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AN ANALYSIS OF HUMAN FATALITIES AND BUILDING LOSSES FROM NATURAL DISASTERS

Annual project report 2016-17

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Cover: Flooded Queensland, 5 January 2011. Credit: Tatters ☘, Flickr

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EXECUTIVE SUMMARY / ELEVATOR PITCH

Measuring and understanding the impacts of natural hazards in terms of the toll of human life and building damage is a fundamental first step to enabling efficient and strategic risk reduction. By taking a scientific approach to the collection and analysis of accurate information and intelligence, governments, agencies and the wider community are better positioned to reduce disaster risks.

Specifically, the project has provided a longitudinal analysis of the social and environmental circumstances that led to fatalities in order to examine trends over time in terms of exposure and vulnerability. These trends have been interpreted in the context of emerging issues, and how these issues might influence vulnerability and exposure trends in the future. The project has provided an analysis of building damage by hazard and state/territory due to natural hazards.

The outcomes of this project will inform a wide-range of emergency management and government end users to advise on and update policy, practice and resource allocation. Already it has been utilized by NSW and Victoria State Emergency Services to inform education campaigns.

END USER STATEMENT

MARCUS MORGAN NSWSES

Risk frontiers has undertaken post-event research on the Northern Rivers floods for the NSW SES. The research will enable the NSW SES to gain a greater understanding of community behaviour during flood events, including whether evacuation or sheltering in place was/is the preferred option for the impacted community and what precautionary actions people take before a flood. This research will assist the NSW SES in revising plans, warning services and operational strategies to address existing flood risk.

The research also includes updating flood fatality statistics for flash flood events. This will assist in providing evidence-based data to inform policies in regards to prevention, preparedness and response.

NSW SES is already using the outputs of the existing fatalities and impacts research to inform community engagement campaigns to reduce the incidence of motorists and people entering floodwater.
Marcus Morgan NSWSES Senior Planning and Research Officer, NSW SES

PROJECT DETAILS

BACKGROUND

The goal of the project is to measure and gain a greater understanding of the impacts of natural hazards in terms of the toll of human life, injuries and building damage in order to provide an evidence base for emergency management policy and practice.

The foundation for this work is the use of the Risk Frontiers' database *PerilAUS*. The database contains historical data (dating back to the earliest days of European settlement in Australia) on the incidence (magnitude, affected locations, etc.) and consequences (property damage and fatalities, etc.) of such events. In particular, the data contains many of the names of the deceased, which enables the collection of more detailed information on the circumstances of the death from coronial records.

In addition to *PerilAUS*, the Insurance Council of Australia's Disaster List, which lists the insurance cost of natural disasters since 1967, will be used to compile information relating to the costs of building losses due to natural hazards in all states and territories in Australia.

PROJECT OBJECTIVES

The objectives of the project are:

1. An analysis of fatalities, in terms of demographics, social and environmental circumstances surrounding deaths.
2. An analysis of people otherwise affected by natural hazards – injured, near-misses, rescued.
3. An analysis of building damage and losses arising from natural hazard events over the last century.
4. Understand the influence of road characteristics and human behvaiours on flood fatalities.

The hazards to be studied include: floods, cyclones, earthquakes, heatwaves, severe storms and bushfires[1]. The social and environmental factors of interest include:

Social - Age, gender, occupation, preparation, risk reduction activities, knowledge and warnings received, activities and decisions leading up to and at the time of death, capacity to act, mode of transport, medical cause of death etc.

[1] Bushfire loses will be investigated for building loses only. A detailed analysis of bushfire fatalities has already been conducted in previous projects and will only be included here in terms of an overall analysis and comparison of the fatalities from all hazard events.

Environmental - Details of the location and particular hazard: e.g. flood type, flood height and intensity (such as "a one in 100 event"). This will also include, where possible, details on the location of the deceased with respect to the hazard.

MAJOR OUTCOMES ANTICIPATED

The major outcomes expected from the project are:

- A longitudinal and geographical examination of trends in the exposure and vulnerability of people and buildings.
- An understanding of the influence of road characteristics and human behavior on flood fatalties.
- Evidence-based data to assist with appropriate emergency management and government decision making.

PROJECT METHODOLOGY

(1) Update the fatality and building loss data currently held by Risk Frontiers

1) Update the fatality and building loss data currently held by Risk Frontiers.

Over the past 20 years researchers at Risk Frontiers have documented the details of natural hazard events that have caused building damage and/or loss of life in Australia, dating back to European settlement. This database serves as a unique resource in Australia.

The dataset has been updated in respect of the circumstances leading to the fatality. These activities are detailed in full below within the section 'what has the project been up to'.

Data relating to building losses has also been updated. This project outcome will be one of the final outputs in order to ensure the data is as complete as possible.

(2) Statistical analysis of the data

Based on the updated data, a thorough statistical analysis has been undertaken.

This has enabled a thorough examination of the relationship between demographics, social circumstances (warnings received, preparation, reasons behind actions, activities at the time of death, etc.) and the environmental circumstances (location, weather, hazard details, etc.) associated with fatalities.

The analysis of the building loss data has highlighted spatial, temporal and hazard-specific trends.

Utilising details regarding the location of a sample of vehicle related fatalities a site assessement of each of these has been conducted.

(3) Presentation of aggregate results to endusers

A series of conference presentations and reports have and will continue to be prepared in order to discuss, receive feedback and refine the results to ensure the outputs are of use to the end-users.

ETHICAL CONSIDERATIONS

Privacy of the deceased and their families

Only researchers who have received approval from the various coronial ethics bodies to which we have applied will be able to view detailed line data on the fatalities. Aggregated results will be provided to the end-users, or any third party, in the form of tables and figures with commentary on the statistical analysis of various time series, thus protecting the privacy of individuals whose details appear within the data set. Any future CRC researchers who wish to use the data will need to apply and comply with the ethics considerations of the organisations who supplied the data.

Electronic information is stored on the secure Risk Frontiers computer server and is password protected. Hard copy information is kept locked in filing cabinets in researchers' offices and destroyed once it has been entered electronically.

PROJECT DELIVERABLES

Reports:

In addition to the quarterly and annual reports the following deliverables have / will be produced by the team.

Due	Milestone	Deliverable
31-Dec-15		Final report on flood fatalities
31-July-16		Final report with a detailed examination of fatalities from tropical cyclone, earthquake and severe storm in Australia
31-Dec-16		Report on a detailed analysis of all historical natural hazard building losses (by state and time period)
30-Jun17		Report on the influence of road characteristics on vehicle related flood fatalities.

Publications:

The following academic publications will be produced by the team.

Submission Date	Topic
Published in 2014	Heatwave fatalities
Published in 2017	Exploration of flood fatalities
Late 2017	Exploration of influence of road characteristics on flood fatalities
Late 2017	Social research following 2017 floods

WHAT THE PROJECT HAS BEEN UP TO 2016/2017

The main focus up until December 2016 had been concentrated on fatalities from floods, storms, earthquakes and cyclones. Over the last 12 months the following 3 research reports have been completed:

AN ANALYSIS OF HUMAN FATALITIES FROM CYCLONES, EARTHQUAKES AND SEVERE STORMS IN AUSTRALIA

Report:

This report examined the socio-demographic and environmental circumstances surrounding fatalities from cyclones, earthquakes and severe storms (hail, gusts, lightning, rain and tornados). It is the second major milestone from for this project.

The foundation for this work was to use Risk Frontiers' database PerilAUS, which contains historical data on the incidence (magnitude, affected locations, etc.) and consequences (property damage and fatalities, etc.) of natural hazard events in Australia. PerilAUS contains many of the names of the deceased which, during the course of this project, has enabled the collection of more detailed information on the circumstances of many of the fatalities from coronial inquest reports.

The data has been analysed to inform the understanding of the circumstances surrounding the deaths and how this information could best be utilised for emergency management policy and practice. This has included an examination of the data around the following themes: demographics, cause of death, location of the fatality and transport, activity and action prior to and at the time of death, capacity and awareness and, where possible, the severity of the event.

A total of 406 deaths have been identified across the periods under study for tropical cyclones, earthquakes and severe storms. Table 1 gives the breakdown of these figures. Since 1990 (to 2015), over three quarters of the 254 deaths identified have been due to severe storms and, of those deaths, over half were due to the severe storm hazard of gusts. Of those hazard types with large numbers of fatalities (over 20), the majority of deaths have been amongst males (tropical cyclone 84%, gust 75% and lightning 79%). In the majority of natural hazards studied (cyclone, gust, hail, lightning, rain, tornado), the importance of (early) shelter in a sturdy building was noted.

Hazard	Date range	Total fatalities	% fatalities 1990-2015
Earthquake	1989 event	14	0
Tropical Cyclone	1970-2015	192 (54 from 1990)	21.2
Severe Storms:	1990-2015	200+	78.8
• Gusts	1990-2015	142	55.9
• Hail	1990-2015	0	0
• Lightning	1990-2015	48	18.9
• Rain	1990-2015	7	2.8
• Tornado	1990-2015	3	1.2
Total		**406+**	**100**

Table 1: Hazards and date ranges investigated and the total death toll

Recommendations:

- Many of the trends resulting from our analysis of the data support current practices and recommendations of emergency management (EM) groups and the government. Future work should investigate the effectiveness of existing EM recommendations and/ or how they are communicated to the public.
- Community engagement/ education campaigns for the high-fatality hazards of tropical cyclone, gust and lightning should target males.
- Community engagement campaigns should discourage people from sheltering (standing or parking) and camping under large trees during severe weather conditions. Rather, people should be encouraged to shelter in sturdy buildings and, especially in the case of lightning, to do so at the earliest opportunity.

A NATURAL HAZARD BUILDING LOSS PROFILE FOR AUSTRALIA: 1900-2015

Report:

This study examined building damage as recorded in PerilAUS (e.g. Coates et al. (2014)) to determine the national profile of natural peril impacts and frequencies. The analysis employed Risk Frontiers' Damage Index based on a House Equivalent (HE) loss metric introduced by Blong (2003); a simple normalisation correction based on Crompton et al. (2010) and a lower bound event threshold of 25 normalised HE. The latter is equivalent to a monetary loss of around $10m in 2015-16. Normalisation puts historical events on a common footing with losses that would be incurred given 2015 societal and demographic conditions; it answers the question: what would be the losses if historic events were to recur today?

While more analysis remains to be done to validate the HE calculations and the spatial distribution of losses across States and Territories, we find that there have been on average 5.85 events per year causing losses in excess of 25 normalised HE (Figure 1). This frequency exhibits no statistically significant change since 1900. The mean loss per event is $118m with a standard deviation of $430m. The absence of a trend over time is insensitive to the threshold HE employed.

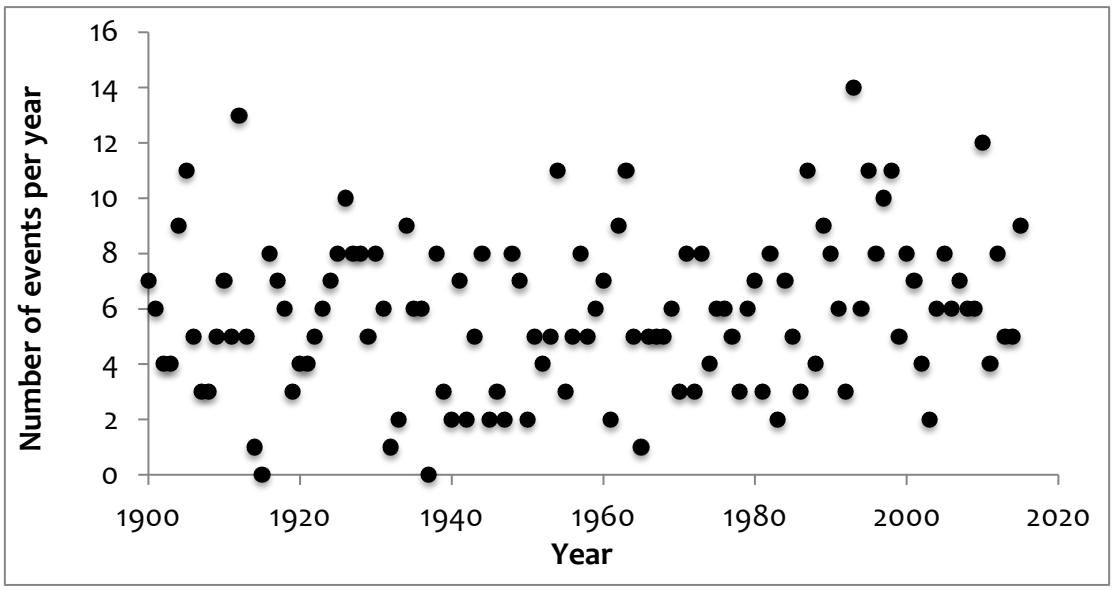

Figure 1: Number of events per financial year (July 1 to June 30) causing normalised building losses in excess of $10m. Events are grouped by financial year to discriminate between Southern Hemisphere summers when many weather-dependent events occur.

The most costly event in terms of building damage is the 1999 Sydney hailstorm, which was also the most expensive insured loss. The losses broadly follow a Pareto distribution in which 20% of events account for 80% of the aggregated normalised building losses and the top 20 are responsible for 50% of those losses. We can expect natural disaster events as costly as the 1999 Sydney hailstorm to occur about once per century, events like the Brisbane floods once every 30 to 40 years and that of the Hobart Bushfires about once a decade.

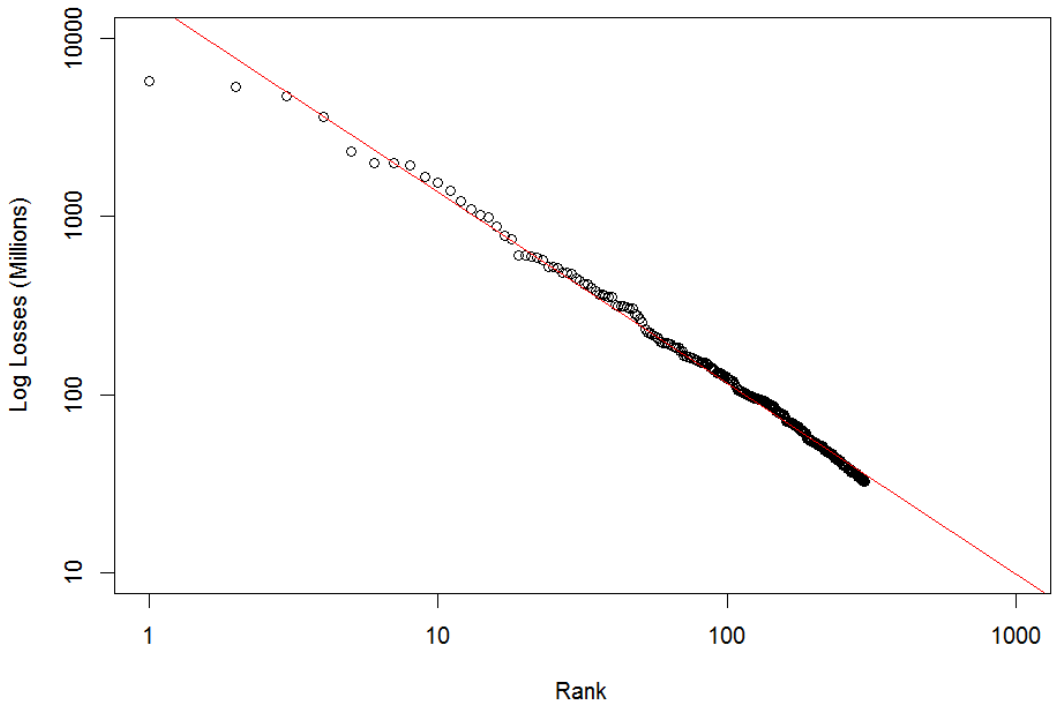

Figure 2: The top 300 normalised losses as listed in Table 2 against rank. The straight line shows a Pareto (power law) distribution.

The pattern of losses shown in Figure 2 demonstrates the 'heavy-tailed' character of the natural peril losses where there is always the possibility of event losses far in excess of the historical mean. This may occur because of an event of higher intensity or larger footprint, that footprint impacting an area of higher-valued exposure, or all of these together.

A preliminary breakdown of damage by perils shows tropical cyclones to have been most destructive and responsible for 30% of the national building damage since 1900. Bushfires, floods and hail have all been similarly costly each accounting for another 18% of building losses, although when hailstorms are combined with other storm events (excluding cyclones), thunderstorms similarly contribute 30% of the losses. Compared with meteorological hazards, geophysical perils have had a minor influence on building damage over the last 116 years with earthquake losses dominated by a single event -- the 1989 Newcastle earthquake. However this time period is too short to predict the frequency of damaging seismic events and, in the case of this peril, as with some others, the spatial pattern of losses shown here could be overturned by another extreme event loss.

While we believe the above results to be robust, further validation of the House Equivalent calculations is required with particular scrutiny on Central Damage Value estimates by peril. Ongoing work will undertake a comparison with the normalised ICA Disaster List (Crompton and McAneney 2008) once this has been

updated by Risk Frontiers later this year and with insurance claims information for key events.

THE INFLUENCE OF ROAD CHARACTERISTICS ON FLOOD FATALITIES IN AUSTRALIA

Report:

This study investigated road design, at sites where flood fatalities had previously occurred, to see how these characteristics influenced the decisions taken by the motorist, the possibility of a vehicle being washed off a roadway and the survivability of people in vehicles that entered floodwaters. Previous work had identified that 48 percent of flood fatalities in Australia were vehicle related with 229 fatalities between 1960 and 2015 (Haynes et al., 2017).

This study investigated road design at 21 sites using a combination of the Risk Frontiers' PerilAus database and recent media articles to identify locations where vehicle related flood fatalities had occurred. These sites accounted for 28 deaths, representing approximately 50 percent of total vehicle related flood fatalities between 2010 and March 2017.

Analysis of each site involved observational assessment of road structure type; roadway side barriers; road side topography; downstream depths adjacent to the roadway; signage; warning systems; lighting; road pavement; road alignment; road grade; speed restrictions; traffic volume; downstream vegetation; ability for a vehicle to be turned around prior to crossing the floodway, causeway or bridge and presence of road side markers and curb and guttering. Eighteen of the twenty-one site were directly inspected on site, whilst the remainder were analysed (using Google street view and media imagery. Local emergency personnel and road operators were consulted to ensure that the data collected through site visits reflected the condition of the roadway at the time of the incidents as much as possible.

The twenty-one sites assessed comprised a mixture of different roadway structures, with the most frequent roadway structure where flood fatalities occurred being floodways (10 sites) and bridges (7 sites). In 86 percent of cases roads were sealed (18 sites) and in 14 percent of cases they were gravel (3 sites). Fifteen sites (73 percent) were located in rural environments, with only one site classified as being in an urban location. The remainder were classified as peri-urban.

Road speed limits varied from 50 to 110 km/h, averaging at some 70km/h. No data was available regarding the likely speed that the vehicles may have been travelling when entering the floodwater. Some 95% of sites were located in upper

catchment areas with small channel sizes where rates of rise may have been rapid and associated with fast flowing floodwater. In at least three cases it has been reported that water either rose rapidly around the vehicle or that the vehicle was struck by a wave of water washing it downstream.

The results of this research indicate some road characteristics that are common among sites where motorists have entered floodwaters and fatalities have occurred. These characteristics variously influence the risk that motorists knowingly or unknowingly enter floodwater, the ability of motorists to turn around upon seeing floodwaters, and the likely survivability of entering floodwaters. It is necessary to consider the influence of different road characteristics on the risks posed to motorists during floods. Observations were also made regarding the need to consider the role of road side barricades in increasing safety and to review signage to ensure it is clear and can be readily interpreted.

ENDUSER ENGAGEMENT

Conference presentations:

Coates, L., Haynes, K., Radford, D., D'Arcy, R, Smith, C., van den Honert, R., Gissing, A. 2017. An analysis of human fatalities from cyclones, earthquakes and severe storms in Australia. Australian and New Zealand emergency Management Conference, Gold Coast, Queensland, May 2017.

Haynes K, Gissing A, Coates L, Keys C, 2016. *An analysis of human fatalities from floods in Australia 1900-2015*. Australasian Fire and Emergency Services Authorities Council & Bushfire and Natural Hazards CRC Conference: Brisbane 2016.

Gissing A, Haynes K, Coates L, Keys C, Roche K, 2015. *Reducing the motorist death toll from floods in Australia.* Australasian Natural Hazard Management Conference. University Club of Western Australia, Perth October 2015.

Haynes K, Coates L, 2015. *Exploring Australian heatwave fatalities*. Australian Heatwave Workshop. University of New South Wales, Climate Change Research Centre. 7-8 September 2015

Haynes K, Gissing A, Coates L, Keys C, 2015. *An analysis of human fatalities from floods in Australia 1900-2015*. Australasian Fire and Emergency Services Authorities Council & Bushfire and Natural Hazards CRC Conference: New Directions in Emergency Management. Adelaide, South Australia September 2015.

Haynes K, Coates L, Dimer De Oliveira F, Gissing A, Bird D, Van den Honert R, Radford D, D'Arcy R, Smith C, 2016. *An analysis of human fatalities from floods in Australia 1900-2015*. BNHCRC Research Advisory Forum, Hobart May 2016.

Haynes K, Coates L, Dimer De Oliveira F, Gissing A,B ird D, Van den Honert R, Radford D, D'Arcy R, Smith C, 2016. *An analysis of human fatalities from floods in Australia 1900-2015*. 56th Floodplain Management Australia Conference, Nowra May 2016.

(A highly commended award was received at the 2016 Floodplain Management Australia conference for this presentation. The award was given to highlight excellence in terms of the quality of the research, its utility for the end-users and the interactive presentation delivery).

Haynes K, Coates L, Dimer De Oliveira F, Gissing A,B ird D, Van den Honert R, Radford D, D'Arcy R, Smith C, 2016. *An analysis of human fatalities from floods in Australia 1900-2015*. Australian and New Zealand Disaster and Emergency Management Conference. Jupiters Hotel, Gold Coast 30-31 May

The research and its outputs were featured in two articles in The Conversation on 23 November 2015 and June 7, an editorial piece in the Sydney Morning Herald and a number of radio interviews, including the ABC.

FUTURE EXTENSIONS OF THE PROJECT

Development of understanding of why people choose not to evacuate
The research team are currently working to finalise the results of a community wide survey and interviews following major flooding in the Northern Rivers Region of NSW. This research will assist NSW SES to improve flood response plans and emergency management policy.

Site visits of rescue locations
The research team are currently seeking flood rescue data from end-users to undertake site visists at locations where rescues have been performed to indentify if road characteristic differs from those where flood fatalities occurred.

Completion of analysis of flash flood deaths
Following industry interest from the NSW State Emergency Service and local councils the research team has completed a draft analysis of flash flood fatalities to assist in providing an evidence base to emergency management policy.

PUBLICATIONS LIST

Haynes, K., Coates, L., Van Den Honert, R., Gissing, A., Bird, D., Dimer De Oliveria, F., Radford, D., D'arcy, R. & Smith, C. 2017. Exploring the circumstances surrounding flood fatalities in Australia - 1900-2015 and the implications for policy and practice. **Environmental Science and Policy** (in press).

Gissing, A., Haynes, K., Coates, L. & Keys, C. (2016). Motorist behaviour during the 2015 Shoalhaven floods. ***Australian Journal of Emergency Management,*** 31, 23-27

Gissing A, Haynes K, Coates L, Keys C (2016) Reducing deaths from driving into floodwaters. **Crisis Response Journal Volume** Issue 2.

Haynes K, Coates L, Dimer De Oliveira F, Gissing A,B ird D, Van den Honert R, Radford D, D'Arcy R, Smith C, (2016). *An analysis of human fatalities from floods in Australia 1900-2015*. **56th Floodplain Management Australia Conference, Nowra May 2016. Conference paper**.

Haynes K and Gissing A. (2016) Flood deaths are avoidable: don't go in the water. **The Conversation**. June 7, 2016.

Haynes K, Dimer De Oliveira F, Coates L. (2015) More people are dying in Western Australian bushfires – but flames are still not the biggest killers. **The Conversation**. November 23, 2015.

Gissing A, Haynes K, Coates L, Keys C, (2015). How do we reduce vehicle related deaths: Exploring Australian Flood Fatalities 1900-2105. ***Bushfire and Natural Hazards CRC & AFAC Conference*. Adelaide. Conference paper.**

Van den Honert R, Coates L, Haynes K, Crompton R, (2015). A century of natural disasters – what are the costs**? *Fire Australia***, Summer 2014-2015, 30-32.

Coates L, Haynes K, O'Brien J, McAneney K J and Dimer de Oliveira F (2014) A longitudinal examination of extreme heat events in Australia 1844-2010: exploring 167 years of social vulnerability**, *Environmental Science and Policy***. 42, 33-44.

CURRENT TEAM MEMBERS

LIST OF CURRENT INTEGRATED PROJECT TEAM MEMBERS

Project Leader	Dr Katharine Haynes
Researchers	Lucinda Coates
	Dr Rob van den Honert
	Dr Matalena Tofa
	Dr Ryan Crompton
	Dr Niyas Madappatt
	Prof John McAneney
	Andrew Gissing
Cluster Lead End User	Corey Shackleton (NSW RFS)
End Users	Elspeth Rae (NSW SES)
	Belinda Davies (NSW SES)
	Melissa O'Halloran (NSW RFS)
	Michael Morgan (SAMFS)
	Damien Killalea (TFS)
	Jennifer Pidgeon (DFES)
	Ed Pikusa (SAFECOM)
	John Richardson (Red Cross)
	Duncan McLuckie (OEH)
	Tim Wiebusch (VICSES)

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Coates L, Haynes KA, O'Brien J, McAneney KJ and Dimer de Oliveira F (2014) Exploring 167 years of vulnerability: An examination of extreme heat events in Australia 1844-2010, *Environmental Science and Policy,* 42, 33-44. DOI: 10.1016/j.envsci.2014.05.003.

Crompton RP and McAneney KJ (2008) Normalised Australian insured losses from meteorological hazards: 1967-2006 *Environ, Science & Policy* 11 (5), 371-378.

Crompton RP, McAneney KJ, Chen K, Pielke Jr RA and Haynes KA (2010) Influence of location, population, and climate on building damage and fatalities due to Australian bushfire: 1925-2009, *Weather, Climate and Society*, **2**, 300-310.

Haynes, K., Coates, L., Van den Honert, R., Gissing, A., Bird, D., Dimer de Oliveira, F., Radford, D., D'arcy, R. & Smith, C. 2017. Exploring the circumstances surrounding flood fatalities in Australia - 1900-2015 and the implications for policy and practice. *Environmental Science and Policy (in press)*.