Natural Hazards Research Australia

Understanding the Black Summer bushfires through research:

a summary of key findings from the Bushfire and Natural Hazards CRC

January 2023

Natural Hazards Research Australia

Natural Hazards Research Australia is Australia's national research centre for natural hazards resilience and disaster risk reduction, continuing the coordinated national research effort of the Bushfire CRC and the Bushfire and Natural Hazards CRC. It began its establishment phase on 1 July 2021, funded with $85 million from the Australian Government, and is currently working closely with the government, partners and research sector to develop and implement a new strategic research agenda for Australia. For more information, visit www.naturalhazards.com.au.

Natural Hazards Research Australia's staff work from Wurundjeri, Yuggera, Turrbal, Burramattagal and Dharawal Countries. We thank and acknowledge the Traditional Custodians of these lands and all the lands where we work, live and walk, and pay our respects to Elders past, present and emerging. We recognise that these lands and waters have always been places of teaching, research and learning, and that sovereignty has not been ceded. We are committed to strengthening reconciliation and building resilience through respectful and empowering relationships with First Nations communities, peoples and partners.

Cover photo: North Black Range, NSW, December 2019. Courtesy of Ned Dawson/NSW Rural Fire Service.

Right: Kangaroo Island, January 2020. Photo: New Matilda, Flickr (CC BY 2.0).

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www.naturalhazards.com.au

Understanding Black Summer

The 2019–20 bushfire season was devastating for Australia. Record-breaking high temperatures and low rainfall in the year leading up to it saw large parts of the country, on a scale not seen previously, burn ferociously in what is now often referred to as Black Summer; although the fire season started in the north of the country in August 2019 and progressed southwards through to March 2020.

Tragically, 33 people lost their lives in the fires, while thousands more were affected by smoke inhalation and other impacts. By season's end, bushfires had burned a record 19 million hectares, destroyed more than 3,000 homes, displaced tens of thousands of people, and estimated to have killed billions of animals.

In response, several states and territories held post-fire inquiries and reviews, and the Australian Government conducted the Royal Commission into National Natural Disaster Arrangements.

Based on the severity and impact of the fires, the Government granted the Bushfire and Natural Hazards CRC $2 million funding to explore the immediate issues arising from Black Summer. In addition, the CRC and partner agencies allocated funds for more specific research projects. This Black Summer research program complements the findings of the post-fire inquiries and reviews, and adds insights that can be applied not just to the areas immediately affected by Black Summer fires, but to all Australian communities managing the threat of severe bushfires.

This publication provides a top level summary of all the research conducted through the Bushfire and Natural Hazards CRC that directly related to the Black Summer fires. The reader can view the projects over four broad themes, scan the key findings and follow links to the full reports.

Importantly, this publication outlines the next steps for this line of research under Natural Hazards Research Australia and draws connections with the broader range of research projects being conducted in the Centre. This will form the basis of much of our discussion with our partners in coming months to ensure that the research is both useful and used.

Andrew Gissing
CEO, Natural Hazards Research Australia

Image: North Black Range, NSW, December 2019. Photo: Ned Dawson/ NSW Rural Fire Service.

A decade of fire risk

These foreground graphics show the Australian Seasonal Bushfire Outlooks for southern fire seasons each summer between 2010–11 and 2019–20, including both August and December 2019 Outlooks (bottom row) that show above normal potential (in red) of bushfire across the country. Source: Bushfire and Natural Hazards CRC.

The map in the background shows the total area burnt across Australia in 2019–20. Source: National Indicative Aggregated Fire Extent Datasets, DAWE, as featured in the Australian State of the Environment Report 2021, Australian Government, 2022. Recreation: Natural Hazards Research Australia.

The pattern of fire risk and the actual area burnt illustrates that the areas affected during Black Summer had been regularly identified as areas of high bushfire risk over the past ten years.

Black Summer research program

Building on existing knowledge and expertise, the Bushfire and Natural Hazards CRC developed the Black Summer research program – a suite of research projects to gather insight, data, knowledge and a basis for further study into what happened that season and how that information could be used to reduce future disaster risk.

Based on the long history of anticipated summer fire risk in Australia (shown on page 3), some of the fundamental principles that drove the development of the Black Summer research program were:

1. Why was this season worse than previous years, with similar bushfire risk in affected areas?
2. Are there new capabilities that can be demonstrated by applying the outcomes of recent research to reduce bushfire risk and improve operational outcomes?
3. How can we better learn from the disasters of 2019–20?

The projects summarised in this report were shaped around these fundamental principles and all serve to shed light on each of them.

This research program was also developed to support the outcomes of state and territory inquiries and the Royal Commission into National Natural Disaster Arrangements and to assist in understanding how we could better prepare for and respond to fire conditions like those experienced in 2019–20.

A national priority

While the Royal Commission into National Natural Disaster Arrangements report acknowledged that state and territory governments have primary responsibility for the management of natural hazards and emergencies, it also specified that Australia needs a national approach to natural hazards – a 'whole of country' strategy that maximises coordination and cooperation at federal, state and territory levels.

As a result, the Bushfire and Natural Hazards CRC's Black Summer program comprised both state-specific and nationally focused projects, enabling emergency services and governments to learn lessons from Black Summer that will help reduce the devastating impact of bushfires in future seasons. The lessons and knowledge derived from these projects, as detailed in this publication, can (in most cases) be applied across the country, not just within the state or territory that they were conducted.

Collaborative knowledge creation

Over eight years, the Bushfire and Natural Hazards CRC developed a portfolio of local, national and international projects, with a pool of ideas and resources that could be shared between emergency services, industry, government, non-government, academia and beyond. By prioritising meaningful collaboration and developing cohesive and evidence-based policies, strategies, programs and tools, the CRC helped to build a more resilient Australia to benefit the emergency management sector as well as the whole community.

The Black Summer research program is an extension of the CRC's focus on collaboration. All the projects included in the program were designed to maximise knowledge sharing and collaboration, to ensure that a whole-of-country approach is applied to natural hazard management.

The program was designed to directly complement the independent research being completed by state and territory agencies while facilitating smooth collaboration. The CRC was able to leverage close partnerships in all states and territories and fund research that directly contributed to the knowledge they needed, as well as addressing the essence of the findings of the Royal Commission into National Natural Disaster Arrangements – helping agencies understand how they managed the Black Summer fires and what can be improved in future.

This approach allowed agencies the freedom to conduct research that was relevant to them without having to balance their needs with those of other agencies, while also creating outputs that are highly transferable and allow collaboration across the country. The result is a program of research with highly engaged partners, working independently to improve the protection of all Australians.

This model of direct engagement laid the foundation for collaboration and forward-looking momentum at Natural Hazards Research Australia, including the partner-driven utilisation of several Black Summer projects. Natural Hazards Research Australia continues to work closely with governments, partners and the research sector to develop and deliver strategic research for the nation.

Right: Bees Nest, NSW. Photo: Gosford Bulk Water, Facebook.

Benefits of the Black Summer research program

"I encourage you to digest the findings, consider how best to use them in your operations and planning, and importantly continue to build the deep relationships required to have ensure this knowledge and research is useful, useable and used."

Rob Webb, CEO, AFAC

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The sheer scale and severity of Black Summer challenged Australian communities, the environment, fire agencies and our science. The lives and livelihoods affected by these bushfires, and the impact left in their wake, motivate us to look to the future to prepare ourselves for the next challenge.

Despite the many disasters that have affected Australia since then, we recognise the importance of gathering the lessons from such a major event. These lessons are not just for those directly affected by the 2019-20 fires, but for all jurisdictions who take on the responsibility and the risk to keep Australians safe.

The Black Summer research program took a targeted approach to address real problems and provides useful insights into the key issues that arose out of Black Summer bushfires. It gives guidance regarding what more needs to be done in our neverending search for knowledge.

This valuable work complements the Royal Commission into National Natural Disaster Arrangements alongside other reviews and inquiries, and seeks to take a longer-term view to meeting our future needs. It brings together operational insight and research to deliver a sound evidence base that can be used to prepare for future events.

The release of this work is timely. As climate influences that dictate our hazard landscape begin to shift, bushfire will return to Australia and fire agencies across the country will use every tool available to respond. I encourage you to digest the findings, consider how best to use them in your operations and planning, and importantly continue to build the deep relationships required to have ensure this knowledge and research is useful, useable and used.

Sarah Harris, Manager of Research and Development, Country Fire Authority (Vic)

Black Summer was a significant event for all communities affected, and for emergency services. With climate change, we are expecting to see these events occur more frequently and potentially worsen. Therefore, we need to understand the fire behaviour and operational response to improve our capability and preparedness for future occurrences.

The most beneficial outcome of this research was the targeted focus on individual fires to comprehensively understand fire behaviour. This is essential to be able to predict these events in the future. The collaboration and engagement between the Bushfire and Natural Hazards CRC, researchers and agencies was essential to ensure the research needs of the agencies were understood by the research team.

There is still further research required. I think it is important that some of the project teams work together and share data and knowledge to build a complete picture of Black Summer.

Oliver Costello, Director, Jagun Alliance Aboriginal Corporation

This program was important in enabling First Nations people to gather to meaningfully discuss what kinds of cultural land management research they would like to see happen on their Country, and how they would like to lead and collaborate. Over recent years, there has been a rapid growth in interest surrounding First Nations peoples' cultural land and fire management in southern Australia, and a significant growth in new management initiatives. However, there has been limited research support for these initiatives, and limited opportunities to network and collaborate across regions or interstate.

Having the opportunity to gather and yarn over a few days was really important, particularly where we were able to do this in person. It's through this kind of engagement that people – Traditional Owners, rangers, government agencies, researchers – actually form relationships and start to figure out how they might work together. Through the project's workshops, participants were able to really debate and discuss how they would like to engage with research to support cultural land and fire management in the future.

It is important that government agencies and funding bodies engage and collaborate when it is appropriate, and this research worked to ensure the researchers and agencies were engaged to listen and participate, rather than direct the workshops and findings. It's encouraging that we've found agencies and the Bushfire and Natural Hazards CRC keen to support this kind of research and work respectfully.

David Field, Fire Behaviour Analyst, NSW Rural Fire Service

The 2019–20 bushfire season was the worst season NSW has ever experienced. Severe, prolonged drought and repeated intense heatwaves were significant drivers of low fuel moisture and extreme fire behaviour throughout the season. This research highlights both the severity of the 2019–20 season and that the existing metrics of fuel availability and soil dryness can continue to be improved upon. It is essential that our understanding of fuel availability and dryness continues to be improved and refined through research such as this.

Ricky Archer, CEO, North Australian Indigenous Land and Sea Management Alliance

North Australian Indigenous Land and Sea Management's modus operandi is full collaboration with Indigenous community leaders and their researchers. This research program provided a great opportunity to connect that collaboration directly with key emergency management sector players and begin the all-important 'round table' discussions and commitment to building effective partnerships. The program supported Indigenous-led community collaboration and experience sharing across state and territory borders that was ground-breaking and may prove pivotal in driving the next steps towards more effective partnerships between Indigenous communities and the emergency management sector at scale in remote Australia.

Facilitating direct collaboration amongst community leaders and with emergency management agency decision makers has helped define practical needs and steps for developing partnerships, including the need and ways for ongoing, respectful engagement with local Indigenous leadership at the grassroots in all states and territories. The project has also shown the fundamental value of Indigenous groups across state and territory borders holding their own forums, sharing concerns, creative ideas and strategies to improve resilience of community and Country.

What Aboriginal people have to offer the stewardship and protection of Country is of growing interest to the nation. This project created an important opportunity for Indigenous knowledge, skill and commitment to holistic wellbeing to be offered to the emergency management space by Indigenous landowners themselves, in their terms.

A snapshot of Black Summer research findings

The Bushfire and Natural Hazards CRC focused on four main themes of research in response to Black Summer:

- fire predictive services
- cultural land management
- community-centred disaster risk reduction
- bushfire data and reconstruction.

The projects within each theme have delivered crucial research findings and outcomes that enable emergency services and governments to learn lessons from Black Summer to help reduce the devastating impact of bushfires in future fire seasons.

Some projects focused on what could be learned at a national level, while others analysed specific fire behaviour or technology in Queensland, New South Wales, Victoria, South Australia and Western Australia.

Based on the central issues identified by the Royal Commission and state and territory inquiries, the research program was designed around four broad themes:

1

FIRE PREDICTIVE SERVICES:

to boost situational awareness before and during bushfires, and to enhance the sharing of risk information and warnings with communities.

Modelling fire weather interactions

Understanding moisture in the landscape

Established and emerging uses of predictive services in Victoria

Identifying water sources using satellite imagery

Mapping surface fine fuel moisture content

2

CULTURAL LAND MANAGEMENT:

to learn from Traditional Owners on how to reduce landscape risk through better integrated cultural land management knowledge and practices.

Cultural land management in southeast Australia

Indigenous fire and land management in northern Australia

"This research was really about understanding what was happening in the landscape and what was driving the extreme fire behaviours, and learning better ways to support the environment, people and culture."

Dr John Bates, former Research Strategy Director, Natural Hazards Research Australia

3 COMMUNITY-CENTRED DISASTER RISK REDUCTION:

to understand and assist communities and governments in enabling effective and efficient community participation and leadership in disaster preparation, relief and recovery.

Community attitudes and experiences of the 2019-20 NSW bushfire season

Community-led recovery

Understanding experiences and recovery capabilities of diverse communities in Gippsland

4 BUSHFIRE DATA AND RECONSTRUCTION:

to analyse data and reconstructions of specific fires for intelligence on how best to better understand how to manage fires, and to reduce the risk of fires in future.

QUEENSLAND
Wind speed reduction factors

VICTORIA
Spread and behaviour of the eastern Victorian fires

SOUTH AUSTRALIA
Mitigating risk using prescribed burning in Kangaroo Island and Mount Lofty Ranges

Fire risk modelling for Kangaroo Island

Kangaroo Island Black Summer fire reconstruction

NEW SOUTH WALES
Effects of prescribed burning in NSW

Suitability of aviation tracking data for use in bushfire suppression

Extreme fire development on NSW south coast

Property damage and resilience on NSW south coast in January 2020

Informing post-fire recovery planning of northern NSW rainforests

WESTERN AUSTRALIA
Yanchep bushfire analysis

Validating fuel moisture estimates in Yanchep

Fuel moisture and fire history of south-west WA from Sentinel 2 satellite imagery

Photo: North Black Range, NSW, December 2019. Photo: Ned Dawson/ NSW Rural Fire Service.

Fire predictive services

This theme focused on boosting situational awareness before and during bushfires and enhancing the sharing of risk information and warnings between states and with communities. The findings enable a richer understanding of what can be provided to emergency agencies to help predict and respond to bushfires even more effectively in future.

Modelling fire weather interactions

Photo: Janice Newnham

The Bureau of Meteorology

This project was led by Dr Mika Peace at the Bureau of Meteorology with emergency services in Queensland, New South Wales, Victoria, South Australia and Western Australia.

Researchers used advanced super-computer simulations of selected periods from five severe bushfires from Black Summer using the ACCESS-Fire model – a high-resolution model that, due to its complexity, is not able to be run operationally in real time when bushfires are occurring. The objectives of this project were to test the reliability and stability of the ACCESS-Fire model in those different environments, and to determine whether the ACCESS-Fire model could identify the drivers of extreme fire behaviours that were not identified by existing operational models. Researchers investigated meteorological drivers of extreme fire behaviour at five fire locations: Badja Forest (NSW), Green Valley Talmalmo/Corryong (NSW/Vic), Kangaroo Island (SA), Stanthorpe (Qld) and Yanchep (WA).

Key findings:

- The drought and heatwave conditions experienced in the lead up to and during all five fires were a key factor in priming the landscape for extreme fire behaviour, but local weather conditions were also important when combined with the very dry vegetation.
- Unusual fire activity occurred in the overnight period when fire intensity and rate of spread is typically expected to decrease. Interactions between strong winds above the ground, topography and the fire plume circulation were key drivers accelerating surface fire spread at night.

Read the full report here:
www.naturalhazards.com.au/research/research-projects/modelling-fire-weather-interactions-using-access-fire-model

Next steps

Natural Hazards Research Australia has since expanded this project and its outcomes. This new research is optimising the translation and utilisation of these findings to improve the use of this knowledge in practice. Researchers at the Bureau of Meteorology are using the ACCESS-Fire model to develop a range of Fire Behaviour Analyst, Intelligence Officer and more general fireground professional development training programs and workshops. This is enabling the application of these findings in risk communication, operationalisation for bushfire situational awareness and fireground safety advice for fire crews. To learn more, visit www.naturalhazards.com.au/research/research-projects/translation-observed-and-modelled-extreme-bushfire-behaviours-improve

- Pyrocumulonimbus (pyroCb) clouds or fire generated thunderstorms were a feature of the 2019–20 fire season and the number of pyroCb clouds recorded was an Australian record for one season. However, the five fires examined were not all associated with pyroCbs, highlighting that it is not the sole weather phenomenon associated with extreme fire behaviour.
- Fire-affected wind near a fire plume can be much stronger than the background winds and destructive winds can occur, including extreme fire-front winds and fire generated vortices. For example, for the bushfires that occurred close to the coast – Yanchep in Western Australia and on Kangaroo Island – the combination of heatwave conditions, the temperature difference between the hot land and the cooler water, and local topography led to complex winds that changed the bushfire behaviour.
- Sea breezes, the local environment and the fire caused erratic, variable winds along active fire lines which at times stretched for several kilometres.

The results show the benefits of enhanced simulation capability and supercomputer power. Due to the level of detail, data and computer power required, it is currently not possible to use these models as predictive tools when bushfires are burning. They do however make a valuable contribution to understanding the drivers of extreme fire behaviours and provide opportunities to integrate that knowledge into operational management of bushfires.

This project highlighted the complexity of the fire environment and fire management and shows how a coordinated multidisciplinary approach can help create more effective fire behaviour predictions. By looking back and examining the five fires, the research team enabled a better understanding of why such extreme fire behaviour occurred. The results can now be used to support learnings from Black Summer through our partner agencies.

Understanding moisture in the landscape

Photo: Bureau of Meteorology and Australian National University

The Bureau of Meteorology

Australian National University

Read the full report here:
www.naturalhazards.com.au/research/research-projects/soil-and-fuel-moisture-precursors-fire-activity-during-2019-20-fire

This project was conducted in two parts, led by Dr Paul Fox-Hughes (Bureau of Meteorology) and A/Prof Marta Yebra (Australian National University), with emergency services in Queensland, New South Wales, Victoria, South Australia, Western Australia and the Australian Capital Territory. It examined whether existing Bushfire and Natural Hazards CRC research on soil and fuel moisture can be further integrated to understand the conditions that led to Black Summer fire behaviour.

For the first time, this project examined the interaction of atmospheric parameters with soil and fuel moisture content over scales of days, weeks, months and years. Consideration of these timeframes, and the compounding interactions between them (as seen leading up to Black Summer), are crucial when fire managers are making accurate assessments of potential fire activity. Trend analysis can also be useful in understanding the risk posed by changing levels of moisture in the landscape – allowing natural hazard history to be linked to current risk.

Researchers investigated the soil and fuel precursors of six significant fires, using two CRC-developed tools, to determine whether more accurate predictions of elevated risk of severe fire can be developed. The fire regions studied were Bajda Forest (NSW), Stanthorpe (Qld), Green Valley Talmalmo/Corryong (NSW/Vic), Kangaroo Island (SA), Yanchep (WA) and Orroral Valley (ACT):

- Dr Paul Fox-Hughes' team examined soil moisture using a system called JASMIN, producing soil moisture data sets at a range of depths that are consistent with Australia's weather and climate prediction system.
- A/Prof Marta Yebra's team examined vegetation moisture using the Australian Flammability Monitoring System, developed through previous CRC research, to produce live fuel moisture mapping from satellite data.

Researchers examined multi-annual to annual variation of rainfall distributions, multi-week influence of soil moisture on live fuel moisture content, multi-day influence of heatwaves on vegetation moisture, and soil and fuel moisture properties that distinguished the 2019–20 fire season from the previous two seasons.

Each of the meteorological and moisture variables investigated in this study contribute information that helps us understand the drivers of fire risk at each site during the 2019–20 season:

- Fuel moisture content provided the most immediate indicator of present fire risk.
- Soil moisture content is a significant contributor to fuel moisture, permitting assessment of future changes in fuel moisture content.
- Both integrated changes in meteorological parameters. As such, the meteorological parameters (temperature, precipitation, atmospheric moisture represented by vapour pressure) contributed to an understanding of the underlying soil dryness and consequently the fuel that likely influenced the ignition and spread of the bushfires.

The outcomes of this research demonstrate the value of understanding trends in soil and fuel moisture, and the likely benefits of improved measures of landscape and fuel moisture in fire danger predictions.

The findings confirm impressions of fire practitioners regarding the extremity of conditions antecedent to the 2019–20 fire season. Importantly, the datasets used in the project present a measurable and spatially coherent approach to estimating fire risk from observed and modelled soil and fuel moisture. Operational application of the datasets and approaches used here will assist in producing accurate soil and vegetation moisture forecasts for prediction of fire risk in the future.

Established and emerging uses of predictive services in Victoria

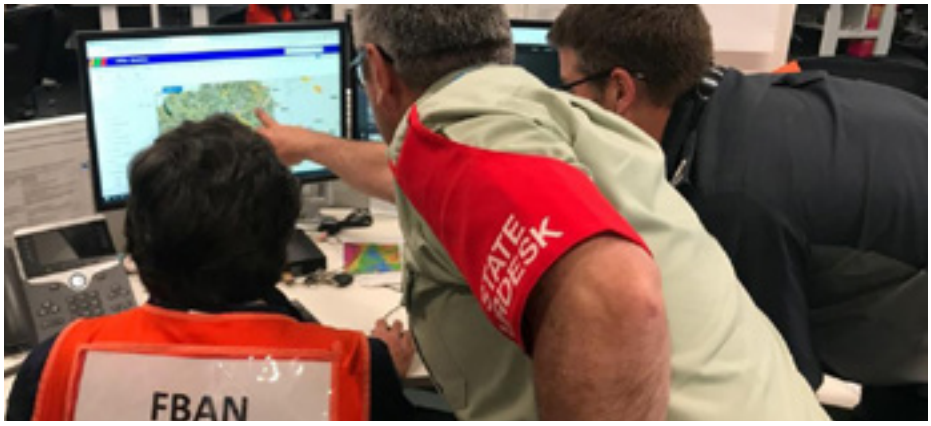


Photo: Timothy Neale

This project was conducted by Dr Chloe Begg (Country Fire Authority), Dr Graham Dwyer (Swinburne University of Technology), and Dr Timothy Neale and Dr Ian Pollock (Deakin University). Researchers focused on assessing the effectiveness of the relationships between Fire Behaviour Analysts (FBANs) and the users of their advice within emergency management, and how the predictive services roles and outputs can be further developed to increase community safety in Victoria.

Researchers conducted semi-structured interviews with key practitioners who either perform the FBAN role or use predictive services in Victoria – including state regional commanders, state agency commanders, incident controllers, public information officers, planning officers, operations officers and intelligence officers.

Key findings included:

- FBAN advice and products are used to inform operational decisions, inform the development and release of public information and warnings, and support planned burning. Most interviewees agreed that the design and framing of outputs should be standardised for public dissemination, although there was less agreement that standardisation is required for operational purposes.
- Trust is an important factor in the high-pressure contexts of incident and land management. Although there is a high level of trust in FBAN outputs amongst users of predictive services, there is variability amongst users in terms of the level of trust they place in particular FBANs' outputs and advice. For FBANs, having fireground experience and 'local knowledge' were seen as important factors in eliciting trust.
- FBAN advice and outputs were found to be produced in a sufficiently timely manner for users' purposes.

Read the full report here:
www.naturalhazards.com.au/research/research-projects/established-and-emerging-uses-predictive-services

Next steps

Natural Hazards Research Australia has since expanded this project and its outcomes. This new research will define the role of fire predictions in agency communications with the public during an emergency. Researchers at Country Fire Authority (Vic), Emergency Management Victoria, RMIT University, Queensland University of Technology, Deakin University and Swinburne University are working with the sector to optimise predictive map design and dissemination, to ensure that these maps will support public protective action decision making during a bushfire. To learn more, visit www.naturalhazards.com.au/research/research-projects/predictions-public-understanding-design-communication-and-dissemination

- There was general support amongst users and FBANs to release FBAN predictive outputs to the public, with appropriate guidance and instructions. There is support for predictive outputs being used to facilitate community decision-making and planning in relation to bushfire hazards and incidents.
- The benefits of releasing FBAN outputs publicly, including the trust-building between agencies and communities, outweigh the risks. However, some uneasiness existed around potential political and legal risks to emergency management organisations and staff, or the potential for members of the public to misinterpret the outputs, leading to increased risk of maladaptive behaviour. Researchers noted that these concerns are often poorly founded or can be substantially mitigated through education.
- Regarding the future of the FBAN role, FBANs were seen to play a very important role in the future planning for and responding to bushfires. There was agreement that predictive services generally are a vital part of future emergency management arrangements in Victoria and Australia.
- It is clear that FBANs (and predictive services in general) will need to become further integrated into emergency management arrangements outside of state control centres and will need to spend more time interacting with users and practitioners, for example on firegrounds and in incident management centres and regional control centres. This would contribute to growing FBANs' skillsets, maintaining trust with users, educating users about outputs, and helping to adapt those outputs for users' needs.

Based on these findings, researchers recommended that emergency management agencies:

- explore which FBAN outputs could be released to the community to support their planning and decision-making during bushfire seasons
- explore how FBANs and predictive service outputs can be utilised to better support other relevant functions such as the conduct of planned burning and public information
- explore the ongoing training and development needs of FBANs
- work with FBANs to develop continuous learning processes which can be used to improve predictive services after bushfire and planned burning seasons.

These findings are relevant to many other states and territories in Australia.

Identifying water sources using satellite imagery

Photo: Country Fire Authority

Australian Government
Geoscience Australia

This project was led by Leo Lymburner at Geoscience Australia, with support from the National Aerial Firefighting Centre. It explored the integration of Geoscience Australia's Digital Earth Australia (DEA) data with satellite imagery from Sentinel-2 to provide near-real-time information about accessible water near active fire grounds.

DEA Waterbodies provides information about 300,000 bodies of water across Australia, anything larger than four Olympic swimming pools in size, including dams, lakes and large rivers. This data is updated every 16 days and is critical information for aerial firefighters, especially in remote areas. Researchers worked with the National Aerial Firefighting Centre and Country Fire Authority to evaluate how well the current DEA Waterbodies product provides both start-of-season and near-real-time information. They found that DEA Waterbodies is suitable for start-of-season, severe fire danger periods and start-of-fire information for command centres seeking to identify water availability close to air bases and developing fires. However, researchers also found that key improvements can be made to DEA Waterbodies to significantly increase its usefulness for pre-flight information for pilots, including:

- inclusion of smaller waterbodies to improve use for aerial firefighters, possibly by applying the DEA Waterbodies workflow to Sentinel 2 imagery or relaxing the minimum size constraint (at present, waterbodies need to be larger than 3125m^2 to be detected)
- increasing the frequency that waterbody fill level information is collected (currently every 16 days) and then delivered to firefighters
- the addition of a waterbody-aircraft suitability measure, which would indicate to aerial firefighting teams whether a specific body of water is suitable for use by aircraft.

Researchers compiled these analyses and recommendations into a proof-of-concept for an updated operational DEA Waterbodies web service, accessible through the National Aerial Firefighting Centre's Arena spatial platform, that would include more up-to-date fill levels and waterbody suitability for different types of firefighting aircraft across Australia. This revised system, if resourced adequately, could prove highly useful for the National Aerial Firefighting Centre, as well as state and territory firefighting agencies, control centres and aircraft operators.

Read the full report here:
www.naturalhazards.com.au/research/research-projects/identifying-water-sources-using-satellite-imagery

Next steps

Natural Hazards Research Australia has since expanded this project and its outcomes. Researchers at the National Aerial Firefighting Centre, Geoscience Australia and FrontierSI are developing a proof of concept spatial product whose primary use is identifying the locations of accessible water bodies in near real time. To learn more, visit www.naturalhazards.com.au/research/research-projects/identifying-water-sources-aerial-firefighting

Mapping surface fine fuel moisture content

Photo: rewat wannasuk/Alamy Stock Photo

Australian National University

This project was led by Li Zhao, with A/Prof Marta Yebra and Prof Geoff Cary at the Australian National University.

Moisture content of dead fine fuel (vegetation) plays a decisive role in determining fire ignition and spread, and it is also an important input variable for many fire danger rating systems. Consequently, mapping dead fuel moisture content is crucial and necessary for bushfire management, but is not yet regularly accessible and available at a continental scale for Australia.

This project helped fill this gap by building on the research from the Bushfire and Natural Hazards CRC project *Mapping bushfire hazard and impact*. The earlier research involved developing new theory to couple vegetation's vapour exchange with the capillary flux from the soil to model litter fuel moisture content. This information could then be used to map dead fuel moisture content in greater detail (specifically, at 1-hour time steps and 5km spatial resolution) for a pilot area in Victoria.

This project calculated soil moisture estimates using a physics based dead fine fuel moisture content model. These estimates were improved by the coupling model proposed in the earlier research, especially for subsurface litter that is in contact with soil.

Results demonstrate the feasibility of mapping hourly dead fine fuel moisture content at 5km resolution. The methodology has the potential to be extended at a continental scale and delivered to stakeholders in a timely fashion, via the Australian Flammability Monitoring System. This information can help with improvements to fire danger ratings, predictive services and fire behaviour.

Read the full report here:
www.naturalhazards.com.au/resources/publications/report/mapping-surface-fine-fuel-moisture-content-black-summer-final-report

Cultural land management research

This theme focused on how to learn from and empower First Nations cultural fire and land management agencies across both northern and southern Australian landscapes, and how these practices integrate with non-First Nations land management practices.

Cultural land management in southeast Australia

Photo: Tony Jansen

Jagun Alliance Aboriginal Corporation

UNIVERSITY OF WOLLONGONG AUSTRALIA

One Point Five Degrees

DEAKIN UNIVERSITY

This project was conducted by Oliver Costello (Jagun Alliance Aboriginal Corporation), Tasmin Dilworth and Dr Katharine Haynes (University of Wollongong), Tony Jansen (One Point Five Degrees) and Dr Timothy Neale (Deakin University). Researchers developed foundations for First Nations-led and co-designed research programs that empower and enable cultural fire and land management practices in southeast Australia, to improve landscape management and community resilience.

Researchers convened a project steering group of cultural land management experts and advisors currently engaged in cultural fire management operations or research in New South Wales and Victoria, as well as a government advisory group and a research advisory group to assist with advice. In addition to hosting regular meetings with these groups, researchers conducted several workshops to progress regional conversations regarding the potential for First Nations-led cultural fire and land management research.

Findings revealed that research projects and institutes relating to land and fire management need to proceed from core understandings:

- There is a widespread need for a holistic and integrative approach that recognises all research and research outcomes impact Country and First Nations communities. First Nations communities are both rights-holders in relation to Country, and critical stakeholders in relation to creating resilient, healthy Country and people.
- Cultural land management is an essential part of creating well-prepared and resilient communities and landscapes anywhere in Australia.
- Research institutes need to develop a First Nations research strategy that is underpinned by foundational commitments to meaningfully support cultural land management practices. This strategy should include practical actions that can be taken immediately to empower First Nations leadership and enhance First Nations engagement and inclusion. Priority should be given to embedding these commitments and actions through institutional structures and resourcing decisions.

Read the full report here:
www.naturalhazards.com.au/system/files/2022-04/cultural_land_management_in_southeast_australia_black_summer_final_report_0.pdf

Next steps

Natural Hazards Research Australia has since expanded this project and its outcomes. Researchers at Jagun Alliance Aboriginal Corporation, Deakin University, Australian National University, the University of Melbourne, NSW Department of Planning, Industry and Environment, and the University of Wollongong are developing a framework to include First Nations voices and representation in governance structures of institutions and land management agencies. This new research involves regional on-Country workshops with First Nations land management organisations, Traditional Owner groups, governmant land management agencies and university researchers. To learn more, visit www.naturalhazards.com.au/research/research-projects/cultural-land-management-research-and-governance-south-east-australia

Researchers used these findings to inform 10 key recommendations that research organisations can follow to support cultural land management and First Nations-led and co-designed research programs:

1. Formal acknowledgement by research organisations of the equivalent value of First Nations knowledge, practice and science to Western understandings and knowledge systems.
2. Recognise the holistic and highly diverse context of First Nations ways of being and caring for Country.
3. Make clear commitments to supporting First Nations people to get on Country and engage in cultural stewardship practices to build the resilience of Country and people.
4. Establish a First Nations research strategy with dedicated research streams or project areas for cultural stewardship research that supports First Nations-led research pathways.
5. Create avenues to recognise Traditional Owners as research partners and end-users of research.
6. Include First Nations voice and representation in governance structures of institutions and land management agencies.
7. Establish meaningful and ongoing pathways for Traditional Owner inclusion and consultation to ensure research agendas and processes reflect Traditional Owner aspirations and priorities.
8. Develop a framework of broad research principles, protocols and processes to guide more ethical and collaborative cultural land management research.
9. Embed multiple aspects of capacity building into research frameworks and processes.
10. Support opportunities for developing First Nations governance, collaboration and knowledge sharing.

Researchers proposed a staged approach to utilising these recommendations within research organisations such as Natural Hazards Research Australia, to be guided by the project team and an interim Indigenous Research Committee, consisting of members from the project steering group. Utilisation is suggested to include presentation of key findings as the basis for developing a First Nations research strategy; the establishment of Terms of Reference for the Indigenous Research Committee; identifying priority recommendations and research projects for implementation in the short, medium and longer terms; identifying resource requirements to implement the recommendations and research projects; and co-developing, with First Nations partners, a cultural land and fire management research agenda and priorities.

Indigenous fire and land management in northern Australia

Photo: Djabugay Aboriginal Corporations

Djabugay Aboriginal Corporations

Dalkarra and Djirrikay Authority

This project was led by Glenn James and Danny Burton (North Australian Indigenous Land and Sea Management Alliance; NAILSMA) and supported by Otto Campion (Aboriginal Research Practitioners' Network; ARPNet), Barry Hunter (Djabugay Aboriginal Corporation), and Jimmy Morrison, Ted Gondarra and James Bayung (Dalkarra and Djirrikay Authority).

There is a lack of cohesive collaboration that underpins emergency management in remote areas of northern Australia. Researchers addressed this gap by focusing on the development of partnerships between First Nations leaders and emergency service agencies. Using collaboration and First Nations-led advocacy as a foundation, this research explored research priorities and developed a future research strategy and strategic partnership framework.

The project used the participatory action research method that prioritises flexible collaboration so that First Nations researchers and their communities can guide the research. Researchers created an agency reference group – comprising representatives from emergency management agencies, Charles Darwin University, Red Cross and NAILSMA – who conducted a series of community discussions and workshops with First Nations community members and researchers in the Northern Territory and north Queensland. A final workshop was hosted by Djabugay people on their land, facilitated by Djabugay leader Barry Hunter.

Researchers developed a thorough and informed list of gaps in the ways that emergency management agencies currently collaborate with northern Australian communities, and used these gaps to provide practical relationship pathways, including:

- detailed modelling of different approaches to sustainable involvement of First Nations leaders and land management groups in emergency management partnership roles
- cost–benefit analysis of the different partner models to inform policy, operational change and short- and long-term government emergency management budget planning

Read the full report here:
www.naturalhazards.com.au/system/files/2022-04/indigenous_fire_and_land_management_black_summer_final_report.pdf

Next steps

Natural Hazards Research Australia has since expanded this project and its outcomes. Working closely with the North Australian Indigenous Land and Sea Management Alliance, this new research is currently preparing for a forum of First Nations representatives from communities in the Kimberley, Northern Territory and north Queensland, as well as senior emergency management and other relevant agency representatives, to explore constructive changes and empower First Nations communities and land managers. To learn more, visit www.naturalhazards.com.au/research/research-projects/connecting-indigenous-people-and-emergency-management-sector-effective

- → reviewing laws and regulations to align with agreed partner roles, responsibilities and performance
- → understanding the parameters of formal roles and responsibilities, decision-making capabilities, cultural prohibitions/sensitivities, access rights etc. on different land tenure types
- → developing communication and emergency management tools for local communities, including tools for First Nations partners to guide agency partners in cross-cultural modus operandi
- → developing the 'two toolboxes' approach to maximise the effectiveness of working together, including monitoring criteria
- → investigate opportunities and challenges of state and territory emergency management agencies collaborating with each other to support the partnership approach with First Nations communities across the north
- → streamline engagement and partnership approaches for agencies in relation to common features across communities and identify approaches to accommodate unique circumstances.

Research that is driven using these pathways would ensure that First Nations researchers and communities are a focal end-user, with emergency management agencies not only benefitting from their research but also strengthening their interactions with community researchers so that future opportunities can be developed in collaboration. This allows the research to be used as it develops, to benefit communities, relationship building and short-term achievable change.

These pathways are also aimed at the national agenda for partnering with First Nations land managers, seeking to inform the future research priorities of Natural Hazards Research Australia. Future research should aim to encourage discussion, experience sharing and broader engagement of First Nations leaders and influential emergency management agency staff in collaborative workshops hosted by communities on Country. The groups and research model used in this project can form an ongoing opportunity to benefit the entire emergency management sector.

Community-centred disaster risk reduction

This theme focused on understanding and assisting communities and governments in enabling effective and efficient community participation and leadership in disaster preparation, relief and recovery.

Community attitudes and experiences of the 2019-20 NSW bushfire season

Photo: NSW Rural Fire Service

Read the full report here:
www.naturalhazards.com.au/research/research-projects/community-attitudes-and-experiences-201920-nsw-bushfire-season

This project was commissioned by the NSW Rural Fire Service and completed by Dr Josh Whittaker, Dr Katharine Haynes, Carrie Wilkinson and Stephanie Samson at the University of Wollongong, and Dr Matalena Tofa, Dr Tamsin Dilworth, Jessica Collins and Lillian Tait at Macquarie University.

Researchers investigated community attitudes and experiences of the 2019-20 bushfire season in NSW over the Christmas and New Year period, specifically looking at how people were affected by the bushfires and what actions they took. Themes covered included risk communication, preparedness and how this changed due to the length of the fire season, and the experiences of tourists and visitors. Researchers conducted a total of 202 in-depth interviews with people affected by the fires, including residents, tourists and visitors. A further 1,004 people completed an online survey to provide quantitative insights.

Key findings included:

- Most people were aware of the heightened level of risk during the bushfire season and used a range of information sources and channels to obtain information about fires. Many people reported that Fires Near Me NSW was not updated frequently enough. Despite this, the participants indicated a strong preference for Fires Near Me NSW as a source of information during bushfires.
- The length of the fire season and the repeated threat of bushfire was a significant factor that influenced people's planning, preparation and responses. The extended fire season required many people to adapt to fire as an everyday part of their life, juggling work, schooling and family celebrations with ongoing monitoring, preparation and responses to fire.

- People with previous experience of bushfire described a heightened sense of awareness of bushfire risk leading into the season. Many used knowledge gained from past experience to plan and prepare. However, some felt that past bushfires could not prepare them for the scope and severity of the fires that occurred during the 2019-20 season.
- Most people had considered that they might need to take shelter during a bushfire. While there was a range of sheltering options available, such as actively sheltering in a well-prepared home under some conditions, or using a formal shelter such as a Neighbourhood Safer Place, many had not engaged in active planning or preparation for sheltering.
- While most tourists, visitors and those who owned holiday homes were aware of bushfire activity in the vicinity of their travel destination, they did not think they would be directly affected. Continuing with annual holiday plans and wanting to escape smokier conditions at their primary place of residence were the main motivations for people to travel during the bushfire threat.
- Many people were aware of activities that had been undertaken to reduce bushfire risk, including hazard reduction, Asset Protect Zones and NSW Rural Fire Service community engagement. On the whole, these activities were viewed positively and were believed to have reduced bushfire risks. Community engagement with NSW Rural Fire Service brigades was viewed particularly positively and presents a valuable area for further developing community planning and preparation for bushfire.
- Around one third of people surveyed were unsure whether their house was built to regulations to reduce bushfire risk.
- People who were affected by these fires experienced a range of issues in the aftermath. Difficulties accessing services at evacuation centres and finding out whether houses had survived were challenging for many residents. Many visitors and tourists to fire-affected areas had trouble returning home due to fuel shortages and the inaccessibility of information about road closures. Critically, COVID-19 compounded the impacts of the fires on many people and has hindered recovery.

The findings highlight the complexities of community preparedness and responses to bushfire, and the need for integrated and holistic responses to risk reduction – a shared responsibility between governments, fire and emergency services, businesses and communities at risk.

The NSW Rural Fire Service uses research such as this to evaluate and measure the effectiveness of its work during emergency events, and to enhance warnings and engagement approaches for future events. These findings present numerous opportunities for the NSW Rural Fire Service, other government agencies and communities to reduce future bushfire risk.

Community-led recovery

Photo: Blazeaid

This project was completed by Prof Lisa Gibbs, Dr Colin Gallagher, Dr Kate Brady, Dr Claire Leppold and Greg Ireton from the University of Melbourne, Andrew Haywood, Yvette Clarke and Stewart Davies at Bushfire Recovery Victoria, and Fyowna Norton and Vaughn Brandenburg at Emergency Management Victoria.

Researchers examined the ways that governments can better support and enable communities to lead their own recovery after bushfires, which is increasingly important in a country that depends on the integration of federal, state and local government approaches with the impacted communities to tackle resilience.

Researchers explored the ways that governments can best leverage existing and emerging community organisations, networks and capabilities, and support community-led decision making, in post-disaster bushfire recovery. The research explored the following research questions:

- How can government best support community-led deliberative decision-making processes in post-disaster bushfire recovery?
- How can government best leverage existing and emerging community organisations, structures and networks in post-disaster bushfire recovery?

The findings show that a flexible approach – in which government and recovery organisations are led by community needs – is key for successful recovery. Central to achieving community-led recovery is a deliberative, democratic approach that is centred on inclusion, fosters deliberation processes in communities, and allows for real community influence over decision-making and policy.

Read the full report here:
www.naturalhazards.com.au/research/research-projects/community-led-recovery

Next steps

Natural Hazards Research Australia has since expanded this project and its outcomes. Researchers at the University of Melbourne and Bushfire Recovery Victoria are developing, testing and validating a self-assessment tool for Community Recovery Committees, to improve the shared understanding between communities and agencies. To learn more, visit www.naturalhazards.com.au/research/research-projects/community-led-recovery-evidence-dimensions-and-supports-community

The findings from this project expand the current knowledge of how community structures may modify the decision-making function of community recovery committees and shape residents' perceptions of community recovery. This project developed a set of resources to broaden the knowledge base and disseminate best practice, both within and beyond end-user organisations, including:

- a theory and evidence-based factsheet on community-led recovery, providing a snapshot of existing evidence and frameworks relating to recovery
- an analysis of community group structures that inform how community recovery committees and government bodies engage with existing community social structures
- a self-assessment tool that community recovery committees can use to describe their own key dimensions and scope, helping to anticipate the forms of support they will likely require
- research guidance for end-user organisations to support recovery progress monitoring to provide a broad benchmark by which to track recovery, service utilisation and satisfaction over time, and to identify recovery priorities within the community.

These resources can be used by community engagement staff, other state and local government staff, community recovery committee members and not-for-profit staff who are involved in recovery. These efforts will form the basis for recovery progress monitoring and benchmarking and will support activities within disaster-affected communities and risk areas. However, interactions between governments and communities are complex, and so a proposed research agenda was developed that identifies next steps in research and application of the research findings.

Understanding experiences and recovery capabilities of diverse communities in Gippsland

Photo: Country Fire Authority

VICTORIA UNIVERSITY

Read the full report here:
www.naturalhazards.com.au/research/research-projects/understanding-experiences-and-recovery-capabilities-diverse-communities

This research was commissioned by Victoria University's Institute for Sustainable Industries and Liveable Cities and delivered in partnership with Gippsland community members and the Victorian Council of Social Service. Researchers explored how the communities in East Gippsland and Wellington Shires experienced their strengths and capabilities following the 2019-20 bushfires and COVID-19 lockdowns and impacts, including:

- the capabilities and gaps that exist within these communities
- the key influences that shape these capabilities
- which capabilities are most important to the communities
- what is needed to support and grow these capabilities.

Community capability was explored through the participants' lens of the strengths and experiences of their recovery process, acquired through an online community conversation, semi-structured interviews and focus groups. The data collected was thematically analysed and categorised. Capabilities were then extracted from those themes and assessed by adapting an asset-based community development approach. An online survey saw 614 people from fire-affected communities in the East Gippsland Shire, Wellington Shire, other areas of Gippsland and regions of NSW give their views on communications, personal and community resilience, and attitudes towards the future.

Overall, community members did not feel that their capabilities were well understood by those outside their community. The most important strengths and capabilities identified by the communities were attribute-based, such as hopeful, supportive and compassion. These were seen to underpin how communities function and were also strongly associated with resilience. The full report provides a functional assessment of community capabilities and an indicative status of some of these strengths, with insights into how they manifest in communities and how to identify what is most important and why.

When looking at challenges and needs, generosity, kindness, resilience and active volunteering were seen as the most-needed strengths. COVID-19 was identified as the main challenge since the bushfires, followed by damage to the environment, anxiety, and overall fatigue. COVID-19 restrictions were felt to have exacerbated pre-existing issues and vulnerabilities within communities and amplified the impacts of the bushfires in directly and indirectly affected communities, increasing and compounding the trauma. Conversely, where people had the resources and ability to adapt, restrictions had contributed to building strengths through online networks and communication. The people communicating and trust in them determined how information was received and heard by different communities.

There were significant differences in how culturally diverse people viewed their communities, the information they receive and from whom they prefer to receive it. This reinforces the importance of having an improved understanding of the similarities and differences between and within communities and their diverse demographics, including their social, physical and cultural nuances. Participants also emphasised that communities see improved communication with state and local government as important.

The novel nature of recovery in specific community contexts provides a starting point for assessing and understanding capability for recovery in a practical sense and reveals important opportunities to inform future recovery. The study found that the overarching context of recovery at the community scale was complex and fragmented. The place-based, context-specific nature of recovery, and the lack of clarity around the role of the community in the recovery process, further complicated this issue. Listening to communities offers an opportunity to learn from their experiences and to support the development of community-led practical pathways that aid recovery and build resilience.

There are also opportunities to leverage these capabilities, particularly using local knowledge to strengthen management of natural hazard risk. Recovery from future disasters should consider the impact of increasingly dynamic events on communities and the point at which their ability to recover may be exceeded, so that this risk can be managed. There is a critical need to continue to build data and knowledge of community capabilities to support resilient community recovery and ensure that targeted policy making and programs are in place to support capability, prior to events occurring.

Bushfire data and reconstruction

This theme included groups of smaller projects at a state level across Qld, NSW, Vic, WA and SA. Each project looked at a specific element of the Black Summer bushfires in detail to understand what additional knowledge, technology or tools can be used to understand fire risk, behaviour and damage specific to different geographical areas, vegetation types or assets.

QUEENSLAND

Wind speed reduction factors

Photo: Regi Varghese/AAP

Read the full report here:
www.naturalhazards.com.au/research/research-projects/wind-speed-reduction-factors

This project was conducted by Prof Hamish McGowan and Katherine Rosenthal from the University of Queensland, and Raymond Bott and John Myles from Queensland Fire and Emergency Services.

Researchers evaluated wind reduction factors (WRFs) used in Queensland, including during Black Summer, to quantify to what extent vegetation reduces wind speed in open spaces, how this varies between vegetation types and how this affects fire behaviour. Researchers also explored opportunities for improving the accuracy of fire spread modelling using more accurate WRFs.

Wind is a key driver of fire behaviour and can be highly variable and difficult to predict, particularly within the lowest 1–2km of the atmosphere where wind interacts in complex ways with topography and vegetation. Vegetation type and density are important contributors to wind reduction, with researchers testing multiple vegetation types throughout Queensland, as well as measuring density using Light Detection and Ranging (LiDAR) technology.

This research found that the use of approximated static WRFs (as opposed to dynamic WRFs) has caused errors in the fire spread model outputs produced by fire simulation applications such as PHOENIX RapidFire and SPARK. To reduce error in fire spread modelling, researchers concluded that the development of dynamic WRF modelling capabilities should be a priority.

A dynamic WRF model is a discrete, empirically derived WRF profile, illustrating the change in WRF at specific heights measured within a fuel type in the field. Dynamic WRFs should respond to key wind, fuel, fire and topography parameters that change over time and space, while static WRFs do not reflect the variation in WRF across different vegetation profiles in the landscape. The end goal should be to replace all static WRFs with dynamic WRF profiles in fire spread models.

These findings provide preliminary insight into the relationships between vegetation and meteorology in the Australian context, which is essential for the development of empirically based dynamic WRF profiles for all fuel types.

The methodology used is transferable and will be applied to other sites containing other priority fuel types. Anemometer measurements and LiDAR scans may then be used as key datasets for underpinning and validating the development of advanced dynamic WRF modelling capabilities in the next generation of fire spread models. Until this capability is developed, the new quick-reference WRF profile assessment resource developed by this project will enable FBANs near the fire ground to quickly identify the WRF values most relevant to the ensuing fire spread. These values may then be communicated to fire spread modellers.

NEW SOUTH WALES

Effects of prescribed burning in NSW

Photo: NSW Rural Fire Service, Hawkesbury District

UNIVERSITY OF WOLLONGONG AUSTRALIA

NSW National Parks and Wildlife Service

Read the full report here:
www.naturalhazards.com.au/research/research-projects/bushfire-meets-prescribed-burn

This project was conducted by Dr Owen Price, James Barker, Simin Rahmani and Carrie Wilkinson from the University of Wollongong, and Donald MacDonald from the NSW National Parks and Wildlife Service. Researchers developed a data collection methodology and associated database that can be used to analyse the effects of prescribed burning operations across NSW in the five years leading up to the 2019–20 bushfire season, to measure whether these burns modified the behaviour of the eventual bushfires.

Being able to analyse and measure the impact of prescribed burns is an important contribution to fire management that is not always fully resourced in land management agencies. This research designed a database that can be used to collect the data required to complete multi-criteria evaluations and statistical analyses of prescribed burns, from planning stages to ultimate outcomes, and allows for the use of this data for other land management needs. The database includes information about area, fuel, moisture and weather variables of each prescribed burn, as well as information sourced from fire mapping, resources used in the burn, smoke impact and weather data.

As part of this project, researchers conducted some preliminary analyses of the impact of prescribed burns on the spread of the NSW 2019–20 bushfires, primarily on the east coast and ranges.

Results suggest that:

- although the 2019–20 fire season was largely driven by drought and influential fire weather, the severity of the fires was still affected by the impacts of previous fires in the landscape
- the proportion of high severity fire was lower in areas that had previous prescribed burns (especially if conducted in the last one or two years) and increased with time since fire in dry sclerophyll forests (the most widespread type of vegetation on the NSW coast). This increase was not observed in wet sclerophyll forests or rainforests
- there was less high severity fire after previous low severity fire in both wet and dry sclerophyll forest
- there were several cases where a prescribed burn gave firefighters an advantage that was not obvious in the geographical information system (GIS) analyses – for example, prescribed burning was found to sometimes slow the bushfire down (sometimes for several days), allowing firefighters time to prepare
- there were two cases where burns outside of the burn perimeter appeared to have effectively reduced fire ignitions and spread from spotting activity – at Pisgah Ridge and McMahons Creek.

These results indicate that while a landscape scale approach is important to observe general trends in fire, it is also necessary to examine smaller scales to determine local variation and effects which can be drowned out at larger scales. To facilitate this, land managers would need higher resolution spatial and temporal data to document variation in weather, fuel structure and fire spread.

The database is only a starting point. It is designed to have much more data incorporated into it, with many more evaluations possible. This includes simple metrics such as percent of planned area actually burnt, or refinement of weather prescriptions for burns to whole-of-program evaluations applied to all burns. The database could include information about fire severity mapping and smoke impact. To measure maximum benefit of prescribed burns to firefighters, additional information is also needed from firefighter interviews and more detailed GIS examinations of bushfire behaviours.

NEW SOUTH WALES

Suitability of aviation tracking data for use in bushfire suppression

Photo: Rick Lang, US National Interagency Fire Center

UNIVERSITY OF WOLLONGONG AUSTRALIA

CSIRO

Read full report here:
www.naturalhazards.com.au/research/research-projects/investigation-suitability-aviation-tracking-data-use-bushfire

This research was conducted by Heather Simpson, Michael Storey and Dr Owen Price from the University of Wollongong, and Matt Plucinski from CSIRO. Researchers developed a process of evaluating aerial bushfire suppression using new data sources – including high-quality aerial imagery and fire severity mapping – combined with interviews of personnel involved in suppression activities.

Aircraft are an important part of bushfire suppression and were used heavily during Black Summer in NSW, with several inquiries highlighting the need for research into their effectiveness. For this project, NSW Rural Fire Service provided firebombing event data from the 2019–20 bushfire season in NSW through the National Aerial Firefighting Centre's Arena database. This data included approximately 7000 aircraft suppression drop locations and times, including helicopters, single-engine air tankers and large air tankers. Researchers examined the data for completeness, accuracy and errors. They found that the type of drop (gel, water, retardant) was unknown in most cases, the quantity dropped was unknown in 45% of cases and the location for the end of drops was often unreliable. Researchers then tested the methods to identify drop objectives based on relationships between drops data and other spatial data, including building locations and weather. They found that objectives included initial attack, extinguishing spot fires, asset protection, pre-emptive laying of retardant lines, or direct attack.

Researchers also conducted interviews with knowledgeable personnel who worked as air attack supervisors during the 2019–20 season, who expressed the view that the aerial program could be improved with further knowledge sharing and training. The interviews also highlighted several operational issues that warrant more investigation using a larger number of aviation specialists.

Finally, researchers created eight case studies that combined interesting features in the drop data with insightful comments from the interviewees, each looking at particular days at a particular part of a fire. Case studies included one example with multiple objectives playing out as one failed and the fire spread changed, several where property protection was the dominant objective, one on spot fires, one successful initial attack and one failed initial attack. Importantly, the research re-affirmed that aircraft are a key contributor to overall fire management strategies, and that the effective use and tasking of aircraft frequently requires ground support to achieve the overall objectives for their deployment.

The air drop data has the potential to enable deep analyses of aircraft use and effectiveness during real bushfire suppression, especially when combined with other contextual information such as objectives and environmental conditions. This project began this process, identifying clear clusters of activity related to weather and distance to houses, cross-checked with interviews in the case studies. The case studies demonstrate the power of a methodology that combines spatial data with interviewee interpretations and available tasking decision-making to accurately evaluate the effectiveness of aerial bushfire suppression.

NEW SOUTH WALES

Extreme fire development on NSW south coast

Photo: NSW Rural Fire Service

UNSW AUSTRALIA

The full report is yet to be published but will be made available shortly on the Natural Hazards Research Australia website.

This research was led by Prof Jason Sharples from the University of New South Wales.

The 2019/20 bushfires have been widely described as 'megafires', which are mainly defined by their ultimate size and the cost of resources that go into bringing them under control. However, the bulk of the damage during Black Summer was instead the result of recurring episodes of extreme bushfires – extraordinarily powerful events with high rates of spread, high fire intensity and profuse spotting. It is essential to understand the factors that cause these fires to escalate into extreme bushfires, sometimes called 'blowing up' where a fire exhibits large contiguous areas of active flaming that can couple with the atmosphere in a way that modifies or maintains the fire's spread.

Several key processes can cause a fire to 'blow up', including dynamic fire behaviours (such as vorticity-driven lateral spread or VLS, fire eruption or junction fires), atmospheric instability and critically low fuel moisture content. The large number of extreme bushfires during the 2019/20 fire season provide a wealth of data for case studies to examine these processes in detail.

This research investigated the role that dynamic fire propagation played in the episodic escalation and development of the Badja Forest Rd (Countegany) fire in NSW, which ultimately merged with several other fires to form the Badja Fire Complex. This complex of fires burnt areas along the NSW south coast with major activity in late December 2019 and early January 2020. This case study draws on available data to identify instances of dynamic fire behaviour and extreme bushfire development, and to investigate their relationship to other environmental factors.

In association with these episodes of dynamic escalation, the research considered the role played by critical fire weather, including foehn winds, extremely low fuel moisture content and atmospheric instability. Researchers drew on a range of available datasets, including linescan imagery, satellite and weather radar data, weather observations and topographic data products to develop a detailed account of the chronology of the fire.

The two main findings of this research were:

- There was strong evidence to support the proposition that dynamic fire behaviour played a significant role in the episodic escalation of the Badja Forest Rd fire. This was particularly driven by multiple instances of VLS at various points across the landscape. Instances of VLS were compounded by critically low fuel moisture content, which resulted in profuse spotting. Fire merging was also identified as playing a key role in some blow-up fires, and in one instance, the development of a pyrocumulonimbus.
- Foehn winds driven by isentropic drawdown had a strong influence on the development of the fire in particular instances. Understanding the role of foehn winds on fire development in this case would require a more comprehensive modelling effort – specifically using high-resolution coupled fire-atmosphere modelling – to obtain a more detailed picture of the interaction between the winds, the terrain and the fire.

Case studies like this one contribute to a more comprehensive understanding of dynamic fire propagation and how it drives blow-up fires and extreme bushfires. This information will facilitate better planning and preparation for future severe bushfire seasons that are expected under climate change.

NEW SOUTH WALES

Property damage and resilience on NSW south coast in January 2020

Photo: Lukas Gibb

RISK FRONTIERS

Read the full report here:
www.naturalhazards.com.au/research/research-projects/january-2020-nsw-bushfires-study

This research was funded through the Bushfire and Natural Hazards CRC's Quick Response Fund and was completed by Steven George, James O'Brien, Salomé Hussein and Jonathan Van Leeuwen at Risk Frontiers. Researchers were deployed to the NSW south coast areas of Moruya, Mogo, Malua Bay, Rosedale, Batemans Bay and Lake Conjola in January 2020 to assess property damage and resilience, specifically building age, performance of construction materials and structural vulnerability due to proximity to bushland.

The majority of damage in these areas occurred in December 2019, as catastrophic weather intensified existing fire fronts. In January 2020, researchers assessed 426 bushfire-affected properties. Industries and infrastructure affected included bowling/services clubs, unit blocks, heritage parks, industrial complexes with numerous businesses, and electricity infrastructure (including power poles and wires along the Princes Highway).

Findings include:

- 92% of buildings observed were completely destroyed, indicating that once a building catches fire, regardless of construction material, it will likely be unsalvageable. Note that this does not include all bushfire-affected buildings, only those observed.
- 'Non-flammable' materials demonstrated some resilience to fire, at times remaining wholly or partially intact. However, the remaining materials (including timber beams, brick/masonry and metal frames), once alight or heat-impacted, would ultimately render the entire building unsalvageable.
- Of the partially damaged properties observed, the building features most often impacted by fire were constructed from timber, such as external stairs, decking or fascia materials.
- Proximity to bushland played a significant role in property loss, where approximately 38% of destroyed buildings were situated within 1 metre of surrounding bush. However, houses situated further distances from bushland were also impacted (mostly by wind-carried embers).

The scale of property loss during the 2019-20 bushfire season presents an opportunity to conduct further damage surveys, prior to recovery and debris removal, which would provide a considerable foundation of evidence to assess performance of newer buildings and inform future building design.

Right: Gosper's Mountain, NSW, December 2019. Photo: Blaxland Ridge Rural Fire Brigade.

NEW SOUTH WALES

Informing post-fire recovery planning of northern NSW rainforests

Photo: Piers Thomas, NSW National Parks and Wildlife Service

Read the full report here:
www.naturalhazards.com.au/research/research-projects/informing-post-fire-recovery-planning-northern-nsw-rainforests

This research was conducted by Dr Ross Peacock (Macquarie University) and Prof Patrick Baker (University of Melbourne). Researchers assessed the impact of the 2019-20 fires on the vulnerability, composition, tree mortality and regeneration of the Gondwana Rainforest of Australia World Heritage area in northern NSW.

Dr Peacock manages a long-term plot-monitoring network in the temperate rainforests of northern NSW, focusing on the impacts of climate change and bushfire on these vulnerable yet highly valuable World Heritage rainforests. It is the longest-running experiment of its kind in Australia, initiated in 1942, providing a baseline to understand pre-fire rainforest conditions. 16 of the 28 reserves in the NSW section saw some fire impacts during the 2019-20 bushfire season, coinciding with very low rainfall and soil moisture. This resulted in 8.6% of the rainforest in these reserves experiencing either low, moderate, high or extreme-severity bushfire. The extent of the fire impacts was greatest in the Hastings-Macleay, New England, and Washpool-Gibraltar Range sections of the Gondwana Rainforests. This research focused on the Hastings-Macleay section using field measures and recovery planning workshops hosted by the Australian and NSW governments.

Key findings included:

- Bushfires entered this area from front or flank spread, leading to attrition of trees on rainforest margins.
- Ember attack was widespread but generally led to the ignition of small, localised areas or of individual trees.
- Mortality rates associated with the bushfires were 20-30% across all tree species, with the proportion increasing with the severity of the fire.
- Large trees with well-developed buttress hollows and scars were more likely to ignite due to the accumulation of dry wood and fuel at their base compared to smaller trees.
- Larger, older trees that had more pre-existing fire scars were more likely to die and collapse after burning. This is potentially an age effect where older and larger (diameter and height) trees have been subjected to more fire-induced wounds and hollows.
- The majority of burnt trees regenerated with basal coppicing (new shoots developing at the base of the tree), which was more abundant where fire severity was low.
- Seedling regeneration of tree species was infrequent due to the lack of a soil or canopy seed bank.
- Options to manage fire risk using conventional zoning and fuel hazard management may be limited. Fuel hazard was not particularly high during the 2019-20 fire season in the Hastings-Macleay section, with most areas burnt in 2019 also having been burnt in 2013. Regardless, this research shows that landscape-level fuel hazard management will not address the risk of individual mature rainforest tree ignition during conditions of significant ember attack when rainforest fine fuel biomass is naturally low.
- The value of the existing long-term monitoring network to update northern NSW reserve fire management strategies is immense.

The full report makes a range of proposals to improve the knowledge base and better inform the spatially explicit bushfire risk assessment process trialled following the 2019/20 fire season. The central recommendation is the scoping of a systematic Monitoring, Evaluation and Reporting (MER) system for the Gondwana Rainforests of Australia World Heritage property that focuses on establishing a baseline to track trends in the nominated World Heritage outstanding universal values or criteria. The availability of existing long-term rainforest monitoring experiments dating from the 1950s, sections of which were burnt in November 2019, was critical to providing preliminary results within months of the fire event to inform post-fire recovery planning. This outcome underscores the critical role that long-term ecological monitoring systems have in rapidly supporting land managers information needs when responding to widespread natural hazards such as landscape-scale bushfires.

Findings from this research will inform future management of rainforest areas across Werrikimbe and Willi Willi National Parks in northern NSW in particular, and more broadly across temperate rainforests in south-east Queensland, NSW, Victoria and Tasmania.

VICTORIA

Spread and behaviour of the eastern Victorian fires

Photo: Clay Stephens, US National Interagency Fire Center

Natural Systems Analytics

Read full report here:
www.naturalhazards.com.au/resources/publications/report/victorian-bushfire-case-studies-black-summer-final-report

This research was conducted by Owen Salkin from Natural Systems Analytics.

During Black Summer, the fires in Victoria burnt for three months across 1.5 million hectares. Understanding the interactions between weather, vegetation and landscape is essential in determining the propagation and spread of the eastern Victoria bushfires.

This project was predominantly a data collection and mapping exercise, producing a reliable record of what occurred and when, in eastern Victoria during Black Summer. Researchers systematically collected multiple sources of information, including weather data, fire reports, photographs and other data, into an easily accessible data archive. Researchers also provided an overview of seasonal and long-term climate influences such as climate change, El Nino, Indian Ocean Dipole and stratospheric warming/negative Southern Annual Mode.

This project completed a preliminary reconstruction of the bushfire spread and behaviour for most fires in eastern Victoria between November 2019 and March 2020, including:

- mapping the progression of 96% of the area burnt by the Black Summer fires in Victoria. Researchers mapped the progression of 44 fires, 33 of which were larger than 100 hectares.
- beginning preliminary investigations into:
  - the factors that contributed to the fires' development
  - the weather conditions
  - key fire behaviours
  - the influence of previous fires.
- providing an initial chronological summary containing data that is verifiable and consistent
- providing data for many additional studies that will improve fire behaviour models, defining uncertainty in predictions, and improving prevention, preparedness and response.

This project also identified several opportunities for further research, including:

- documenting the weather in eastern Victoria and improving forecasts
- investigating upper-level weather and fire weather interactions (for example, pyrocumulonimbus)
- using satellites for situational awareness and post-fire analysis
- improving and validating fire models
- improving tools for fire behaviour analysts
- providing a template for capture and storage of base level data to undertake reconstruction of future fires.

With this information, it is now possible to show what occurred during these fires and when, allowing the investigation of what led to these bushfires and how to better predict future occurrences.

SOUTH AUSTRALIA

Mitigating risk using prescribed burning in Kangaroo Island and Mount Lofty Ranges

Image: Hamish Clarke

UNIVERSITY OF WOLLONGONG AUSTRALIA

THE UNIVERSITY OF MELBOURNE

WESTERN SYDNEY UNIVERSITY

Read the full report here:
www.naturalhazards.com.au/system/files/2022-04/risk_mitigation_from_prescribed_burning_black_summer_final_report.pdf

This research was conducted by Dr Hamish Clarke, Dr Owen Price and Prof Ross Bradstock from the University of Wollongong; Brett Cirulis, Anthony Rawlins and A/Prof Trent Penman from the University of Melbourne; and Dr Matthias Boer from Western Sydney University.

The Black Summer bushfires in the Mount Lofty Ranges (at Cudlee Creek) and on Kangaroo Island resulted in significant community and environmental impact. The Mount Lofty Ranges fire caused major social and economic impacts to a mixed agricultural landscape very close to Adelaide, generating significant public and political concerns. The Kangaroo Island fires significantly impacted the Island community which relies heavily on nature-based tourism as part of its economy.

This research focused on answering questions about the effectiveness of prescribed burning in mitigating risk in these two areas. Researchers ran large-scale fire behaviour simulations and Bayesian risk quantification for both landscapes, similar to the kinds of analyses completed as part of the Bushfire and Natural Hazards CRC's *Hectares to tailor-made solutions* project and which led to the development of the Prescribed Burning Atlas – a website that assists and informs tailored prescribed burning strategies across the country.

In Kangaroo Island, they found a clear relationship between the areas subject to prescribed burning and the amount of area subsequently burnt by bushfire – that is, higher rates of prescribed burning resulted in less area burnt by bushfire, which translated into reduction in loss of life and property. Risk mitigation was found to be more sensitive to edge treatment (burning near the interface between vegetation and buildings) than landscape treatment (burning large areas of bush), although both reduced risk.

In the Mount Lofty Ranges, researchers found complex patterns of risk in the aftermath of the 2019–20 bushfire. In the absence of further bushfires, the area at risk of burning is likely to rise substantially by 2025, regardless of prescribed burning rates, with a similar result for vegetation exposed to too-frequent fire. Despite this, risks to life, property and infrastructure are projected to remain similar to current levels.

This research contributes to the evidence base for prescribed burning in South Australia, with future work potentially examining new management values and empirical relationships between prescribed burning and fire-affected areas in 2019 and 2020. The researchers also incorporated the output from these case studies as a new landscape in the Prescribed Burning Atlas.

Kangaroo Island Black Summer fire reconstruction

SOUTH AUSTRALIA

Photo: Rob Hartill, South Australian Country Fire Service, Promotions Unit

RMIT UNIVERSITY

This project was conducted by Simon Ramsey, A/Prof Karin Reinke, Nur Trihantoro, Prof Simon Jones and Chermelle Engel at RMIT University. Researchers investigated how geostationary satellite earth observations can be used to reconstruct fire activity.

For this project, researchers explored whether fire predictions over the Black Summer period on Kangaroo Island can be revisited – specifically whether adjusting the variables will see a measured change in impact on model predictions. In the absence of persistent empirical observations of the Kangaroo Island fires, high-temporal-resolution data available from geostationary satellites like Himiwari-8 allows the re-creation of a spatial account of fire spread over time.

A previous project from the Bushfire and Natural Hazards CRC and RMIT University led to the development of the Biogeographical Region and Individual Geostationary HHMMSS Threshold (BRIGHT) algorithm to detect and monitor bushfires.

For this project, researchers collated available Himawari-8 imagery for processing hotspots using the latest implementation of the BRIGHT algorithm. They used the Advanced Himawari Imager onboard Himawari-8 to provide infrared imagery at 2km spatial resolution in 10-minute intervals. Combined with the BRIGHT algorithm, this allowed researchers to reconstruct the Black Summer bushfires on Kangaroo Island using spatio-temporal clustering. They then conducted a validation of hotspots to report estimates of confidence. Finally, researchers generated a spatial database of fire activity at nominated temporal intervals and aggregates.

BRIGHT data was used to create four new outputs. These include the original BRIGHT hotspots generated using the BRIGHT algorithm and hotspot data with additional fields added for spatial, temporal and draft (unverified) fire radiative power flags, and two cluster identifiers: BRIGHT Himawari-8 Hotspots and cleaned BRIGHT Himawari-8 hotspots. Two additional data sets were created using the spatio-temporal clustering: fixed-timed Himawari-8 hotspot clusters, and Himawari-8 hotspots superclusters.

This information provides new ways to measure the change in fire activity, as observed from space, in response to fire spread and fire suppression activities. The advancement of this technology allows bushfires to be detected and monitored in quasi-real time and will inform fire suppression activities, for example, identifying potential waterbombing drop zones with increased accuracy.

Read the full report here:
www.naturalhazards.com.au/system/files/2022-04/kangaroo_island_reconstructions_black_summer_final_report.pdf

SOUTH AUSTRALIA

Fire risk modelling for Kangaroo Island

Photo: South Australia National Parks and Wildlife Service

THE UNIVERSITY OF MELBOURNE

Read the full report here:
www.naturalhazards.com.au/system/files/2022-04/fire_risk_modelling_for_kangaroo_island_black_summer_final_report.pdf

This project was completed by Erica Marshall, Denis Kultaev, Sarah McColl-Gausden, Dr Alexander Filkov and A/Prof Trent Penman from the University of Melbourne.

The 2019–20 bushfires had significant impacts on people, property and biodiversity across South Australia, including on Kangaroo Island where bushfires affected an area of approximately 200,000 hectares. Risk modelling helps to understand fire risks and potential impacts, and provides a methodology for investigating alternative burning strategies, management scenarios and decisions.

For the first time on Kangaroo Island, this research applied a modified and validated Fire Regime and Operations Simulation Tool – which combines the PHOENIX RapidFire behaviour model with Bayesian networks – to systematically model the bushfire risk over the last 50 years and to estimate bushfire patterns on the island more effectively in the future.

This project used three simulated fire management scenarios (one for bushfires only and two prescribed burning scenarios) to estimate the impacts of fires on human life, property and biodiversity on Kangaroo Island. The results provide the first insight into how fire behaviours are likely to shift in terms of extent, frequency and intensity on the island.

Findings showed that the prescribed burning scenarios resulted in a small decline in the frequency of bushfires (especially very high and extreme intensity bushfires) compared to the bushfire-only scenario. The modelling also showed that:

- prescribed burning can reduce the frequency and intensity of wildfires, but ultimately the levels of burning required to achieve this result in a greater area of the landscape burned overall
- while a decline in the frequency of very high and extreme intensity fires was observed after prescribed burning, there was an overall increase in the area of the landscape that would experience very high or extreme intensity fires at least once over the next 50 years
- prescribed burning and bushfires in combination could result in a greater total area burnt over the next 50 years
- exposure to people and property under severe fire weather conditions did not change between the prescribed burning scenarios used for this analysis.

This research also measured the previous impacts of fire on the tolerable fire intervals on Kangaroo Island. The minimum tolerable fire interval is the minimum time between fires that is required for an ecosystem to continue growing healthily. This research found that prescribed burning resulted in a greater area burnt before reaching the minimum tolerable fire interval than would be expected from bushfires alone, resulting in the exposure of a larger area of vegetation exposed to fire below minimum tolerable fire interval.

These results align with previous research that suggests prescribed burning can reduce the frequency and intensity of bushfires but ultimately, the levels of burning required to achieve these outcomes result in a greater area of the landscape burned overall.

With these results, fire managers are now better able to understand the benefits and limitations of different management strategies on fire risk, and the likely impacts for people, property and biodiversity on Kangaroo Island. The methods developed through this research – including the use of the Fire Regime and Operations Simulation Tool – could be applied to a range of case study sites in South Australia and may provide helpful estimates of future fire risk that could be incorporated into management decisions across the state.

Right: Playford Highway, Kangaroo Island, January 2020. Photo: New Matilda, Flickr (CC BY 2.0).

WESTERN AUSTRALIA

Yanchep bushfire analysis

Photo: Joe Fontaine

Murdoch University

Read the full report here:
www.naturalhazards.com.au/resources/publications/report/yanchep-bushfire-analysis-black-summer-final-report

This research was conducted by Dr Joe Fontaine at Murdoch University.

The Yanchep bushfire (11–15 December 2019) was one of several significant Western Australian fires that season, burning more than 12,300 hectares of diverse vegetation, including coastal dunes and heath, limestone heath and woodlands. There are still significant knowledge gaps in WA's fire severity classification, drivers and behaviours.

This project helped to close these gaps by:

- classifying fire severity (with 78% accuracy) using two complementary approaches: field-based training data and a battery of remote sensing metrics
- mapping vegetation at a finer scale than was previously available, using soil types and field validation
- determining baseline biomass and vegetation loads for several key vegetation types
- assessing the roles of fire weather, vegetation and prior management in determining fire severity, revealing clear interactions of previous fire in the 2–3 years beforehand, with beach associated vegetation burning at lower severity and limestone heath burning at higher severity.

These advancements help develop fire knowledge for the Yanchep region's fire community and contribute to growing local fire science capacity, providing key insights for end-users in WA. In the WA context, the findings can be used to: map fire severity across the Swan Coastal Plain and wider southwestern conservation area; update vegetation maps and fuel load estimates in the Perth regions; expand data sets and analyses about the interplay between vegetation, fire history and fuel moisture; and develop ecological feedbacks to fuel loads and bushfires.

The results can also be applied more broadly by enabling fire severity mapping, informing fire operations, providing fine-grained vegetation maps and fuel loads, and enabling an understanding of how prescribed burning in coastal plain vegetation types can influence bushfire spread and suppression.

Validating fuel moisture estimates in Yanchep

WESTERN AUSTRALIA

Photo: Joe Fontaine

Australian National University

This research was conducted by A/Prof Marta Yebra and Shukhrat Shokirov at the Australian National University.

As mentioned above, the Yanchep bushfire (11–15 December 2019) was one of several significant fires in Western Australia during the 2019–20 bushfire season, burning more than 12,300 hectares including structures, suburbs and native nature reserves. The burnt areas included very heterogenous vegetation, including many threatened species.

Since vegetation moisture is a crucial factor influencing fire behaviour, several remote sensing methods have been developed to calculate live fuel moisture content, to replace costly and time-consuming field-based methods. Researchers of this project had earlier developed a method to estimate live fuel moisture content from coarse-resolution data called Moderate Resolution Imaging Spectroradiometer (MODIS) data. However, higher spatial resolution satellite sensors can detect live fuel moisture content changes in more detail, which is essential for fire management.

For this project, researchers adapted previous methodology for estimating live fuel moisture content using Sentinel 2 imagery to produce maps of moisture content at much higher spatial resolution. They applied field measurements (albeit limited data) of live fuel moisture content of dominant plant species on three sites in Yanchep to validate the Sentinel 2 satellite's measure of moisture.

While dominant plant species *individually* didn't match as closely with Sentinel 2-based live fuel moisture content estimates, dominant species' moisture *on average* showed a higher correlation with the satellite data. This demonstrated good performance of the Sentinel 2 live fuel moisture content algorithm, especially given the limitations of the field data.

This research serves as a basis for further validation of Sentinel 2-based live fuel moisture content estimates against the field estimates, to better understand the uncertainties in both moisture content estimation methods (field vs satellite). This research also contributes to the improved use of remote sensing-based live fuel moisture content maps, which are an invaluable resource for bushfire risk assessments and prescribed burn activities.

Read the full report here:
www.naturalhazards.com.au/resources/publications/report/validation-fuel-moisture-content-estimates-australian-flammability

WESTERN AUSTRALIA

Fuel moisture and fire history of south-west WA from Sentinel 2 satellite imagery

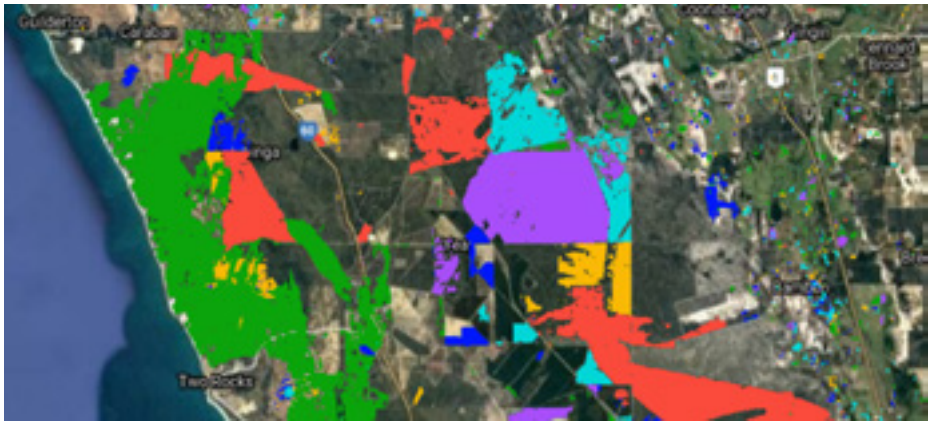


Image: Adrian Allen, Landgate

Read the full report here:
www.naturalhazards.com.au/resources/publications/report/estimating-fuel-moisture-and-fire-history-sentinel-2-satellite

This research was conducted by Adrian Allen, Norman Santich and Passang Dorji at Landgate (Western Australia's land information authority), and Agnes Kristina and Jackson Parker at the Department of Fire and Emergency Services (DFES), as part of a larger project with DFES, the Department of Biodiversity, Conservation and Attractions (DBCA), Australian National University (ANU) and Murdoch University.

Researchers developed a measure for live fuel moisture (that is, vegetation moisture) and fire history from the greater Yanchep region of WA during the summer of 2019–20, using image datasets from the Sentinel-2 satellite and estimates of live fuel moisture to assist in understanding the fire activity.

Fuel moisture is a key factor affecting bushfire flammability, behaviour, damage potential and suppression difficulty. Fuel moisture is also a key contributor to accurate fire danger rating systems and fire behaviour prediction systems.

This project contributed to the objectives of the larger project by improving the understanding of changes in live fuel moisture within the coastal shrubland region of Yanchep, south-west WA, using high-quality satellite imagery.

The resulting time series of satellite images and estimates of live fuel moisture have helped fire managers in WA by providing an improved understanding of the live fuel moisture, rate of change, fire history and burn severity. This project contributes to a better understanding of the prevailing weather and fuel conditions in Yanchep at the time of the bushfire and has been used to inform fire reconstruction research for 2019–20 fires in this region, as well as informing decisions around prescribed burning and bushfire risk as it changes with seasons.

Researchers also developed a detailed fire history of the region, spanning 2016 to June 2021.

Priorities moving forward

The Black Summer research program has provided valuable insights into the bushfires of 2019–20 through targeted data collection and analysis. This program explored how knowledge and tools (developed from reliable recent research) can be used to improve situational awareness and has opened up discussions with communities and First Nations peoples regarding community-centred disaster risk reduction and land management.

The program has allowed us to look at the Black Summer fires from a lesson-management perspective, while also considering how new knowledge, tools and other research outcomes can be applied to provide new approaches to disaster risk reduction and disaster resilience.

Much of the research initiated through the Black Summer research program has been extended by Natural Hazards Research Australia and is now being actively funded and supported, including:

- *Translation of observed and modelled extreme bushfire behaviours to improve fire prediction and fireground safety* – building on the research from the *Modelling fire weather interactions* project
- *Understanding the design, communication and dissemination of predictive maps to the public* – building on the research from the *Established and emerging uses of predictive services in Victoria* project
- *Cultural land management (northern): connecting Indigenous people and the emergency management sector – effective partnerships* – building on the research from the *Indigenous fire and land management in northern Australia* project
- *Cultural land management (southern): cultural land stewardship research in south east Australia* – building on the research from the *Cultural land management in south east Australia* project
- *Community-led recovery: evidence, dimensions, and supports for Community Recovery Committees* – building on the research from the *Community led recovery* project
- *Identifying water sources for aerial firefighting* – building on the *Identifying water sources using satellite imagery* project

The findings of this research were used to inform the national *Research Priorities*, published by Natural Hazards Research Australia to guide research into disaster risk reduction and natural hazard resilience.

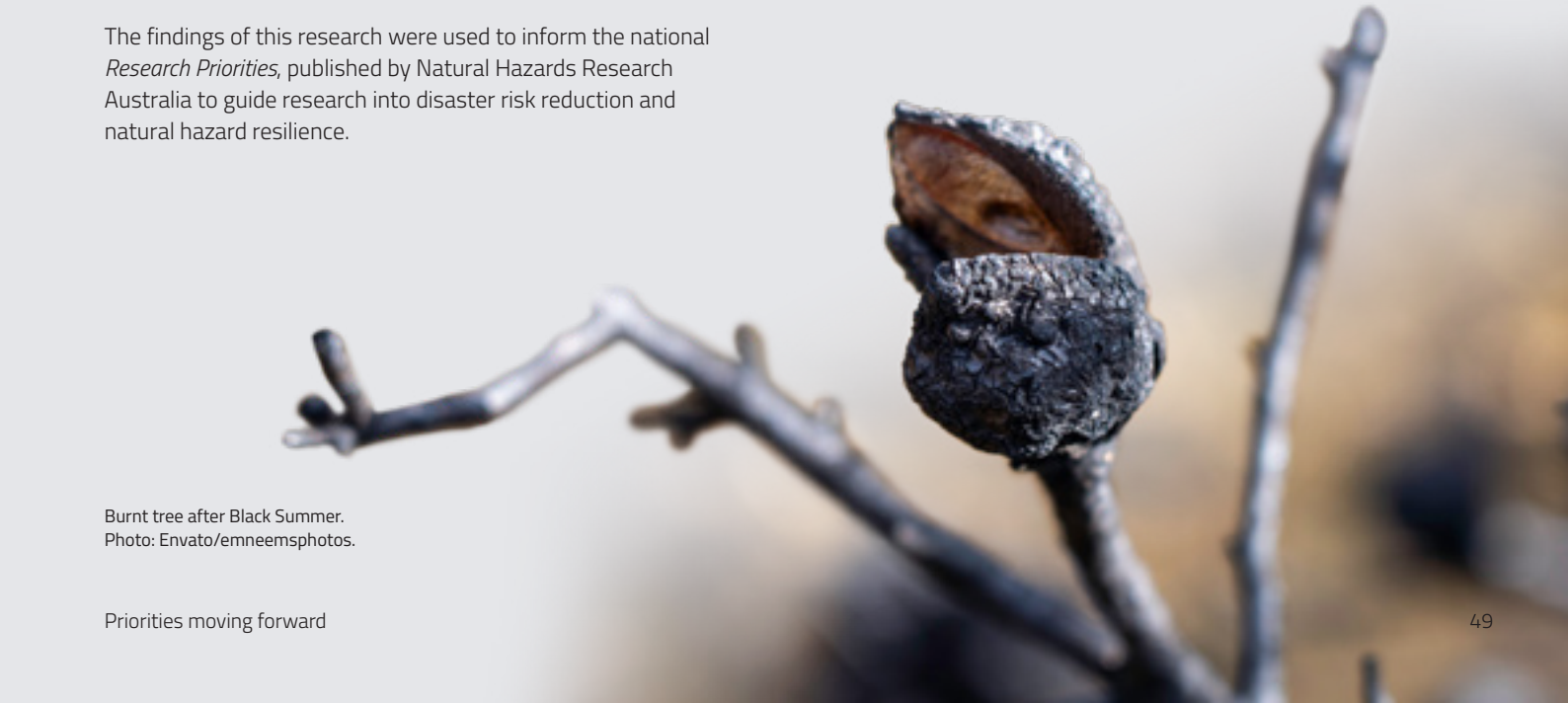
Natural Hazards Research Australia's priorities continue to address critical areas identified through the Black Summer research, including:

- dynamic situational awareness
- natural hazard focused risk management and risk reduction
- incident management and decision-making in a dynamic and uncertain environment
- responsive recovery
- understanding the needs and values of communities through a natural hazard lens
- collecting and managing natural hazards research data.

While this program was substantially supported with a specific allocation of funding from the Australian Government, Natural Hazards Research Australia is making rolling investments into its research portfolio, ensuring that there will always be opportunities to ensure that we learn from disasters.

Most importantly, these findings can now be used by governments, emergency management agencies, industry and other partners to influence decisions and create safer communities and landscapes in the face of future bushfires.

Natural Hazards Research Australia's ongoing research program has a strong focus on learning from disasters, and the benefits that have been achieved through the Black Summer program demonstrate the value of retaining flexibility in the research portfolio to address these significant opportunities when they arise.



Burnt tree after Black Summer.
Photo: Envato/emneemsphotos.

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Find more information about the Black Summer research program at **naturalhazards.com.au/black-summer**

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