Limited Ductile Reinforced Concrete Buildings in Australia

Raneem Alazem[1,3*], Elisa Lumantarna[1,3], Nelson Lam[1,3], Scott Menegon[2,3]

[1] Department of Infrastructure Engineering, Melbourne University, Victoria
[2] Centre for Sustainable Infrastructure, Swinburne University, Victoria
[3] Bushfire and Natural Hazards CRC, Victoria

Most Australian reinforced concrete (RC) buildings have not been designed to withstand seismic actions and are considered to have limited ductility. This poster is to present the findings of the Bushfire and Natural Hazards CRC funded research project, "Cost-effective mitigation strategy development for building-related earthquake risk", which is aimed at evaluating the seismic performance of some selected Australian RC buildings for considerations of cost-effective retrofitting measures.

Introduction

This research was established with the aim of assisting with risk mitigation decisions by providing practical retrofit solutions to identified vulnerable buildings. Several retrofit options for a 2-storey limited ductile reinforced concrete building are presented. The building has been identified to be vulnerable in previous studies (Amirsardari, 2018). The retrofitting options have shown an improvement in the behaviour of the buildings. The retrofit options explored were simple with the purpose of being cost effective and easy to implement. In addition, it can be used as a preliminary study for the development of Australian seismic evaluation and retrofit standards of the existing buildings.

Methods

To determine the most appropriate retrofit method, a seismic assessment of the structure must first be undertaken. For this purpose, SeismoStruct software was utilized. A nonlinear pushover analysis, applying triangular loads, was performed on the structures. This is because triangular loads simulate the earthquake loads better than uniform load applications. The buildings are pushed until collapse occurs, as this provides a better understanding of how the failure mechanism develops

Results

Several retrofitting options were investigated following the same methods. These options Included bracings, walls and a combination of walls and bracings, as seen in figure 1. The performance level of each retrofit can be seen from figure 2.

Discussion

- Bracings are recommended if the purpose is to ensure that collapse occurs at a higher seismic hazard value and that an increase in torsional stiffness is required.
- Walls are recommended if the purpose is to ensure better behaviour across all performance levels, although brittle collapse of structure might be expected.
- Bracings and walls used together are recommended if better performance levels are required at higher seismic hazard values, for high importance structures, as well as increasing torsional stiffness and reducing the chances of brittle failure as ductility increase.

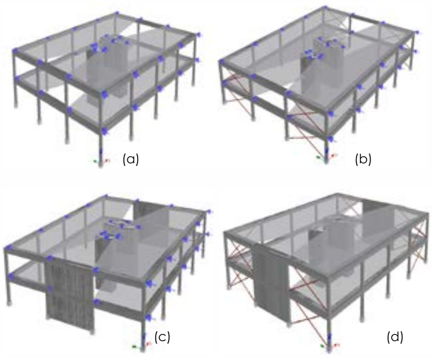


Figure1: Building models with pushover loads assigned (a) unstrengthened (b) bracing retrofit (c) wall retrofit (d) wall and bracing retrofit

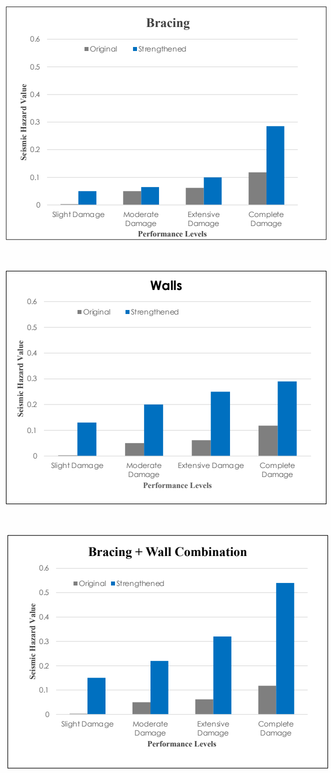


Figure 2: Performance levels of Different retrofit techniques vs. unstrengthened building

For more information, please email ralazem@student.unimelb.edu.au

Australian Government Department of Industry, Science, Energy and Resources | Business Cooperative Research Centres Program | Australian Government Geoscience Australia | SWINBURNE UNIVERSITY OF TECHNOLOGY | afac | THE UNIVERSITY OF MELBOURNE

© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au

FINDINGS

The cushioning factor is a parameter that can show the structural response and have a regressive power relationship with the deformation of the structure.

PARAMETRIC STUDY ON THE MASS OF A FREE-DROPPED-HAMMER ON DYNAMIC RESPONSE OF A REINFORCED CONCRETE BEAM

Maryam Nasim, Sujeeva Setunge, Tariq Maqsood

School of Engineering, RMIT University, Melbourne 3004, Australia

Introduction

In general damage assessment is used to determine the capacity of a structure under given loading scenarios. Impact loading is a common phenomenon in reinforced concrete (RC) structures subjected to extreme loading scenario which acts in a very short period of time. Basically, when a Moving Object (MO) hits a given structure, momentum is conserved by a reactionary force that slows down the structure until it comes to a halt. Some of the kinetic energy of the MO is converted to strain energy in the structure that is being hit.

Structural damage under impact loading is categorised into two different reaction phases: i.e. local response and overall response. A local response is originated based on the stress wave that occurs at the point of immediate loading. The overall response results from free vibration of the elastic-plastic deformation of the system and can last over a longer period of time after the impact loading. This study provides an analytical framework for determining the structural dynamic response of concrete elements based on a parametric study on the mass of a drop hammer impact.

In this study, a series of non-linear Dynamic/Explicit analysis have been conducted using the commercial finite element software ABAQUS to understand the mechanism of impact on a structure and the structural nonlinear inelastic response, for instance, maximum impact forces, the energies of the system and beam's deformation. For a selected beam section, the significance of concrete crushing with the increase in impacted mass is evaluated. Furthermore, the damage behaviour of the beam is studied.

Methods

- In this research, ten different masses of the drop hammer are used to understand the influence of the mass of the hammer on the response of the RC beam and the damage patterns. This study provides a comprehensive overview of the impact response of a simply supported RC beam and Fig1 shows the FE model the impact.
- One important observation is the distinction between free vibrational behaviour and damping behaviour of the structural system. This is demonstrated in Figure 2 by comparing the results from the nominated analysis of the RC beam under impact loading. Lighter impactors (0.2t&0.4t) cause local damage while massive impactors cause severe damage, distinguished by the convex behaviour of the impact force.
- Figure 3 provides the variation of the impact forces derived from the FEM analysis and compares the corresponding values of theoretical impact forces defined by:

$$F_{impact} = \frac{mgh}{d}$$

The capability of a structure to absorb the energy can also be defined by the cushioning factor, which is a relationship between stress and energy absorbance of a material. The cushioning factor can be described as:

$$C = (GT/H)$$

where G is the peak acceleration of the impact, T is the beam thickness, and H is the drop height. Figure 4 compares the cushioning factor in relation to the normalised maximum deformation and the ultimate deformation.

Results

1. The impact force has a non-linear relationship with the mass of the hammer
2. The mass of the hammer has a linear relationship with total energy.
3. The cushioning factor is a parameter that can show the structural response and have a regressive power relationship with the deformation of the structure

For more information, please email Sujeeva.Setunge@rmit.edu.au

Tables and figures

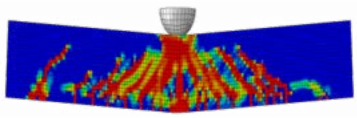


Fig. 1: FE model of explicit impact in ABAQUS

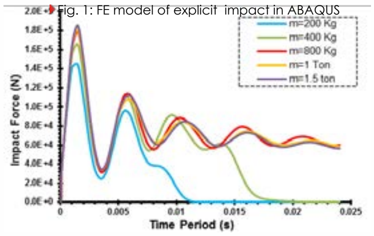


Fig. 2: Impact force for nominated masses of the hammer during the impact

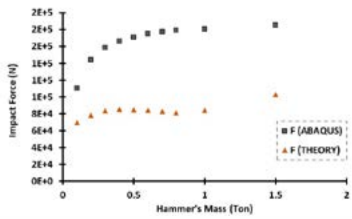


Fig. 3: Normalised maximum impact force relationship with the normalised mass of the impactor

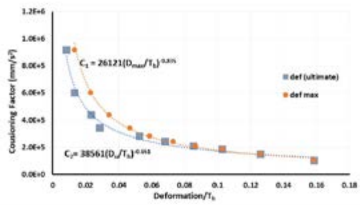


Fig. 4: Cushioning factor's relationship with the beam deformation

Australian Government
Department of Industry, Science, Energy and Resources

Business Cooperative Research Centres Program

RMIT UNIVERSITY

© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au

INFRASTRUCTURE AND IMPACT

FINDINGS

Fragility functions development framework is introduced for bridges subjected to extreme wave-induced forces.

bushfire&natural HAZARDSCRC

Fragility analysis of bridges subjected to extreme waves

Ismail M. I. Qeshta[1], M. Javad Hashemi[2], Rebecca Gravina[1], Sujeeva Setunge[1]

[1] Civil and Infrastructure Engineering, School of Engineering, RMIT University, Melbourne, VIC 3000, Australia
[2] Department of Civil and Construction Engineering, Swinburne University of Technology, Melbourne, VIC 3122, Australia

This study provides a framework for developing fragility functions for bridges subjected to extreme waves. The efficiency of strengthening bridge piers using FRP jackets is investigated. The fragility analyses showed that the fragility of strengthened bridge was reduced by up to 46% for the extensive damage state.

Introduction

Coastal bridges are susceptible to severe damage due to wave-induced forces during extreme events such as coastal flooding, hurricanes, storm surges and tsunamis. As a direct impact of climate change, the frequency and intensity of these events are expected to increase in the future, highlighting the necessity of in-depth understanding of the safety and reliability of coastal infrastructure during these events. The main aim of this study is to provide fragility functions for bridges subjected to extreme wave-induced forces.

Methods

Sed A framework is adopted in this study to develop fragility models for bridges subjected to extreme waves. The framework is based on static analysis, and it accounts for the uncertainties in both wave and structural properties. Figure 1 shows the steps of the methodology. The inundation depth and flow velocity increments are first specified and checked with the Froude number (Fr) limit to remove the unrealistic cases of velocity. In this study, the maximum inundation depth and velocity were selected as 11 m and 20 m/s, respectively. The capacity curves at each inundation depth are obtained using the mean values of concrete compressive strength (27 MPa) and steel tensile strength (500 MPa). The three main damage states are defined for each inundation depth, and their corresponding drift ratios are obtained. The first damage state (slight) defines the first crack load of the pier. The second (slight) and third (extensive) damage states define the yield and peak loads of the pier. The structural models using random samples of concrete compressive strength and steel tensile strength are generated. In this study, 10 random samples of each of the concrete compressive strength and steel tensile strength using coefficient of variation (COV) values of 0.18 (normal distribution) and 0.11 (lognormal distribution), respectively. This means that 100 structural models for each inundation depth are obtained. In addition, 10 random samples were generated for the force coefficients using uniform distribution of the range between 1.25 to 2. For each inundation depth, the calculated forces are checked with 100 structural models, which gives a total number of cases of 1000. For each case, the drift ratios are computed and checked against the estimated damage states of each inundation depth. For one inundation depth, the number of cases at each velocity increment that exceed a certain damage state are divided by the total cases, which provide the damage probability.

Results

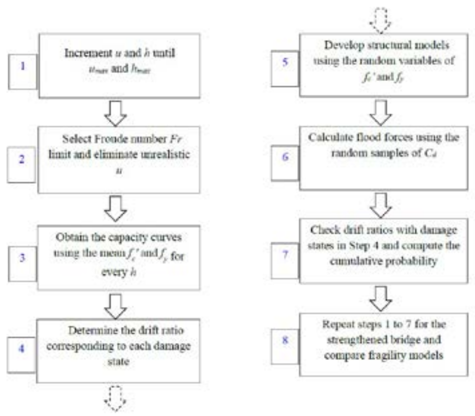
The most significant enhancement in the performance of the bridge was obtained at the extensive damage state, with up to 46% drop in damage probability at a velocity of 15 m/s. Figure 2 shows the fragility curve of both initial (as-built) and strengthened bridge. The maximum drop in damage probability for the slight damage state was about 21% at a velocity of 9.5 m/s, while it was about 40% for the moderate damage state at a velocity of 13 m/s. The fragility analysis results show the effectiveness of the use of fibre reinforced polymer jackets for reducing the vulnerability of bridges. This provides more resilient transport infrastructure that can assist in the post-disaster recovery, and hence reduce the consequent social and economic losses.

Discussion

This study provided a demonstration example of vulnerability evaluation of a bridge. The bridge piers were strengthened using fibre reinforced polymer jackets. The fragility analysis results showed the following main findings:

- A methodology was developed predict the fragility of bridges subjected to extreme waves. This methodology considers the inundation depth and velocity of flow as the main the intensity measures. It can be utilized to examine the effectiveness of different strengthening methods.
- The use of fibre reinforced polymer jackets is effective for reducing its vulnerability under extreme wave forces.
- Future research needs to focus on the investigation of the effectiveness of superstructure strengthening methods (e.g. shear keys and restrainer cables) for extreme waves forces. In addition, more research is needed to develop vulnerability models for bridges subjected to elevated temperatures, particularly from vegetative fires (i.e., bushfires).

Figures



Figures 1: Methodology for developing fragility functions of bridge.

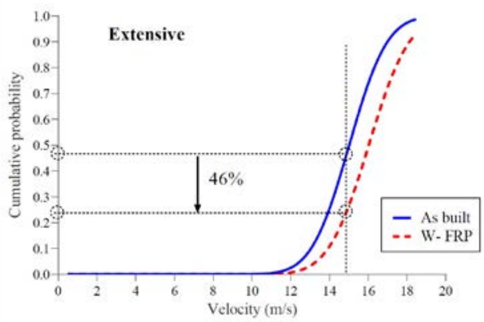


Figure 2: Comparison of fragility curve for as built and strengthened bridge at extensive damage state.

Australian Government
Department of Industry, Science, Energy and Resources
Business Cooperative Research Centres Program

RMIT UNIVERSITY

© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au

Managing the Landscape

bushfire&natural HAZARDSCRC

FINDINGS

Fire hazard risk is less subjective and more accurate by a streamlined capture and processing of fuel layer images.

Fuels3D

Bryan Hally[1], Mark Robey[1], Sam Hillman[1], Luke Wallace[1], Karin Reinke[1], Simon Jones[1] and Simon Ramsey[1]

[1] School of Science, RMIT University, Melbourne VIC

Fuels3D is a workflow solution for the processing of imagery to create 3D points clouds from which fuel hazard metrics are derived. Fuels3D supplements existing visual assessments with repeatable and quantitative estimates of surface and near-surface fuel using image-based point cloud techniques. Trials are currently underway with end-user agencies across Victoria, Queensland, South Australia and ACT.

Estimating Fuel Hazard

Assessment of vegetation attributes used to calculate hazard rating of a plot is typically achieved visually. Visual assessments provide only qualitative information on some metrics and have been demonstrated within the literature to be subjective, and variable between assessors.

Fuels3D takes user-collected information in the form of photographs to derive 3D point clouds from which metrics pertaining to the surface and near-surface layers of a typical fuel assessment plot can be calculated. This process is embedded in a custom workflow which allows end users to provide image data to a web portal and receive plot-specific fuel hazard metric as an output report.

Data Portal

Fuels3D is pioneering a data assimilation system that is end-user driven, in order to ingest imagery with the appropriate metadata attached. The process is driven in part by a series of forms on a data portal powered by an Amazon Web Services (AWS) backend (Fig.1).

Users of the system are given login to accounts, and are asked to submit relevant data, including visual fuel assessment forms for cross-validation of resultant fuel hazard metrics.

Plot Sampling

Fuels3D fuel hazard assessment is performed by photographing sample areas using a consumer-grade mirrorless camera or equivalent.

A typical plot consists of nine 2m circular sample areas (Figure 2), to fit within a typical fuel hazard assessment plot.

Sampling is performed by standing approximately 2m away from the sample centre and orienting the camera so that the image top aligns with the top of a custom scaling object. By raising and lowering the camera in a zig-zag motion, depth and structural information can be collected.

Sampling continues until the user returns to the starting point. Photos are then taken in a pattern overhead the sample to complete a dome of images.

Data Processing

Data is processed using a series of point cloud tools developed in Python. For image-based processing, sample images are processed using a Python workflow and the Metashape processing module, with minimal user intervention to supply control information.

Subsequently, point clouds are driven through a ground filtering process, separated into layers, and the surface information is taken through an orthophoto classification process to derive vegetation structure from which hazard metrics are calculated..

For more information, please email bryan.hallye@rmit.edu.au

Tables and figures

Figure1: Fuels3D web portal for uploading images to be processed.

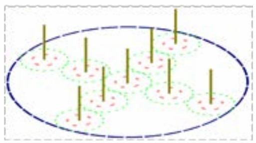


Figure2: Example sampling scheme over a fuel assessment plot.

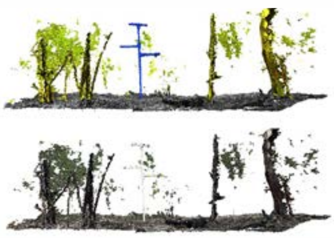


Figure3: Example sample plot with fuel layer classification applied

Australian Government Department of Industry, Science, Energy and Resources | Business Cooperative Research Centres Program

CFA | ACT Government | Government of South Australia Department of Environment, Water and Natural Resources | RMIT UNIVERSITY

© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au

bushfire&natural HAZARDSCRC

FINDINGS

We found **there is no one-size-fits-all solution for prescribed burning.** Risk mitigation varies by region and management value.

From hectares to tailor-made solutions for prescribed burning

Hamish Clarke[1,2], Brett Cirulis[3], Trent Penman[3], Owen Price[1], Matthias Boer[2], Ross Bradstock[1]
[1] Centre for Environmental Risk Management of Bushfires, University of Wollongong, NSW
[2] Hawkesbury Institute for the Environment, Western Sydney University, NSW
[3] School of Ecosystem and Forest Sciences, University of Melbourne, VIC

Prescribed burning is a central feature of fire management, yet we lack a robust quantitative basis for understanding and comparing its effectiveness at mitigating risk for different regions and management values. This project aims to address these gaps and provide support to agency decision makers across southern Australia

Introduction

The express purpose of our research is to support the delivery of effective, 'tailor-made' prescribed burning solutions across southern Australian ecosystems by providing a quantitative trajectory of risk reduction for multiple values in response to differing prescribed burning strategies. The project is divided into two phases: fire behaviour accounting and risk accounting.

Methods

A large number of fire behaviour simulations were carried out with the PHOENIX RapidFire model, with key inputs including ignition location, fuel type and arrangement, local weather streams and fire history including combinations of different rates of edge and landscape treatment. We use Bayesian decision networks to estimate the level of risk mitigation available through different prescribed burning treatments.

Results

The project has generated a large amount of output, spanning raw simulation results, risk estimates, cost effectiveness and climate change impacts. An example of the intersection between prescribed burning treatment, location and climate change is shown in Figure 1. In the NSW Nandewar region, increasing edge and landscape have similar effects in reducing area burnt by wildfire. Climate change has the potential to strongly reduce this effectiveness, although some scenarios suggest similar effectiveness to current levels.

Discussion

The Prescribed Burning Atlas is a tool for end users to explore, query and use outputs of the project. It can be used to guide the implementation of 'tailor-made' prescribed burning strategies to suit the biophysical, climatic and human context of all bioregions across southern Australia.

Project output is at the landscape-scale (~200,000 ha) and draws on all case study locations across southern Australia. At the Prescribed Burning Atlas users can:

- select from 13 case study landscapes (Fig 1);
- select different treatment rates (between 0 and 15% p.a.) and treatment locations (edge and landscape);
- explore the area burnt by wildfire and associated risk across five management values (life loss, house loss, road damage, powerline damage and area burnt below minimum tolerable fire interval) for selected landscapes and treatment strategies;
- explore the cost-effectiveness of different treatment options;
- explore the effects of climate change on the risk mitigation available from prescribed burning (Fig 2);
- read FAQs and access project publications

For more information, please email hamishc@uow.edu.au

Project outputs

Figure 1: The Prescribed Burning Atlas is now live. Users can register at https://prescribedburnatlas.science

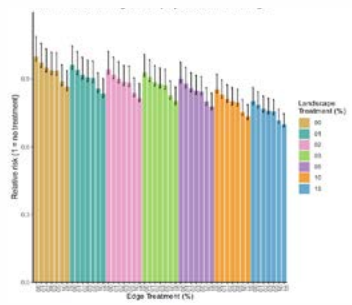


Figure 2: PROJECTED INFLUENCE OF CLIMATE CHANGE ON AREA BURNT BY WILDFIRE IN THE NSW NANDEWAR CASE STUDY LANDSCAPE. COLOURS SHOW AMOUNT OF LANDSCAPE TREATMENT, WHILE NUMBERS ON X-AXIS SHOW AMOUNT OF EDGE TREATMENT. BLACK BARS SHOW THE RANGE OF CLIMATE CHANGE PROJECTIONS (EVANS ET AL. 2014). IN MOST SCENARIOS CLIMATE CHANGE IS PROJECTED TO DECREASE THE RISK MITIGATION AVAILABLE FROM PRESCRIBED BURNING.

Australian Government Department of Industry, Science, Energy and Resources | Business Cooperative Research Centres Program
UNIVERSITY OF WOLLONGONG AUSTRALIA
THE UNIVERSITY OF MELBOURNE
WESTERN SYDNEY UNIVERSITY

© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au

SYNTHESIS

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

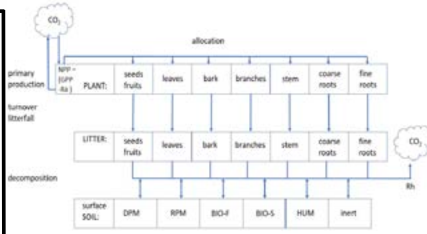
An interdisciplinary approach to examine trade-offs between environmental objectives and prescribed burning

Tina Bell[1], Malcolm Possell[1], David Pepper[1], Danica Parnell[1], Senani Karunaratne[1], Mengran Yu[1], Mana Gharun[1], Mathias Neumann[2], Mark Adams[2]

[1]The University of Sydney, New South Wales
[2]Swinburne University of Technology, Victoria

Model predictions for prescribed burning in the greater Blue Mountains

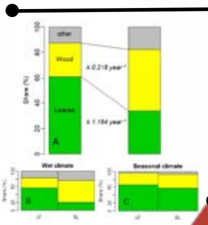
- The FullCAM carbon accounting model was applied to eucalypt open forest sites in the Blue Mountains region that underwent prescribed burning and fieldwork.
- Calibrations to fractions of surface litter would improve simulations of the effect of prescribed fire on forest component pools.
- Recommendations on collecting field data and model structure are made to improve alignment between them.



Carbon stocks and flows incorporated in the FullCAM model applied to forest ecosystems by deploying the forest system option.

Litterfall and standing litter in forests: implications for fuel loads

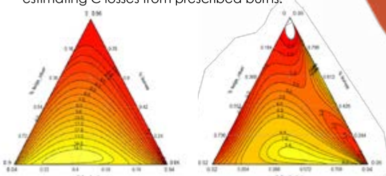
- Data for standing litter (SL) and litterfall (LF), including both fine (leaves) and woody fuels (twigs, bark <20-26 mm) were compiled for forests in Australia.
- The average mass of SL is 11 t ha⁻¹ and ~5 t ha⁻¹ of leaf and woody litter is added annually.
- Olsen's decomposition constant (k) varied substantially with different fractions of fine and woody fuels.



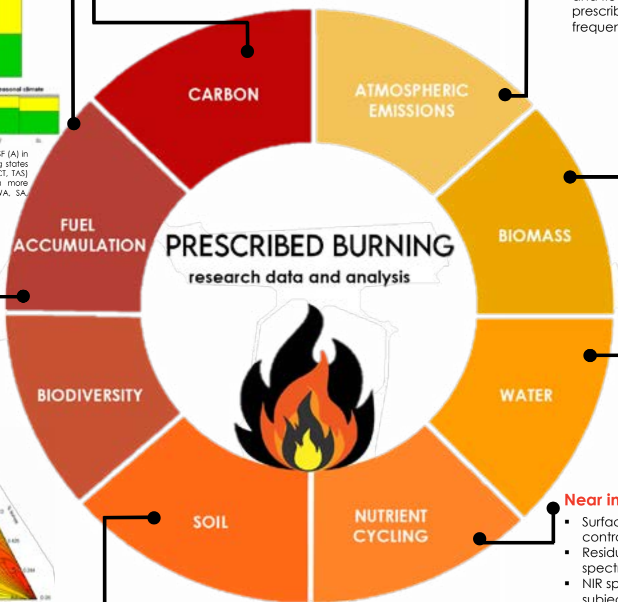
Proportional differences of LF and SF (A) in forests in Australia, and (B) among states with a wet climate (VIC, NSW, ACT, TAS) compared to (C) those with a more pronounced seasonal climate (WA, SA, NT).

Estimating carbon stocks and biomass in surface fuel layers

- Empirical data was used to generate prediction tools for estimating C and biomass in surface fuel layers.
- Models estimated a biomass range of 1 to 14.5 t ha⁻¹ and a carbon content range of 0 to 8 t ha⁻¹.
- Ability to model C content of individual fractions in surface fuel layers is important and can assist in increasing accuracy in estimating C losses from prescribed burns.



Biomass and carbon response surfaces developed using 80% of the data from all sites in the ACT, NSW and VIC, before and after prescribed burning.



Modelling emissions from prescribed burning using FullCAM

- FullCAM was assessed in simulating CO_2 emissions from prescribed burns under different fuel load scenarios plus wildfire.
- Total carbon emissions depended on the fuel loads (size of the pools e.g. leaf litter) and the pool-specific rate of combustion.
- Calibration of FullCAM should be possible, accommodating considerable site variation.
- FullCAM provides a solid framework for understanding and tracking stocks and flows of carbon exposed to prescribed burns at different frequencies.

Estimated amount of carbon (C) emitted (mean ± standard deviation) for sites in NSW.

Site name	Carbon emitted (t C ha⁻¹)
Joadja	6.81 ± 1.20
Martins Creek	5.74 ± 2.51
Left Arm	4.41 ± 0.43
Spring Gully	3.31 ± 0.08
Helicopter Spur	2.93 ± 0.89
Kief Trig	2.82 ± 0.58
Lakesland	2.50 ± 0.33
Paterson	2.48 ± 0.43
Haycock Trig	2.05 ± 0.47

Prescribed burning and sampling at 100 sites

- Burn units from locations in Victoria, NSW and the ACT were surveyed.
- Burn units are paired sites measured before and after fire or in adjacent unburnt and burnt areas.
- Total sampling effort in this project has amassed to 100+ burn units.

Modelling evapotranspiration (ET) using generalised additive models (GAMs)

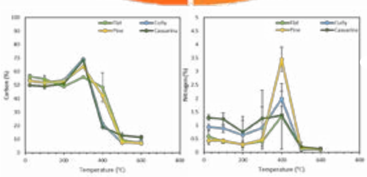
- GAMs for predicting evapotranspiration (ET) developed for Victoria and NSW, using site details, soil properties, climate and enhanced vegetation index (EVI) as variables.
- Changes in ET due to prescribed burns were more obvious in Victoria than NSW.
- EVI and climatic variables were the best predictors for changes in ET due to prescribed burning.

Effective predictors (orange shading) of GAMS developed for predicting ET: prescribed fire (fire) solar radiation, discount factor value at 5 and 95% confidence intervals (df5 and df95), maximum temperature (T_{max}) and minimum temperature (T_{min}).

State	Fire	Solar radiation (MJ m²)	EVI	df5 (mm)	df95 (mm)	T_{max} (°C)	T_{min} (°C)
NSW							
Victoria							
Combined							

Quantifying the conversion of vegetation to ash

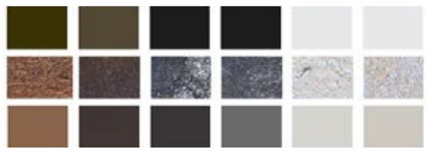
- Combustion studies can be used to determine fire intensity and residence time from the type and amount of charred material, charcoal and ash produced.
- Greater amounts of carbon were lost when fuels were heated at 300 °C or more.
- Small amounts of biomass, carbon and nitrogen was lost when heated ≤ 200 °C, regardless of the fuel burnt.
- Nitrogen was more abundant when heated at 400 °C, though at low levels (< 5%).



Carbon and nitrogen (%) at each temperature for leaves. Points represent mean ± standard deviation.

Near infrared spectroscopy (NIR) as a fire severity metric

- Surface fuels from forests and woodlands were combusted under controlled conditions in the laboratory.
- Residue colours were more uniform when described using NIR spectroscopy compared to the visual Munsell Colour System.
- NIR spectroscopy reduces inaccuracies with conventional subjective colour scoring.
- NIR spectroscopy data can be used in regression models to predict C and N content in residues, and the temperatures they were formed at.



Comparisons of Munsell colour, ash residue and L*a*b colour of turpentine bark from the trial material burnt at temperatures between 100 and 600 °C.

Australian Government
Department of Industry, Science, Energy and Resources
Business Cooperative Research Centres Program

For more information, please email tina.bell@sydney.edu.au

THE UNIVERSITY OF SYDNEY

© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au

bushfire&natural HAZARDSCRC

FINDINGS

Suppression firing is a prominent containment tool. It occurred on half of the **large fires** in **Victoria** and ranged from ~1 to ~20,000 hectares of burn area. One-fifth of the total fire perimeter length was **contained** by **backburning**.

Suppression Firing Prevalence & Practice

Heather Simpson[1,2], Prof Ross Bradstock[2], Assoc. Prof Owen Price[2]

[1] Bushfire and Natural Hazards CRC Student
[2] Centre for Environmental Risk Management of Bushfires, University of Wollongong

Suppression firing (backburning and burning out) is widely used in practice but largely ignored in fire research. This prominent containment tool can account for hundreds to thousands of hectares of fire burn area. The practice occurs at such frequency and scale that it may confound other fire research and detection is difficult without operational data.

Introduction

Suppression firing, an encompassing term for backburns and burnouts, is used by firefighting agencies around the world. Yet we know little about the extent of its use and its impact on containment. We examine the prevalence and practice of suppression firing in Victoria, Australia.

Methods

Operational data from a five year period (2010-2015) was used to identify and map suppression firing on large fires (500+ ha). A keyword search of Situation Report comments was performed and the suppression firing was reconstructed from this data as well as visual inspections of available line scans, eMap extract data, and operational maps. ArcGIS 10.4.1 was used to map the suppression firing. Fires were grouped into 5 major fuel types (mallee, grassland, heath, woodland, and forest) based on the dominant fuel type by area of the final fire polygon. We performed a series of geoprocessing steps to generate: external perimeter, perimeter aligned road, suppression firing perimeter, and suppression firing aligned road.

Results

Half of the 74 large (500+ ha) fires had suppression firing. Twenty-six of which also had enough data to map the suppression firing location. Area burnt exclusively by suppression firing operations ranged from <1 ha to ~20,000 ha on different wildfires. Suppression firing was used to contain one-fifth of the external wildfire perimeter.

Suppression firing typically occurred during intervals of low fire spread and resulted in modest fire behaviour. Perimeter suppression firing was generally conducted by ground crews, while aerial ignition was usually reserved for internal burnout operations. Roads were often used for control lines. For the 26 wildfires we mapped, suppression firing occurred along 77% of the perimeter aligned road.

Discussion

As suppression firing forms such a large proportion of fire perimeter, it should be viewed as an important intervening variable in the degree to which landscape features impact fire cessation. Unidentified suppression firing can confound other types of fire research, especially research that is solely reliant on remote assessment techniques. One-sixth (13) of the 74 wildfires we studied had suppression firing operations that burnt 500+ ha which is well in excess of the reliable detection size for remote sensing. In such cases, access to operational data is important to delineate between natural and human-caused wildfire spread. However, there are quality issues with operational data as it is generated for fire management, not research purposes. Further research could establish production rates, ignition thresholds, and operational windows for conducting suppression firing, but better quality data is required.

For more information, email Heather Simpson hs507@uowmail.edu.au

Tables and figures

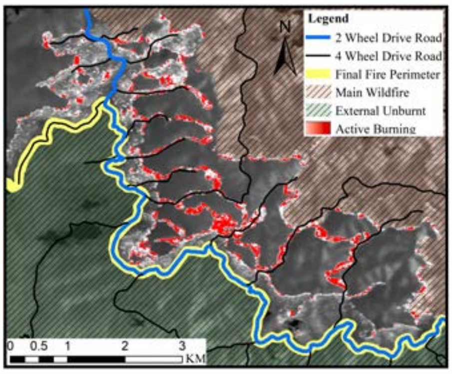


Figure 1 Linescan image of a burnout operation in progress. The ignition pattern of this ~1,000 ha burnout uses terrain features to promote a lower intensity 'backing' fire that will burn downhill from the roads/ridgeline. A backburn has been completed along the road to secure a containment line prior to the ignition of the burnout.

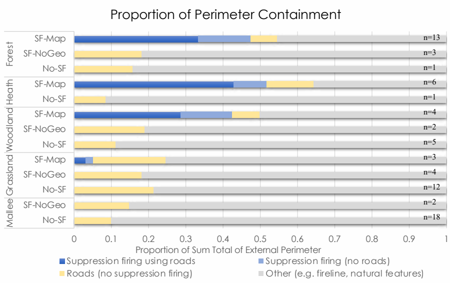


Figure 2 The proportion of external wildfire perimeter that was contained by roads, suppression firing, or other undetermined features. Fires are grouped by dominate fuel type. SF-Map fires had sufficient data to map the suppression firing, SF-NoGeo fires had descriptions of suppression firing but there was insufficient geographic data to map the extent, and there was no evidence of suppression firing on the No-SF fires.

Australian Government
Department of Industry, Science, Energy and Resources
Business Cooperative Research Centres Program

UNIVERSITY OF WOLLONGONG AUSTRALIA

© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au

Policy, Political Engagement and Influence

FINDINGS

Successful **disaster resilience** policy relies on **effective implementation** enacted through governance arrangements informed by the **Subsidiarity[1] Principle**.

Implementing disaster resilience policy in the Australian Federation

Susan Hunt[1,2]

[1] Bushfire and Natural Hazards CRC, Victoria
[2] Fenner School of Environment and Society, Australian National University, Canberra, ACT

Disaster resilience policy is being implemented across Australia via a range of programs and activities. However, even the best policy can falter without effective implementation. To optimise the success of disaster resilience policy in Australia, all levels of government and the community need to ensure that evidence about how to enable disaster resilience is applied to implementation practice.

Introduction

Australia, like many other nations has embraced resilience as a national approach for disaster prevention, preparedness, response and recovery. Australia's National Strategy for Disaster Resilience (NSDR), adopted in 2011, aims to shift the emphasis away from 'picking up the pieces' after a disaster toward self-reliance and shared responsibility between all levels of government and the community. Importantly, this requires an understanding and awareness of disaster risks and what actions we can take to adapt to, or mitigate those risks. Given the longevity of the NSDR there appears to be a high level of acceptance of resilience as the basis for disaster policy in Australia. Notwithstanding this, there is a lack of evidence about how to operationalise resilience across the whole system to achieve a more disaster resilient nation.

Methods

This research investigated how disaster resilience policy is being implemented in Australia with the aim of identifying pathways, mechanisms and limitations to good practice. A literature review revealed the determinants of disaster resilience which informed the development of a Provisional Disaster Resilience Policy Implementation Framework consisting of four good practice policy domains: Social Capital, Community Competence, Economic Development and Information and Communication, each of which were associated with a number of operational-level objectives.

The theory and practice of Australian Federalism was also examined in order to consider the national context for policy implementation. This supported the proposition that achieving national disaster resilience hinges on working effectively in the conditions created by Australia's federal arrangements. These include federal power-sharing and financing arrangements, coordination mechanisms, sectoral roles, responsibilities and capability; and the opportunities and constraints they present for strategic and systemic disaster resilience policy implementation. These concepts were incorporated into the Provisional Framework. The Provisional Framework was tested using interviews and the study of documents from five good-practice disaster resilience initiatives being implemented at federal, state, and local government and in the business and the Not-for-Profit sectors.

Results

The major project outcomes were the development of a Disaster Resilience Policy Implementation (DRPI) Framework and the identification and inclusion of a 5th Policy Domain, Subsidiarity. Subsidiarity captures the significance of federal governance and its implications for disaster resilience policy implementation.

Going forward, the DRPI Framework is a tool that can be used to incorporate evidence about how to implement disaster resilience into everyday practice. Other research findings suggest that policy makers and practitioners at all levels of the system:

- Identify and democratically assign roles and responsibilities for the design and delivery of disaster resilience initiatives with an appreciation of the system-wide context.
- Promote trust between all levels of government and between government and the non-government and business sectors to ensure better connectivity and the free low of information and ideas.
- Apply behaviour change theory and practice to disaster resilience programs, including risk communication.
- Support cross-training between government and community service organisations to build reciprocal knowledge and skills in community development and government administration.
- Foster a commitment to authentic community and stakeholder engagement to implement all disaster resilience activities, including a willingness to learn together by engaging with conflict.
- Encourage disaster mitigation by working with stakeholders to reduce financial barriers and perceived and actual legal risks that restrict open access to, and use of hazard information.
- Capitalise on under-explored opportunities to enhance business participation in disaster resilience.

For more information, please email susan.hunt@anu.edu.au

Table 1 Disaster Resilience Implementation Framework

Policy Domain	Social Capital	Community Competence	Economic Development	Information & communication	Subsidiarity
Theme	Trust	Collective-efficacy	Sustainability	Behaviour change	Power-sharing
Policy Objectives	Networks	Political partnerships	Security	Resilience narratives	Capacity-building
	Place-based attachment	Stakeholder engagement	Economic diversity	Trusted information	Open access to information
	Community engagement	External Leadership	Equitable resource distribution	Skills and infrastructure	Negotiated roles and responsibilities
	Internal leadership	Local risk awareness	Shared (equitable) risk allocation	Multi-directional information flow	Coordination
		Community participation			Stakeholder engagement

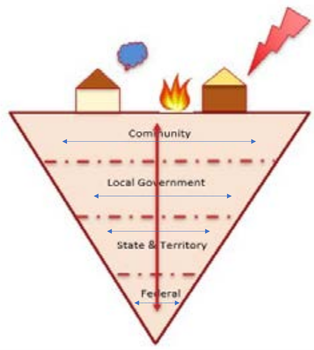


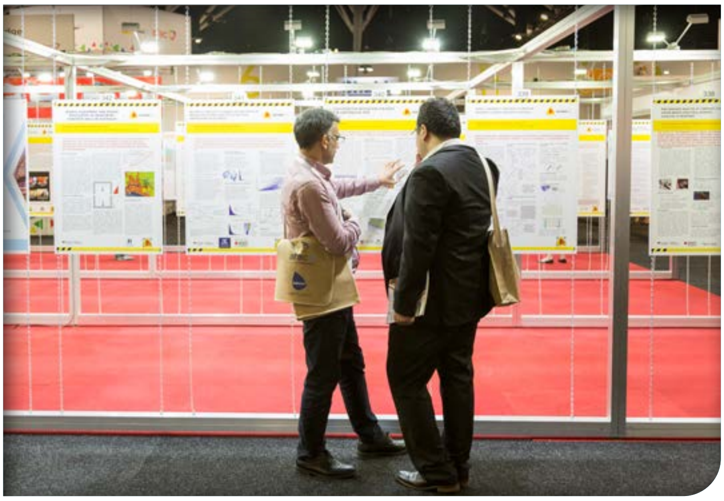
Figure 1 Multi-directional policy implementation
An authentic application of subsidiarity will reflect a combination of top-down and bottom-up approaches. Subsidiarity can also be three dimensional rather than being confined to a vertical decentralisation or centralisation interpretation.

[1] 'Subsidiarity – the concept that decisions should be taken as close as possible to the citizens by the lowest-level competent authority' (Head, B., 2007. Taking subsidiarity seriously: what role for the states? In *Federalism and regionalism in Australia*. Chapter 10. eds Bellamy, J.A., and Brown, A.J., ANU Press, p.160 at https://press-files.anu.edu.au/downloads/press/p52401/pdf/book.pdf [accessed: 11 July 2020]).

Australian Government
Department of Industry, Science, Energy and Resources
Business Cooperative Research Centres Program
Australian National University

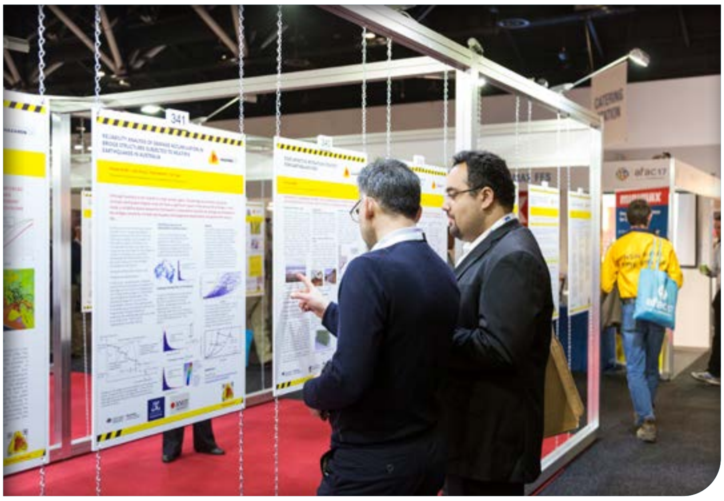
© 2020 Bushfire and Natural Hazards CRC bnhcrc.com.au


362
355
356
THE AUSTRALIAN FLAMMABILITY MONITORING SYSTEM
349
350
COMMUNITY-LED RECOVERY
IN AN EMERGENCY AND DISASTER
HAZARDS
343
344
Resilience of remote Indigenous
Communities – how we can achieve it?
337
338
COMPUTATIONAL INVESTIGATION OF BRIDGES
VULNERABILITY UNDER HEAVY FLOOD
331
332
CORRELATION OF PEAK WIND LOADS
AT BATTEN-TRUSS CONNECTIONS



306
TRANSFORMING RISK ANALYSIS AND MITIGATION PLANNING IN AUSTRALIA

afac17
powered by INTERSCHUTZ
People's Choice Poster Award 2017
VOTE FOR YOUR FAVOURITE POSTER USING:
1. VOTING FORM
Complete the tear-off voting form on your badge or collect one from the AFAC and Bushfire and Natural Hazards CRC stand. Then drop your vote into the barrel located within the Knowledge Lounge.
2. TWITTER
Tweet the number of your favourite poster using the hashtag #AFAC17
Please note: One vote per delegate
The winner will be announced at the closing ceremony
342
SEISMIC ASSESSMENT AND DESIGN PHILOSOPHY OF REINFORCED CONCRETE WALLS IN AUSTRALIA



341

FLOOD MANAGEMENT IN A CHANGING CLIMATE
THE HEAT IS ON — AND HAS BEEN FOR A WHILE, NEW RESEARCH SHOWS

Bushfire and Natural Hazards CRC

e office@bnhcrc.com.au
w www.bnhcrc.com.au

@bnhcrc
@bnhcrc
Bushfire and Natural Hazards CRC

LEARN MORE about the CRC in:

Highlights and Achievements 2013–2021

Hazard Notes 2013–2021

Postgraduate Research

Research Posters

Australian Government
Department of Industry, Science, Energy and Resources

AusIndustry
Cooperative Research Centres Program