WE RISE TOGETHER

LIFTING AUSTRALIA TO BE THE GLOBAL LEADER IN FIRE & FLOOD RESILIENCE BY 2025

MINDEROO FOUNDATION

FIRE & FLOOD RESILIENCE BLUEPRINT

Version 1: September 15, 2020

Signs of regrowth are seen amongst the bushfire affected blue gum forestry west of Parndana on February 23, 2020 in Parndana, Australia. Photo Credit: Lisa Maree Williams via Getty Images.

FOREWORD

For many Australians, 2020 will be the toughest year of their lives.

Our nation, devastated by drought, bushfires and floods, now grapples with the fear and disruption of a pandemic and the economic hardship that will bring.

From early January, Minderoo Foundation has been on the frontline in fire ravaged communities across Australia, working with our partners.

We've performed and funded thousands of hours of recovery work. We have looked in the eyes of people who have lost everything. We've shared their pain, been inspired by their courage, and have actively listened to figure out how we could best help.

What we were told repeatedly by these people was that they did not want to leave their land while they rebuilt. We took that feedback and with it we designed, constructed, and delivered the Minderoo Foundation Recovery Pod. Together with partners, this innovative temporary housing solution has now created a 'home' for hundreds of Australian families – with more being delivered every day.

But without a game changing intervention we know the fires will return.

We must rise — together — to make these disasters a thing of the past. This means going to the root cause of the problem, and to bring to fruition the best available modern and forward looking solutions.

Minderoo Foundation is proud to present this Blueprint to lift Australia to be the global leader in fire and flood resilience, developed in conjunction with our outstanding and dedicated partners.

Our first mission, Fire Shield, aims to ensure no dangerous bushfire in Australia will burn longer than an hour by 2025.

This extraordinary task will require unprecedented cooperation across communities, governments, industry, not for profits and the research sector. It is the kind of challenge we are prepared to take on: to assist in its orchestration, bringing together the best minds and ideas in lockstep with partners, and most importantly emergency services.

To protect Australia and, one day, the world from the deepest ravages and heartache of fire and flood.

Andrew Forrest, Chair
Nicola Forrest, Co-Chair

Minderoo Foundation

Top: Adrian Turner, Nicola Forrest AO, Kim Wilkie and DrAndrew Forrest AO at Minderoo Foundation Fire Fund announcement press conference in Perth, Western Australia – January 2020. Photo credit: Benjamin Horgan

A kangaroo escapes as a fire front approaches a property in Colo Heights, Australia. – November 15, 2019. Photo credit: Brett Hemmings/Getty Images

CONTENTS

ABOUT US

Minderoo Foundation is a modern, philanthropic organisation that tackles tough, persistent issues with the aim of driving systemic change. Australia's resilience to fires and floods is one of the most significant and complex challenges facing the country today and one on which our social, economic and environmental future depends.

In the aftermath of the devastating "Black Summer" fires across Australia in 2019-2020, Minderoo Foundation established the Fire Fund — recently renamed to Fire and Flood Resilience Initiative — and committed AU$70 million to response, recovery and long-term resilience.

Our vision is audacious. We want to reduce harm caused by fire and floods by harnessing the collective power of communities, industry, government, philanthropy and the research sector to lift Australia to be the global leader in disaster resilience by 2025.

Our journey so far...

Our recovery efforts started in January 2020, while Australia was still burning. Our team was deployed into towns and regions affected by the bushfires to gain an understanding of what each community needed. Communities visited included Kangaroo Island and Woodside in South Australia; Armidale, Wytaliba, Tenterfield, Torrington, Drake, Moruya, Mogo, Malua Bay and Merimbula in New South Wales; and Mallacoota and Bairnsdale in Victoria.

We met with people who had lost their homes, livestock, infrastructure and businesses and listened to their stories. We are so grateful for all those who shared their stories.

We are extremely proud of all our many programs in helping the community recover. The highlight for us all has been the deployment of temporary housing pods to those in need. Our team has covered thousands of miles across New South Wales and South Australia and as at August 2020, 182 pods have been delivered in 216 days. Our commitment plus those of our partners will see 256 pods to be delivered in 259 days.

Our journey from here.

Our role is unique. We see ourselves as an **enabler**, facilitating dialogue, orchestrating and convening groups (people, businesses, government, philanthropy and the research sector). We rely on ground truth from active community-focused programs, including temporary accommodation pods, to identify the most important resilience related problems. Our priority is to enable the the most effective solutions to be delivered faster.

We are inclusive, accountable and **community first** in our approach. Our collaborative method to lifting resilience is proven and builds on the experience we have from our on the ground response to the most recent fire season.

We are **outcome-focused** and **evidence based**. As a not for profit, we go where the evidence takes us.

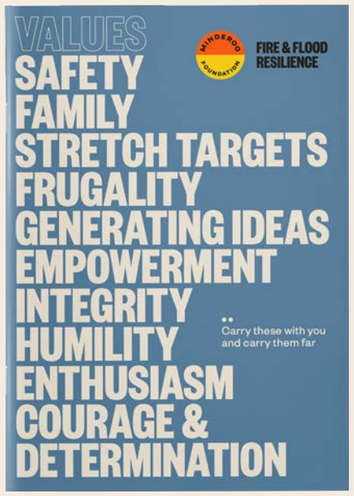
Finally, we are an **impact investor**. We will make investments when and where they are needed to lift resilience through place-based and systemic change and to ensure that solutions benefit the most disadvantaged groups. We are a values driven organisation and have a strong balance sheet to help ensure the program is a success, together with partners.

Philanthropists and others are seeing Australia burn and saying, will we be next? I am saying, you may well be — so help create a blueprint for Australia and that blueprint can be used for California, that blueprint can be used for Brazil, that blueprint can be used all over the world. Let's start it here. We have had the warning light.

Dr Andrew Forrest AO
January 2020

Left: Recovery pod located on Kangaroo Island, South Australia – 19 February, 2020. Photo credit: Minderoo Foundation Fire Fund team.

Right: Values booklet created for distribution to Fire Fund staff and volunteers.



THE MOONSHOT

An audacious vision requires an innovative approach. We take inspiration from the Apollo mission of the 1960s. What was thought impossible, 10 years later was possible. We will use a similar missions-based approach to achieving our own moonshot. Our initiative, through collaboration with our partners, will translate big, bold, complex challenges into concrete problems to solve, based on a clear, time-bound ambition with a view to lasting change.

Our initiative will be built on the following underlying principles:

- **Be evidence based:** mission priorities and success measures will be underpinned by robust research and evidence.
- **Be world class:** reflective of best practice approaches to fire and flood resilience globally.
- **Be collaborative:** partner with diverse stakeholders in communities, emergency services, industry, academia, philanthropy and government.
- **Be scalable:** willingly seek out unconventional approaches that have the ability to deliver outcomes at scale.
- **Be an enabler:** open up opportunities for broader stakeholder investments in order to create lasting fire and flood resilience.

●●

At 9:32 a.m. EDT, the swing arms move away and a plume of flame signals the liftoff of the Apollo 11 Saturn V space vehicle and astronauts Neil A. Armstrong, Michael Collins and Edwin E. Aldrin, Jr. from Kennedy Space Center Launch Complex 39A. Photo credit: David Neff/Contributor

THE BLUEPRINT IS COMPRISED OF MULTIPLE MISSIONS.

Fire Shield:
Imagine if we could put out any fire in less than an hour?

Resilient Communities:
Imagine if every community in our country had the skills and resources to cope with fire and flood disasters?

Healthy Landscapes:
And what if we could improve our ecosystems' "immunity" to fire and flood disasters?

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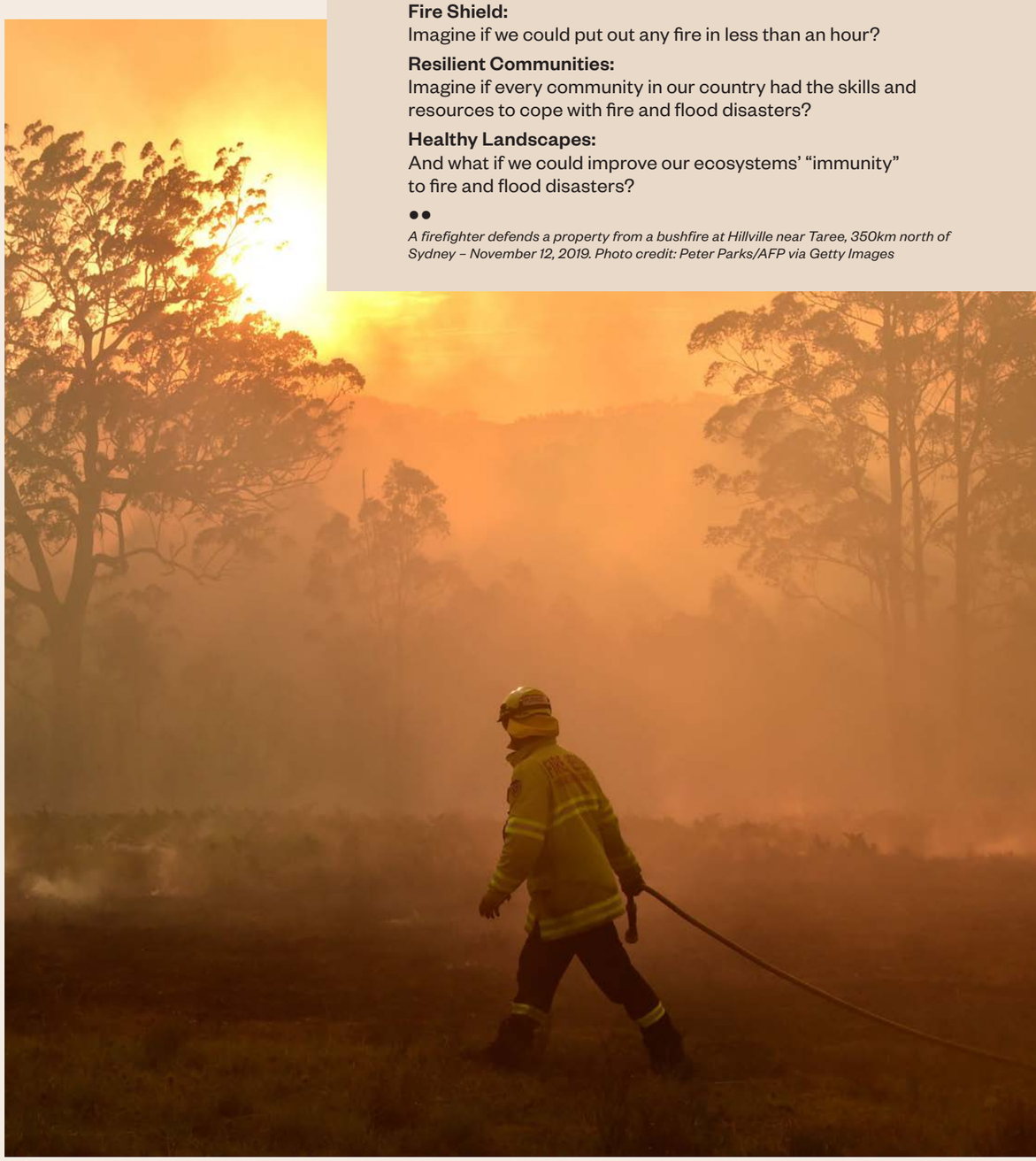
A firefighter defends a property from a bushfire at Hillville near Taree, 350km north of Sydney – November 12, 2019. Photo credit: Peter Parks/AFP via Getty Images



OUR PARTNERS

These big, bold targets have the power to deliver significant and lasting generational change. But we cannot achieve them by ourselves. We are deeply grateful to all our partners to date and to Australia's emergency services, front line responders, and other charity and volunteer organisations. There has been a tremendous amount of hard work and goodwill that has been invested in the spirit of collaboration to create this blueprint.

We also note that the blueprint is a "living document" that will be refined over time as the evidence base for the initiative's missions deepens and extends. We welcome further collaboration to build on the blueprint and mobilise our missions for a fire and flood resilient Australia.

Accounting for Nature

Advance.org

Allianz

AustCyber

Australasian Fire and Emergency Service Authorities Council

Australian Academy of Science

Australian Business Roundtable for Disaster Resilience & Safer Communities

Australian Energy Market Operator

Australian Lions Foundation

Australian Red Cross

BackTrack Works

BlazeAid

Boston Consulting Group

Bushfire and Natural Hazards CRC

Business Council of Australia

Commonwealth Bank of Australia

Conservation International

Deloitte Australia

WE HAVE WORKED CLOSELY WITH MANY FEDERAL AND STATE GOVERNMENTS AND EMERGENCY SERVICES DEPARTMENTS.

We are very grateful for their support and contribution to this blueprint.

Disaster Relief Australia

Finch

Firetech Connect

Fortescue

Givit

Hertz

IAG

Insurance Council of Australia

International Union for Conservation of Nature

KPMG

Lifeline

Macquarie Infrastructure and Real Assets

Movember

Munic Re

National Australia Bank (NAB)

National Bushfire Recovery Agency

Optus

Resilience New South Wales

Resilient Cities Catalyst

Risk Frontiers

Rotary Australia World Community Service Limited

Science & Technology Australia

Suncorp

SwissRe

Telstra

The B Team Australasia

The Nature Conservancy

The Salvation Army

Turner

Wesfarmers

Westpac

Wonnarua Nation Aboriginal Corporation

WHY WE NEED A BLUEPRINT

In the last two decades, climate induced natural disasters – including fires and floods – have wreaked havoc on Australian communities, causing over AU$25 billion in damage and AU$100 billion in downstream economic costs. Over 350 lives have been lost, millions of hectares of forest and bushland burnt, with irreversible damage to communities, livelihoods and cultural lands.[1]

2019-2020 TO DATE

1500+

There were an estimated 1500 bushfires.

17 MIL+

Estimated over 17 million hectares had been burned across NSW, VIC, QLD, ACT, WA and SA.

3,300

Estimated over 3,300 houses destroyed.

3 BIL+

Estimated 3 billion animals were killed or displaced.

33

Tragically 33 people lost their lives in the fires.

*WFF Australia July 2020

THE EVENTS OF 'BLACK SUMMER' FIRES 2019-2020 WERE DEVASTATING.

The cost to lives, landscapes and wildlife due to fire and floods in a single year (2019-2020) is unprecedented. Insurance claims for damage are expected to exceed AU$2.5 billion.[2]
It is estimated that as many as 70 of our nationally threatened species have had more than half of their of their known habitat burnt during 2019-2020.[3] Our unique vegetation was most affected. Of the 30 threatened species that had 80 per cent of their range burnt, 29 were plants.[4] In addition to this devastation, fires were quickly followed by torrential rain and flash floods that caused a further AU$45 million damage on the east coast.[5]
Recovery efforts are still underway.

A fire rages in Bobin, 350km north of Sydney – November 9, 2019.
Photo credit: Peter Parks/Contributor via Getty Images

Scientific predictions suggest an increase in the scale, frequency, and severity of fires and floods in the coming decade with climate change as the primary driver.[6] The cost of these disasters is expected to reach an average of AU$33 billion per year by 2050.[7]

Building disaster resilience is vital to limit the risk and cost associated with these events.[8] Evidence from a study in the United States suggests that every US$1 spent on resilience saves US$4–11 in response and recovery costs.[9] A 2017 study has indicated that Australian Federal and State Goverment spending on recovery from disasters may be as much 27 times the funding directly provided for natural disaster resilience.[10]
It is time to reverse this trend.

●●

Resident pats his dog after returning to find his house destroyed in the bushfires near the small town of Nana Glen, some 600kms north of Sydney – November 13, 2019. Photo credit: William West/AFP via Getty Images

ECONOMIC COST

Building disaster resilience is vital to limit the risks and costs.

NATURAL DISASTERS INCREASE

IN FREQUENCY SEVERITY & SCALE

BY 2050

AU$33BIL

per year economic cost

2000 TO 2020

AU$2.5BIL

in damage

THE RESILIENCE OFFSET

Currently Australia spends up to **27 TIMES** more on recovery than on resilience. A U.S study shows that this may be a worldwide problem. It is time to reverse this trend.

DEFINING RESILIENCE

The UN definition of resilience, captured within the Sendai Framework for Disaster Risk Reduction (2015-2020), is as follows:

The ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management.[11]

The Australian Government's National Disaster Risk Reduction Framework articulates the urgent need for a focused and nationally coordinated effort to improve disaster resilience.

It describes several 'drivers for action':

- Natural hazards are more frequent and intense, and disaster impacts are long term and complex.
- People and assets are more exposed and vulnerable, and the disaster costs are growing.
- Essential services are interconnected and interdependent.[12]

We have used both the Sendai Framework and the National Disaster Risk Reduction Framework as the framing for the development of this blueprint.

A NSW Rural Fire Service firefighter mops up after a bushfire in the suburb of Llandilo in Sydney, Australia – November 12, 2019. Photo credit: Sam Mooy/Getty Images

Disaster risk is influenced by:

Hazard

The probability of an event like fire and flood occurring.

In the next decade, summer fires are expected to be nearly twice as frequent as in the past decade, significantly increasing fire hazard (Figure 1).[13] Some regions, including the south east, will see their fire hazard double by 2050. Major rainfall disruptions (including floods) are expected to become 56 per cent more frequent in Australia over the same period.[14]

Exposure

The social, economic, built and natural environments in the path of hazard.

Preliminary analysis suggests that around one-third of Australia is expected to be exposed to increased fire hazard over the next decade, with a significant increase in exposure in highly populated areas in south east Australia, among others.[15] A changing climate is also expected to increase exposure of Australian communities to coastal flooding, as well as flooding from storms and high rainfall events. For example, in the next decade, some regions in south-east Queensland are expected to experience a 75 per cent increase in the number of residential buildings exposed to flooding from storms and high rainfall events, with damage costs almost doubling.[16]

Vulnerability

The potential for environments to be adversely impacted by hazard

Areas with above-average hazard are also some of the most populous areas in Australia. Preliminary analysis indicates these areas contribute 65 per cent of Australia's GDP, contain 70 per cent of Australia's critical institutions and around half of Australia's critical infrastructure, and are home to 21 million people, in addition to precious indigenous and natural assets.[17] This makes them vulnerable to adverse impacts from hazard, and investments in resilience will be critical to limiting this vulnerability.

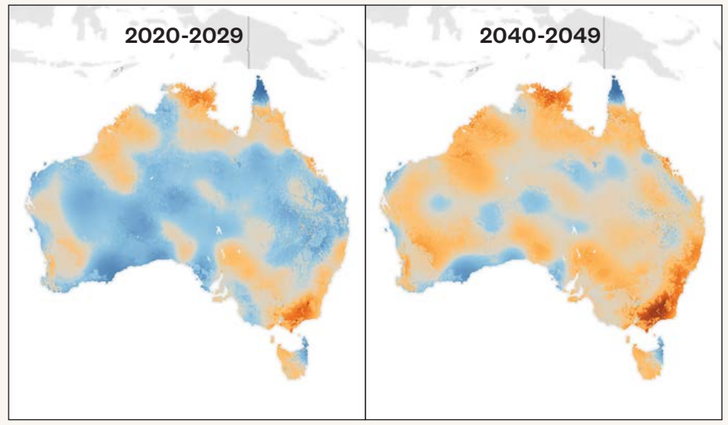


Figure 1: Over a third of Australia (~2.4m sq km) will experience increased summer fire hazard over the three next decades, based on an RCP 4.5 carbon emission scenario. South east Australia may be ~2.5x more likely to experience summer wildfire with ~24% more land area exposed to increased hazard[18]

OUR MISSIONS

Our blueprint identifies three missions, to be achieved by 2025:

FIRE SHIELD

What if a fire never became a disaster?

Mission: reduce the scale and impact of bushfires by being able to extinguish dangerous fires within an hour by 2025.

RESILIENT COMMUNITIES

What if every community had the skills and resources to mitigate their disaster risk and bounce back stronger?

Mission: lift Australia's 50 most vulnerable communities to be on par with Australia's 50 most resilient communities by 2025.

HEALTHY LANDSCAPES

What if our environment was optimised for risk reduction and natural ecosystem resilience?

Mission: halve hazard exposure in Australia's 50 most fire and flood prone regions by 2025.

Residents watch a large bushfire as seen from Bargo, 150km southwest of Sydney, on December 19, 2019. Photo credit: Peter Parks/Contributor

These missions do not specify solutions to all of the challenges posed, they will be developed collaboratively. Our priority is to inspire unconventional approaches and new step change breakthroughs. Indeed, the missions and their solutions will evolve based on evidence, and stakeholder knowledge and experience. Crucially, however, goals are quantified – so we will know when they have been achieved, or if approaches are failing and need to be re-evaluated.

In today's uncertain and fast-changing world, where big trends such as technological change and fire and flood disasters are compounded by unexpected shocks such as COVID-19, the need for evidence based solutions is particularly important. Once we have addressed these challenges and lifted resilience in Australia, we envisage enabling global partners to adapt and apply the same learnings in other parts of the world.

Our collaborations will also lead to the creation of a Disaster Resilience Data Collective, to provide shared access to nationally and globally significant information.

MISSION DESIGN ELEMENTS

Ultimately, our initiative will contain multiple missions, operating in parallel. Missions are designed on the following eight principles:

Clear and ambitious	A small number of high-value, ambitious technical goals. Comprehensive design and scope with clear, measurable performance goals.
Outcome first	Clear end-user, clear transition path, ongoing engagement with off-ramp opportunities.
Fast fail	Learn fast, learn smart, move forward. Clear stage gates with ongoing assessment of progress and realignment with the end goal in mind.
High standards	Set a high bar for performance excellence. Attract high-calibre contributions with a track record of delivery.
Open and collaborative	Co-design, collaboration and co-delivery. Everyone owns the delivery of the mission and everyone owns the outcome.
Resourced for results	Sufficient support and resources to achieve success. Continual optimisation through ongoing project management.
Well-managed	Robust planning, monitoring and evaluation in order to make informed decisions about progress.
Flexible and agile	Processes should support delivery and not be onerous. Informal ongoing discussions are preferred over rigid reporting.

FIRE SHIELD

What if a fire never became a disaster?

Mission: reduce the scale and impact of bushfires by being able to extinguish dangerous fires within an hour by 2025.

This is the challenge we set ourselves for the Fire Shield Mission. Fires become more difficult to extinguish the longer they burn and the larger they become. Detecting and responding to fires quickly can help to minimise the scale of a fire and therefore its potential negative impacts.[19] We may not always want to extinguish fires quickly, given the role of fire in regenerating the landscape and native plant species, but we need to have the capability to extinguish a fire that has the potential to become a disaster. Emergency Management Australia and State-based fire services are a key end user for this mission and we will work closely with them to ensure Fire Shield outcomes can be integrated for the best possible impact.

The Fire Shield Mission will focus on reducing the scale of fires by improving our ability to detect and respond to them.

The mission will use an evidence based approach to achieve the following goals:

Detect
Immediately identify fires from the ground, air and space.

Share
Share information in real time for immediate decisions.

Predict
Better predict what the fire will do.

Respond
Respond quickly to extinguish fires that are deemed to be a threat.

The Fire Shield Mission will draw on the collaboration, knowledge, resources and innovation of emergency services, utility companies, technology companies, governments and communities.

DETECT: IMMEDIATELY IDENTIFY FIRES FROM GROUND, AIR AND SPACE

Our future in 2025: fires are detected early and accurately and monitored to provide real time knowledge for appropriate response.

Insight

Early detection is key to preventing dangerous fires. A CSIRO experiment showed that within two hours of ignition, fire area increased by 300 per cent. In even moderately dry summer conditions, every ten-minute delay in detection can see a fire's area grow by up to 1500 m^2 (or 0.15 ha).[20]

Manual and citizen-sourced detection is still often relied on in Australia to detect fires[21] although satellite observations are increasingly the primary form of fire detection in more remote areas.[22]

A range of technologies have been developed to improve the accuracy and timeliness of detection.[23] For example:

- **Advanced satellites:** Himawari-8 can detect infrared radiation (the energy emitted by volcanic eruptions and fires) at a spatial resolution of under 2 km.[24] It can detect hotspots every ten minutes.[25]
- **The Moderate Resolution Imaging Spectroradiometer**: (MODIS) sensor uses thermal detectors that can identify fire even in the absence of smoke.[26] However, MODIS is not above Australia permanently and this data is available with a temporal resolution of four observations per day.[27]
- **The Latrobe Valley Information Network:** The network has 45 multifunction sensors covering 1470km^2 in Victoria. These sensors are coupled with an online real-time map and alert.[28] The network's use extends beyond disaster response to providing information to help farmers decide where and when to water crops, such as live and historic rainfall data, and information on soil moisture and localised micro-climate weather conditions.[29] Attentis, the company behind the network, won the 2019 Best Government IoT Project[30] for its innovative approach.
- **Networked Systems:** There are bushfire detection, mapping and intelligence systems being developed in other countries that combine satellite and ground-based sensor data with deep machine learning software to detect fire as early as three minutes after ignition. [31] These systems have not been tested in Australia.

This Mission will look further afield to incorporate novel ways of providing situational awareness for our emergency services and communities.

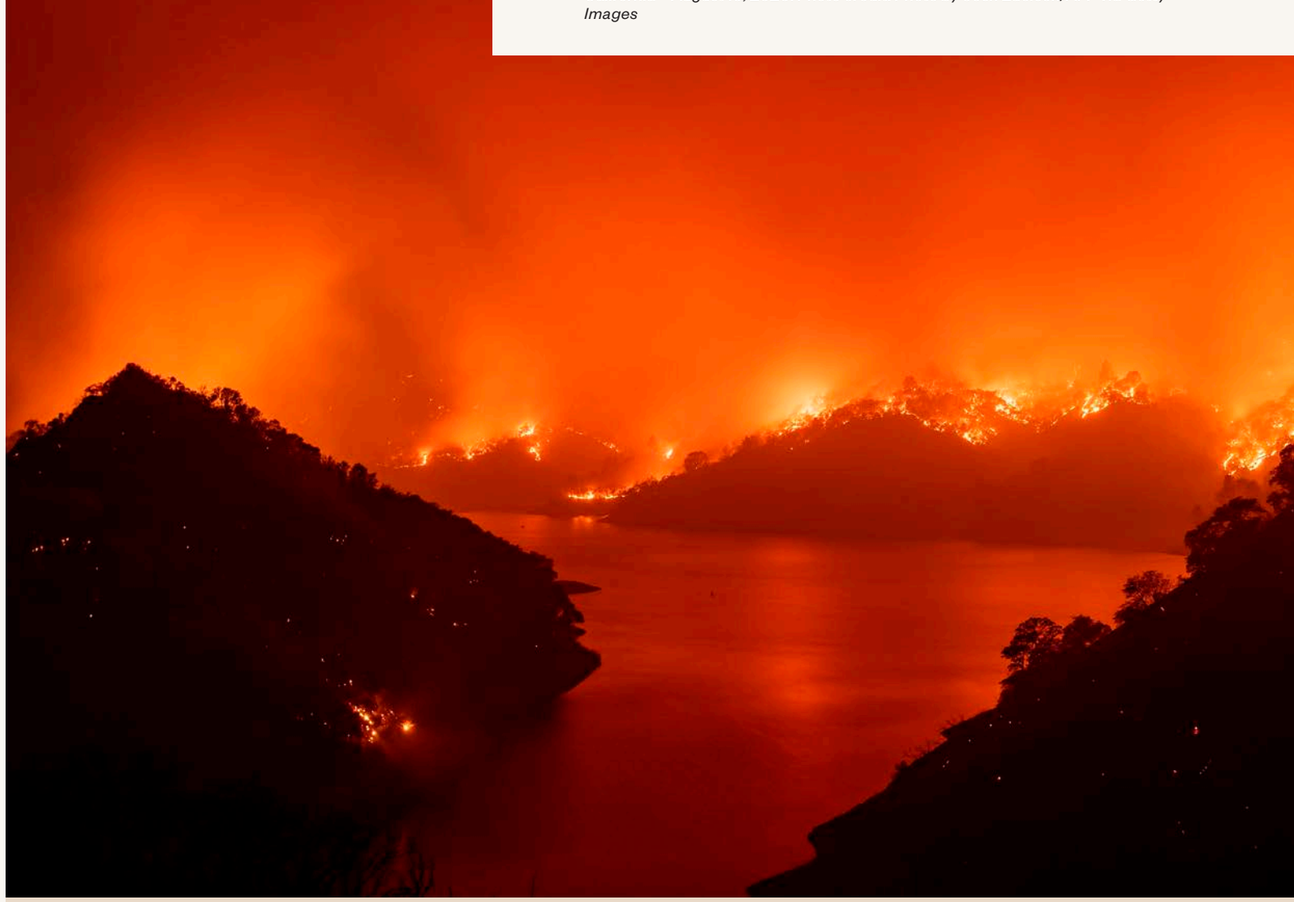
OUR OPPORTUNITY

A combination of emerging technologies will provide us with more accurate, near-real-time detection and understanding of fires, allowing communities time to safely evacuate and emergency services more time to respond. Ground-based, aerial and satellite detection capabilities will detect indicators of ignition, such as heat, smoke or lightning strikes, in real time and transmit location data and images to alert emergency services personnel.

CALIFORNIA FIRES

The devastating images from California in August 2020 illustrate the effect bushfires can have on people, habitats and homes. The two largest fires now burning in California – started by lightning – are both already in the top five largest fires in the history of the State. It is a sobering reminder of the need for us to come together to take on the ongoing threat of fire across our societal, natural, built and economic environments.

Flames surround Lake Berryessa during the LNU Lightning Complex fire in Napa, California – August 19, 2020. Photo credit: Photo by Josh Edelson/AFP via Getty Images



SHARE: INFORMATION IN REAL TIME FOR IMMEDIATE DECISIONS

Our future in 2025: Every first responder, emergency services representative and community member has timely, accurate and relevant information about fires in their area.

Providing people on the ground with accurate, timely and relevant information is critical for informed decisions and actions before, during and after disasters.[32] Australia has seen significant progress in disaster communication in recent years, with a national focus on engaging and empowering communities.[33] But sometimes communications can still breakdown just when they are needed most. Two-way communication of information from emergency services to the community, and from the community to emergency services, is vital.

Enhanced situational awareness requires data to be seamlessly incorporated from multiple trusted detection sources.

This data can be used to provide intelligence to the people who need to make quick decisions and take fast actions. There are examples of data integration platforms that can provide inspiration for solutions that could be used in a firefighting context. These platforms could integrate data feeds not only from satellites and aerial imaging but also from many different sources and thousands of devices (including smartphones, GPS trackers, cameras, audio devices and wearable technology) to provide up-to-date information and overcome device compatibility challenges.[34]

Solutions are also being developed to provide real-time traffic flow and incident data to enable emergency responders to find the fastest route to people in need of help and divert the public away from a specific area.[35] It will be important to understand the effectiveness of these capabilities in rural and remote areas where fires are likely to occur, rather than in technologically connected cities.

Sometimes there are communication break points that occur when fire events move so fast that warnings cannot keep up,[36] fires cause infrastructure outages,[37] or systems are overwhelmed.[38] This can slow the communication of life-saving information,[39] and cause confusion. [40] Communications compatibility challenges also exist between private sector operators (that use Ultra High Frequency (UHF) radios) and Government Radio Network (GRN) radio users, [41] between users in different states[42] and between different agencies within the same state. This can hamper efforts to provide emergency services with timely, complete and accurate information.[43]

A New South Wales police officer prepares to flee his roadblock on the Princess Highway near the town of Sussex Inlet – December 31, 2019. Photo credit: Sam Mooy/Getty Images

An ACT Rural Fire Service member oversees water-bombing operations taking place on a fire in Bungendore, Australia – January 9, 2013. Photo credit: Brendon Thorne/Stringer

Insight

There is an opportunity to make information easier to access and interpret by emergency services and communities.

Currently, information can be challenging to interpret due to:

- **Incomplete information or information presented in a way that is difficult to comprehend.** For example, during the Black Summer fires, some South Australian communities lacked information about fire direction and estimated time fires would arrive.[44]
- **Fragmentation of different information sources**. Submissions to the Royal Commission, post-Black Summer, have revealed that Australian lives were put in danger due to the lack of real time, ground truth information. Instead, people had to cobble together bushfire and weather information from disparate sources.[45]
- **Language barriers.** Nearly half of all Australians aged 15-65 have some difficulty reading or writing in English,[46] and 25 per cent of Australians speak a language other than English at home,[47] making multilingual warnings vital.

OUR OPPORTUNITY

Improvements in capturing, aggregating, analysing, and sharing data in close to real-time can substantially improve situational awareness and the quality of decision making. The integration of multiple information sources into tailored and actionable hazard notifications will provide the appropriate information in a format that aids decisions by emergency service personnel and provides timely information for the community.

PREDICT: HAVE A FORWARD VIEW TO PREDICT WHAT A FIRE WILL DO

Our future in 2025: We accurately predict the spread and intensity of any fire in Australia.

Short-term predictive capabilities are crucial to protecting life and property. These capabilities help us to understand how fires are likely to spread and develop over time and inform planning and responses from communities and emergency services. When prediction is accurate, it can save communities – in 2018 predictive analytics allowed Queensland Fire and Emergency Services to evacuate thousands of residents from the town of Gracemere before fire struck. [48] However, when prediction is wrong the results can be tragic.

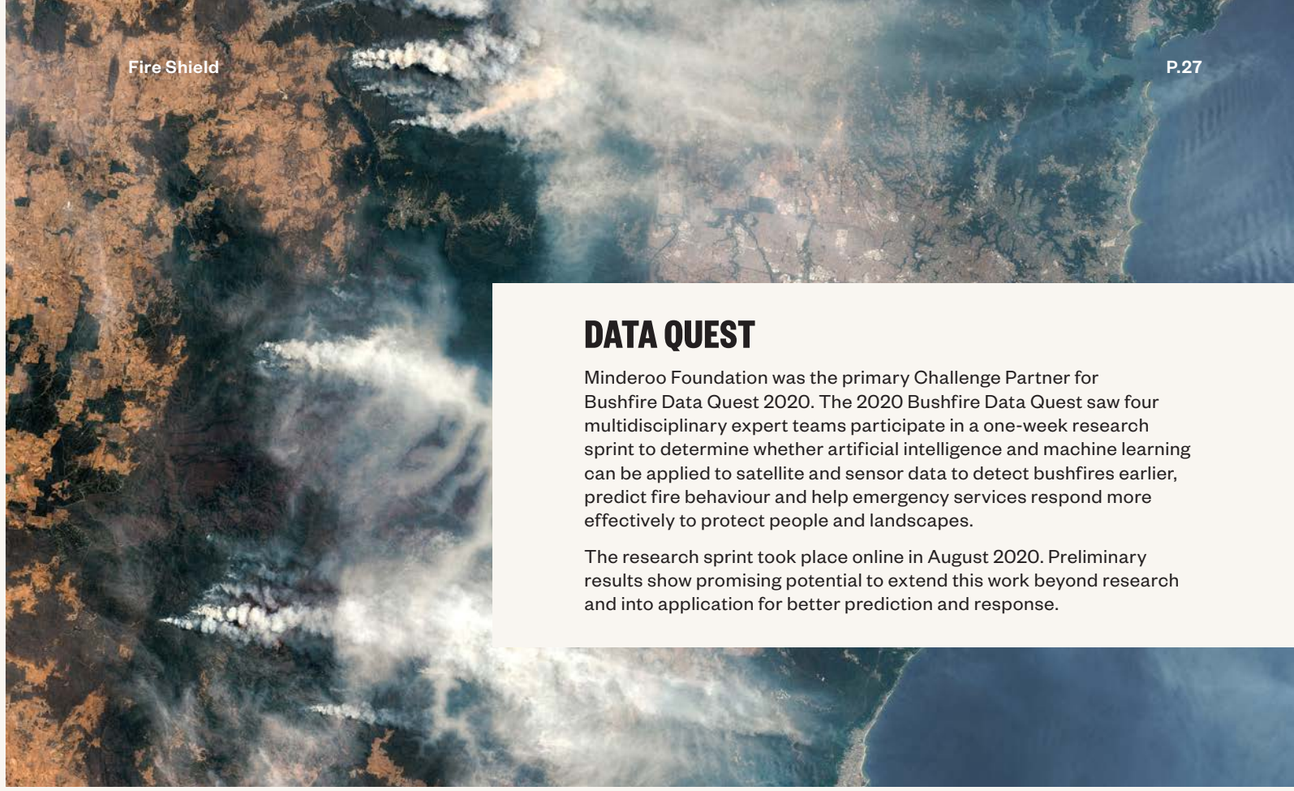
During the 2009 Black Saturday fires, existing fire behaviour models under-predicted the speed at which the fires spread. A key recommendation afterwards was for detailed work to understand how fire progresses across the landscape.[49]

The range of tools in use or in development in Australia include:

- **Phoenix Rapidfire**, a fire modelling tool developed by the Bushfire CRC and the University of Melbourne, now housed at Fire Prediction Services at the Australasian Fire and Emergency Service Authorities Council. It predicts bushfire movement across different types of topography and vegetation, taking account of fire history, roads and other structures, and weather (temperature and wind) conditions.[50]
- **Aurora,** a bushfire prediction, detection and simulation system, developed in a collaboration between the Bushfire CRC and the University of Western Australia, forecasts the progression of wildfire.[51] The system is also linked with an online bushfire map called FireWatch, which predicts expected fire behaviour.[52]
- **Spark**, a simulation toolkit being developed by CSIRO's Data61. Spark aims to allow users to develop custom fire predictions, utilising underlying fire behaviour modelling capabilities. It also provides flexibility in inputs and visualisation tools.[53]
- **Manual fire prediction** methods are also used by response agencies across Australia, often in conjunction with the software tools mentioned above.

Insight

Bushfire prediction in Australia builds on a long legacy of bushfire and natural hazard research, utilising empirical models to predict the spread and intensity of bushfires. Predictive tools are often optimised for local conditions, which means their effectiveness can vary depending on where they are used. They also need ground truth data to improve accuracy and modelling to take into account changing conditions. Few, if any, tools contemplated the scale of the fires last season and the number of pyro cumulonimbus clouds.



DATA QUEST

Minderoo Foundation was the primary Challenge Partner for Bushfire Data Quest 2020. The 2020 Bushfire Data Quest saw four multidisciplinary expert teams participate in a one-week research sprint to determine whether artificial intelligence and machine learning can be applied to satellite and sensor data to detect bushfires earlier, predict fire behaviour and help emergency services respond more effectively to protect people and landscapes.

The research sprint took place online in August 2020. Preliminary results show promising potential to extend this work beyond research and into application for better prediction and response.

A Satellite image of Bush fire smoke over the city of Sydney in Sydney, Australia – December 21,2019. Photo credit: Orbital Horizon/ Copernicus Sentinel Data 2020/Gallo Images via Getty Images

Internationally, other predictive and modelling tools are used including:

- **Prometheus**, a tool developed by the Canadian fire management service, is a deterministic wildland fire growth simulation model. Prometheus provides fire behaviour and spread outputs which can be used for applications such as forecasting fire growth, for operational decision making or planning prescribed burns.[54]
- **WIFIRE Firemap** is a data-driven predictive tool used for predictive modelling and analysis of fires with high spread potential and partners with Californian fire departments. It also provides information on previous fires, weather conditions, satellite detections and vegetation information.[55]

Many organisations are investing in enhancing these predictive tools to make them more accessible, more adaptable to local conditions, and to model more complex fire behaviours. Examples of these complex behaviours include the atmospheric conditions created by extreme fires and the extent to which ember spotting increases the severity of fires. The challenges of modelling such complex behaviours are accompanied by difficulties in accurately predicting fire spread and intensity overnight and sourcing accurate and timely ground truth data.[56]

OUR OPPORTUNITY

Improving how tools predict fire behaviour, and how effectively organisations use those tools to respond to fires, could help to reduce the impact of fires on our communities. As with any modelling problem, data is critical. Improving how we integrate data and modelling with on-the-ground operations will maximise the value of these tools and our responses.

RESPOND: INCORPORATE NEW RESPONSE CAPABILITIES TO ENHANCE SPEED AND EFFECTIVENESS

Our future in 2025: We have the resources, capabilities and coordination to be able to respond to fire within an hour of detection.

Insight

Fast responses typically reduce the damage caused by fire. Data from the US suggests that 90 per cent of fires that were responded to in up to one hour lasted an average of 14 hours, whereas 90 per cent of fires that were responded to after 72 hours lasted up to 47 days.[57]

In Australia, response times to landscape fires are not published consistently at the national level, but examples suggest that responses are often rapid in many regions. Response times are measured from alarm time to the time at which the first responding vehicle arrives at the scene. In Queensland in 2018–19, for example, it took 11 minutes from the time an alarm was raised to respond to 50 per cent of landscape fires, and 20.5 minutes to respond to 90 per cent of landscape fires.[58] It is the exceptions that are problematic – longer burning, larger fires tend to cause more ecological damage, although the extent of life and property loss depends more on fire location than on duration and scale.[59]

As Australia and many other countries around the world experience longer and more severe fire seasons, response resources will become increasingly constrained. Black Summer showed us what the future might hold. From September to December 2019, South Australia deployed around 2000 firefighters to other states but, as major fires continued to burn, those states could not send support to South Australia when it was needed.[60] The same is expected to happen at an international scale as longer fire seasons in the northern and southern hemispheres cause fire seasons to overlap.[61] As recently as August 2020 the Governor of California requested assistance from Australia while firefighters in California fought hundreds of blazes.[62] At this time, the first fires of the Australian bushfire season had already begun in North-east NSW.[63]

If many bushfires of great intensity occur at the same time, there will be a strain on firefighting resources and capacity. Tracking resources across the multiple agencies that fight fires will become more critical to avoid longer response times; a challenge that emergency services are developing tools to address.[64]

The sustainability of Australia's volunteer model will be further challenged by longer fire seasons. Australia relies on volunteer firefighters, with 10 volunteers to each employed firefighter. However, the volunteer firefighting force has declined by 10 per cent over the past decade.[65] Moreover, the Black Summer bushfires had a major impact on Australia's volunteer firefighting force. Access to psychological support services for fatigue and trauma by firefighters was the highest in 2019-2020 since 2005.[66] Fewer volunteers, combined with longer and more intense firefighting campaigns, will have an impact on physical and mental health, and employment, for volunteer fire fighters.

Enhanced and emerging suppression, containment and extinguishment solutions will further enable rapid response to fires across a range of landscapes and weather conditions. Combining existing technologies in new ways can also provide powerful solutions.

Examples of emerging response technologies include:

- **Enhanced water-bombing:** Waterbombers with increased water-carrying capacity and speed.[67]
- **Novel fire retardants:** These include options such as water-enhancing gels that slow water evaporation and enable water to stick to vegetation[68] and those that are non-toxic and/or long-lasting.[69]
- **Aerial drones:** Drones are being tested for a number of uses such as aerial ignition for prescribed burns, scouting and inspection, impact assessment, logistics, search and rescue and clearing supply routes.[70] Drone technology can also be used beyond direct firefighting, such as inspection of remote telecommunication and power assets to direct maintenance and preparation efforts.[71] Integrating drones in firefighting will require regulatory changes that currently restrict their use.[72]

OUR OPPORTUNITY

As larger, longer and more simultaneous fires demand more from our firefighters and firefighting resources, close collaboration between states will be vital. There is a range of promising technologies to trial, adopt, scale and integrate into Australia.[73] Given the range of technologies and protocols that currently exist and compatibility and procedural challenges, new solutions will need to be carefully integrated into existing systems.

A helicopter fighting fires to protect a property in Balmoral, 150 kilometres southwest of Sydney – December 19, 2019. Photo credit: Peter Parks/AFP via Getty Images

WHAT NEXT?

The Fire Shield Mission aims to reduce the scale and impact of bushfires by being able to extinguish dangerous fires within an hour by 2025 in order to stop fires from becoming disasters.

To stop a fire from becoming a disaster and provide emergency services with the ability to put out a fire within an hour there are several things that need to be true. We need to immediately identify when and where fires are igniting. We need to provide that information in an accurate and timely fashion to enhance decision making. We need to know how the fire will behave in order to get one step ahead of it and understand which fires have the biggest potential to become disasters. We need to have the ability to extinguish the fire as quickly as possible, should we identify the need to do so.

Individually these elements will have some effect on our ability to mitigate large scale fire damage, but collectively they will reduce the risk of seeing fires at the scale of those seen in the 2019/20 bushfire season. We will work closely with emergency services, industry and researchers to facilitate and fast track piloting and testing of new technologies in the operational environment to give our emergency services the best opportunity to contain fires within an hour and reduce the potential for devastating impact by 2025.

We will know that we have achieved our goal when we see a measurable reduction in scale and severity of bushfires and the average time between bushfire ignition and response brings us within our one-hour target.

The Australia Flag flies under red skies from the fires in East Gippsland, Australia – January 04, 2020. Photo credit: Darrian Traynor/Getty Images)

RESILIENT COMMUNITIES

What if every community had the skills and resources to mitigate their fire and flood disaster risk and bounce back stronger?

Mission: lift Australia's 50 most vulnerable communities to be on par with Australia's 50 most resilient communities by 2025.

LEADERSHIP KNOWLEDGE RESOURCES INVESTMENT

Insight

Around one-third of Australia's population lives in highly resilient regions while nearly 50 per cent of Australia's population live in communities that have a low-to-moderate level of disaster resilience.[74]

As the climate changes, many communities will face more frequent fires and floods, and the effects of these will be even more widespread.[75] Across Australia, the resilience of communities to disaster is highly varied.[76]

Highly resilient communities tend to have healthy social fabric, diverse and vibrant economies, and robust built environments. This sets them up with strong coping capacity to prepare for and bounce back from disasters. They also have the institutions and networks to learn and adapt over time.[77]

Preliminary analysis suggests many regional and rural communities have lower levels of disaster resilience.[78] Today these communities are home to almost 5 million people and this number is expected to grow over the next decade.[79]

The Resilient Communities Mission will use this blueprint evidence base to identify outcome-focused targets for the following priorities:

Leadership
Empower and enable local leaders to develop and enact resilience plans.

Knowledge
Accelerate new models of resilience education, training and accreditation for generational change.

Resources
Simplify access to resources before, during and after a disaster event.

Investment
Accelerate new investment models to help shift the balance of investment from recovery to resilience.

A community-led but nationally coordinated approach will result in initiatives that are locally relevant and have the potential for wider outcomes across communities.

LEADERSHIP: ENABLE LOCAL LEADERS TO DEVELOP AND ENACT RESILIENCE PLANS

Our future in 2025: Every Australian community has created and enacted its own fire and flood resilience plan.

Communities that lead their own resilience plans are more successful in planning and preparing for potential disasters, and responding to and recovering from disasters if they occur.[80] Some inspiring examples have come to light recently of Australian communities that have actively come together to mobilise and rebuild post-disaster. Pre-disaster planning has the potential to play a valuable role too in preparation and prevention.

Strong community resilience plans are multi-dimensional and address the social, economic, natural and physical environment. They focus on how communities can safely coexist with fires and floods and take action to mitigate their effects.

A strong community resilience plan will help each community to:

Better understand disaster risk and plan for emergencies.
One way to save lives and reduce the costs of disaster damage is to provide communities with a better understanding of the disaster risks they face, so that they can put in place emergency plans that reflect and respond to those risks.[81] Communities can use forward-looking predictive models to understand how their natural hazard risks are changing, and plan and respond to disasters effectively. Effective plans are based on scenarios of possible outcomes.[82]

Prioritise the assets that are most important to them.
A clear view of what is most important to each community will guide planning, investment and actions before, during and after disasters. For example, for Strathewen in Victoria, the school was a vital part of the community:

> **It was extraordinarily important to give the children a sense of continuity and it was really important to give parents an opportunity to go and rebuild their lives.**[83]
> Member of the community – Strathewen, Victoria

For other communities it might be something of social or cultural significance. In Queensland, volunteer firefighters saved a roadside 'Christmas' pine tree that had been decorated by local communities for seven years.[84] A documented, prioritised list of local assets (such as historical, cultural, social, economic and environmental) can provide focus for community and emergency services efforts in responding to fire and flood disasters and building resilience.

Recovery pod construction in Adelaide, South Australia– 22 May, 2020.
Photo Credit: Minderoo Foundation Fire Fund Team

Foster community connection to improve social and mental health outcomes.
Well-connected communities are more effective at solving shared problems, which in turn improves their ability to understand risks, respond to crises, and recover from disasters.[85] Just one of many examples is The Channon, a small community in New South Wales, that has built cohesion and connectedness through village hall meetings, environmental activism groups and monthly food swaps. This helped the community come together to fight fires, build a plan for disaster resilience and, more recently, protect vulnerable people during the COVID-19 outbreak.[86]

Build a vibrant and diverse local economy.
Many areas in regional Australia rely on industries, such as tourism and agriculture,[87] that are vulnerable to disasters.[88] This reliance affects economic sustainability when disasters do occur, as well as communities' ability to invest in resilience.[89] Communities with a vibrant economic vision can stimulate job creation and attract government funding. For example, after the Black Saturday fires in 2009, the Victorian community of Marysville developed an economic vision that helped the community to mobilise AU$135 million of government funding and donations to revamp its nature-based tourism vision. [90] Disaster response can also support local economies by prioritising local contractors in disaster clean-up efforts. In responding to the Black Summer fires, Resilience NSW awarded 99 per cent of bushfire clean-up contracts to local or regional businesses, supporting up to 1000 jobs.[91]

Understand and manage the local natural environment.
Effective community resilience plans include a strong understanding of local land management, including local ecosystems, risks, intrinsic and economic value, and how to live within landscapes most effectively. Annual prescribed burns that target 10 per cent of at-risk land can reduce fire extent by up to 50 per cent, and a single prescribed burn can produce ongoing benefits for up to 20 years.[92] Understanding the natural value of landscapes will also inform how communities prioritise natural assets in their resilience plans.[93]

Sallianne with volunteers from the Turramurra Sikh Temple in Mogo, New South Wales – January 2020.
Photo Credit: Minderoo Foundation Fire Fund Team.

Adapt the built environment in line with the risk of disaster.

Communities can reduce the impact of disasters by:

- Applying integrated land use planning to locate, design and maintain physical structures to account for disaster risk.[94] Current planning regulations do not always prevent assets from being built in disaster-prone areas or compel people to re-locate. As hazard profiles change, land use planning and building standards will need to keep pace.[95]
- Building and retro-fitting the built environment to applicable standards.[96] Much of Australia's building stock was constructed before hazard safety standards were in place; for example, 74 per cent of homes burned in Black Summer were built before bushfire safety standard AS3959 was introduced in 1991.[97]
- Protecting critical infrastructure.[98] Infrastructure failures during disasters have a significant impact.[99] For example, in the Black Summer bushfires, 1400 telecommunications facilities were impacted at the peak of the fires,[100] resulting in outtages of four hours or more to around 27,400 fixed lines.[101] Critical infrastructure can be strengthened by removing it from direct exposure (e.g. underground power lines),[102] modularising (e.g. micro-grids), and investing in spare capacity (e.g. generator power). There is an opportunity to mobilise the knowledge and resources of the public and private sectors to help communities protect valuable local infrastructure that contributes to their resilience.

Communities need support to develop and enact resilience plans, and there is a growing number of initiatives focused on this. A strong community resilience plan requires a level of shared knowledge, community engagement, and local leadership in risk reduction, elements that are not always present in communities affected by disasters.[103] Providing communities with practical guidance and resources sets them up to create and implement effective plans based on shared responsibility.[104]

A number of global, federal and state-based programs have been created, to focus on boosting resilience and post-disaster recovery.

These include:

- The Resilient Cities Catalyst that continues the spirit of the Rockefeller Foundation funded 100 Resilient Cities project.[105]
- The National Bushfire Recovery Agency Assistance Program that provides recovery assistance for families, individuals, small businesses and primary producers.[106]
- Resilience NSW which supports communities in NSW in disaster recovery and building community resilience to future disasters.[107]
- The Victorian Bushfire Reconstruction and Recovery Authority (VBRRA) that has developed tools and resources for community-led recovery.[108]
- The South Australia Council of Social Service (SACOSS) – Disaster Resilience Project that provides practical resources, information, and tools to support communities in recovery and resilience efforts.[109]

OUR OPPORTUNITY:

We see an opportunity to partner with Government agencies and other organisations to support communities on the ground to build upon and extend existing community resilience-building initiatives. We can provide consistent frameworks that can be localised to each community, to help them build disaster resilience – from prediction and preparation to response and recovery.

The remains of burnt out buildings are seen along main street in the New South Wales town of Cobargo – December 31, 2019. Photo credit: Sean Davey/AFP via Getty Images

KNOWLEDGE: ACCELERATE THE CREATION OF NEW MODELS OF RESILIENCE EDUCATION, TRAINING AND ACCREDITATION FOR GENERATIONAL CHANGE

Our future in 2025: All Australians understand what resilience is and what they can do to build fire and flood resilience in their local community.

Knowledge of all aspects of disaster resilience will become increasingly important as communities face more frequent and widespread fire and flood events.[110]

Aspects of resilience range from disaster risk, to mental health and wellbeing, to vegetation characteristics and condition, to land management, to attracting investment in local infrastructure, as well as businesses, and recovery strategies. This knowledge will support communities to develop and execute their resilience plans.[111]

An incredible resilience knowledge base already exists within communities, individuals and organisations. Capturing, storing and sharing this knowledge – between communities, and between generations - will help to maximise the value from this knowledge over time. This can occur through formal education and training as well as less formal peer-to-peer knowledge sharing mechanisms.

Trusted technology enables exciting ways to capture, store and share resilience-related knowledge.[112] Technology is enabling new ways to inspire learning and connect people - and is particularly important in capturing the attention and the voice of youth.

Citizen science networks are examples of ways that technology can be used to create engagement on resilience-related topics. Data visualisation that connects the community to awareness of how responders operate within a fire and flood event allow the community to contribute and engage through web based technologies. Virtual reality is another example, with specific applications including Flood Action VR[113] and FLAIM Trainer.[114]

Insight

People-based networks will be important to building resilience knowledge. There are many examples in Australia and overseas of creating people-based networks to share experiences on flood and fire resilience. For example, in Victoria, Mallacoota's community-led recovery after the 2019-2020 fires was based on that of Strathewen a decade earlier.[115] Mallacoota flew in a member of Strathewen's working group to act as a mentor and share knowledge between the communities. An overseas example is the Fire Adapted Communities Learning Network (FAC Net) in the US which connects fire adapted community leaders and shares success stories and lessons learned through events, tools and resources. There is an opportunity to build on these and other frameworks to create more expansive networks that facilitate peer-to-peer learning and mentoring.

OUR OPPORTUNITY:

A community led, collaborative and systematic approach to building resilience knowledge – both formally and informally – will be an important factor in supporting Australian communities to understand fire and flood, to be aware of the role of fire and flood in natural landscapes, and to build community resilience.

RESOURCES: SIMPLIFY ACCESS TO RESOURCES BEFORE, DURING AND AFTER A DISASTER EVENT

Our future in 2025: Communities can easily identify and access the resources they need to build fire and flood resilience.

There is an opportunity to simplify access to resources for individuals and communities. Preparing disaster resilience plans and putting them into action takes a wide range of resources across the preparation, response and recovery phases. While these resources largely exist, they are not always easy for communities to find or access, especially during recovery when navigating complex systems can be a challenge.[116]

Six recent inquiries into disasters identified the need to simplify access to resources for individuals and communities. [117]

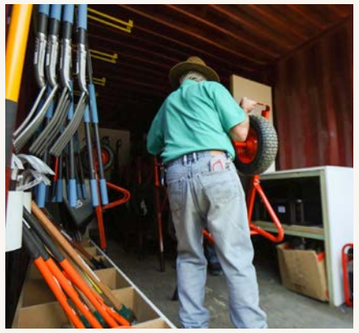
Insight

Accessing mental health support has been raised as a particular issue,[118] with an estimated 840,000 people in Australia without a psychologist registered in their principal area.[119] Telehealth is an emerging remote service model to provide regional and remote communities with disaster recovery support and was used for post-fire mental health services in 2020.[120] Access to mental health services can be streamlined as can the hand off points between mental health and wellbeing services.

TEMPORARY ACCOMMODATION PODS

A major need emerging from the Black Summer fires was temporary accommodation. Our innovative team at Minderoo Foundation designed, developed and created a construction process for the deployment of the recovery pods to be used as temporary housing by those who have lost their homes. The recovery pods are self-contained and equipped with a 2,300-litre water tank and 5 kVA generator. Internally, they have a toilet, shower, two bunk beds and a small open kitchen. As of August 2020, 182 pods have been delivered in 216 days to families in New South Wales and South Australia. Our commitment of AU$3.7 million was supplemented by AU$8.7 million from our partners which will ultimately enable 256 pods to be delivered in 259 days.

Recovery pod delivery and implementation. South Australia and New South Wales – March 2020. Photo credit: Minderoo Foundation



TOOL LIBRARIES

Minderoo Foundation has partnered with Lions International, the Tabulam Shed of Hope and a range of providers to supply tool libraries to regions across NSW. These libraries are stocked with a range of commonly needed tool items and some high value specialty equipment. Tools are loaned out in a library style system where access is given for a period to complete specific tasks. Instead of helping a small number of people in need, many are assisted by having access to the tools they need in recovery works, which are then returned for others to utilise in the future.

ACTIVATING EMPLOYMENT

With the help of a AU$200,000 commitment from Minderoo Foundation, BackTrack is boosting employment prospects and social outcomes, while supporting disaster recovery. The BackTrack Works program provides around 20,000 hours of paid work across over 300 projects each year.[121] BackTrack has helped to repair farm infrastructure in northern New South Wales after Black Summer. Out of BackTrack's broader program participants, 87 per cent subsequently move into full-time employment, training or education.[122]

SUPPORTING FARMERS

To restock the landscape, properties devasted by the Black Summer fires need to rebuild fencing across thousands of acres of land. A commitment of AU$250,000 to BlazeAid by Minderoo Foundation has enabled them to accelerate the rebuild by supplying BlazeAid in New South Wales, Victoria and South Australia with 10 new specialist fencing trailers.

MENTAL HEALTH TRAINING

Many with a mental health issue often fail to receive the support they need because their communities have not recognised the early warning signs they may be displaying. Minderoo Foundation is supporting Lifeline to provide specialised training to key community leaders and gatekeepers in Southern NSW to help them recognise these signs and help link people into getting the assistance they require.

Top: Lions Club volunteers working on one of the tool libraries. Photo Credit: Charbel Azar.
Middle: BackTrack Works team. Photo Credit: Minderoo Foundation Fire Fund team
Bottom: Volunteers rebuilding fences. Photo Credit: Paul Brown.

Case management can be an effective model to help individuals, communities and organisations navigate the various support services available to them.

Since the Black Summer fires, numerous resilience officer programs have been implemented to assist recovering communities via the National Bushfire Recovery Agency, Victorian Bushfire Rebuilding and Recovery Agency and Resilience NSW.[123] Not-for-profit organisations like Red Cross and The Salvation Army also seek to connect people with appropriate support resources.[124] This model has also been applied to offer pre-disaster community guidance, as seen with StormSafe NSW and 100 Resilient Cities.[125]

Disaster Relief Australia (DRA) and Minderoo Foundation volunteers – February 2020. Photo credit: Evelyn Soha, Disaster Relief Australia

Insight

In recent years, recovering communities have been heavily reliant on volunteers to help them rebuild and recover.[126] As disasters become more frequent and affect more areas, the demand for volunteers will only increase. Volunteer activation has the potential to play a larger role in helping communities to prepare for disasters. Volunteer activation opportunities could be directed toward creating jobs and upskilling people to help communities deliver specific resilience-building projects, as well as recovery efforts in a nationally consistent manner.

OUR OPPORTUNITY:

Improving community access to resources pre- and post-disaster involves many parties, from local, state and federal governments, to industry, non-governmental organisations, emergency services and communities. Achieving this will be a significant and high-value effort – and will require coordination at a local level as well as state or national levels, to ensure the right people have access to the right resources at the right time. It will also be enhanced with a consistent national approach to volunteer activation, with upskilling and credentials being transferable across volunteer organisations.

MOBILISING VOLUNTEERS

In a partnership worth more than AU$2.4 million, Minderoo Foundation is working with Disaster Relief Australia (DRA), formerly Team Rubicon Australia (TRA), to enable an army of volunteers to support their fellow Australians, as they respond to fire and flood emergencies. DRA comprises military veterans, emergency responders and motivated volunteers. To date, they have deployed over 2000 specialised volunteers into the field to help in recovery efforts in disaster affected regions and will continue to provide services in the future.

Minderoo Foundation and Disaster Relief Australia volunteers – February 2020. Photo credit: Evelyn Soha, Disaster Relief Australia

INVESTMENT: ACCELERATE NEW INVESTMENT MODELS TO HELP SHIFT THE BALANCE OF INVESTMENT FROM RECOVERY TO RESILIENCE

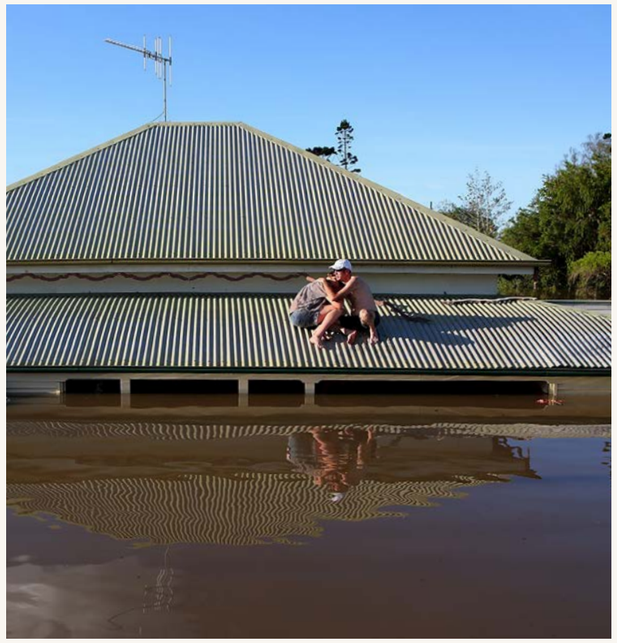
Our future in 2025: There is a strong demand for fire and flood resilience investments and insurance is available and affordable for all Australians.

Insurance helps individuals and communities to rebuild quickly after a natural disaster by recovering economic losses and reducing the social and financial costs of disasters.[127] Economic modelling of three Australian disasters indicates that insurance provided communities with stability after the initial shock and the economic stimulus from claims payouts promoted a more rapid return to normal economic activity.[128]

Underinsurance is also an issue in disasters; for example, in the 2010–11 floods in South-Eastern Australia, almost half the house and contents insurance policies did not cover flooding.[132] Climate-related 'uninsurability' – where the level of risk at a property results in insurance either being unaffordable or refused by the insurer – is rising. Around 360,000 properties are uninsurable, and this is expected to reach 445,000 within the next 30 years due to climate-related risk.[133] Governments are increasingly seeking solutions to address this with such as government-sponsored insurance pooling,[134] government-backed reinsurance,[135] and non-traditional insurance models to protect valuable assets against disaster risks.[136]

Insight

With more frequent and severe disasters, lack of insurance, underinsurance and uninsurability are rising.[129] Across Australia, non-insurance for homes is estimated at 11 per cent, and as high as 17–40 per cent in some areas.[130] More broadly, 60 per cent of total annual disaster costs are uninsured.[131]



A man comforts his daughter on their roof as they inspect damage to their neighbourhood as parts of southern Queensland experiences record flooding in the wake of Tropical Cyclone Oswald on in Bundaberg, Australia – January 29, 2013. Photo Credit: Chris Hyde/Getty Images

Innovative public-private partnerships are being created to encourage resilience investment.

For example, Blue Forest Conservation is partnering with the Rockefeller and Moore Foundations and World Resources Institute to offer Forest Resilience Bonds. Capital is used to invest in projects that protect forest health and mitigate the risk of catastrophic fire. Beneficiaries share in the costs, with modest returns provided to investors.[137] There are other examples where governments seek to stimulate resilience investments like the Queensland Housing Resilience Program co-funded cyclone-safe renovations, which reduced insurance premiums by 7.8 per cent.[138]

One particular challenge is quantifying the benefits of resilience investments and ensuring an attractive return for investors. Insurance Australia Group, National Australia Bank and CSIRO are piloting a Resilience Investment Vehicle to direct public and private finance towards built, social and natural infrastructure that builds community resilience to climate disaster and derives a return for investors.[139]

OUR OPPORTUNITY:

We need to shift the balance between investments in resilience versus recovery. We can support and amplify the efforts of insurers, governments and other organisations to explore new investment models. We can also find affordable and accessible solutions that incentivise behavioural change and protect life and property against fire and flood.

As part of this pilot, the Department of Home Affairs is sponsoring research to quantify the benefits from investments and assess public-private governance arrangements to promote resilience investment.[140] The pilot is a shared approach to applying diverse capabilities from financial services, science and government to address complex resilience challenges.[141]

King tides came within inches of inundating Cairns. The city reportedly spent $millions on new pumping stations that pump storm water out to sea in Cairns, Queensland - March 2010. Photo credit: Ashley Cooper/Construction Photography/Avalon/Getty Images

WHAT NEXT?

To lift resilience in Australia's most vulnerable communities, we will use our underlying evidence base, modelling and on the ground experience to understand the individual risks and needs of these communities. We will collaborate with government, philanthropies and other non-profit organisations under an agreed framework to facilitate upskilling and mentoring programs to support community leaders. We will work with prioritised regions to develop knowledge on disaster resilience and strategic planning term disaster resilience outcomes. We will work with our collaborators to facilitate the streamlining and sharing of information and resources to deliver on community-led resilience planning for as well as ensuring that support services that we have provided during bushfire recovery in the past are expedited in the future.

We will encourage our collaborators to contribute to resilience investments and outcomes to advocate for further investment and changes to insurance models to build disaster resilience across natural, built, economic and social environments.
We will advocate for new models of volunteering and community level support before, during and after disaster events. We will work closely with government and non-government collaborators to facilitate the sharing of knowledge on disaster resilience with all parts of the community, young and old, to ensure that disaster resilience knowledge becomes part of the Australian lexicon for generations to come.

In combination, these elements of the Resilient Communities Mission will increase long term resilience planning and action in communities that are most vulnerable to fires and floods. We will know that we have achieved our goal when the communities that we have worked with are comparable with Australia's 50 most resilient communities. Our measurement will be based on a consistent evaluation framework assessing exposure and vulnerability. It will be based on a combination of data inputs across health, social, environmental, built and economic dimensions in combination with the recently released Australian Disaster Resilience Index developed by the Bushfire and Natural Hazards CRC and the University of New England which measures coping capacity and adaptive capacity.[142]

Commissioner of the New South Wales Rural Fire Service Shane Fitzsimmons talks to members of the Rural Fire Service at Horsley Park Rural Fire Brigade on in Sydney, Australia – December 22, 2019. Photo credit: Jenny Evans/Stringer

HEALTHY LANDSCAPES

What if our environment was optimised for risk reduction and natural ecosystem resilience?

Mission: halve hazard exposure in Australia's 50 most fire and flood prone regions by 2025

LANDSCAPE KNOWLEDGE **LANDSCAPE ACTION** **LANDSCAPE INVESTMENT**

Healthy landscapes are intrinsically linked to resilient communities. Our relationship with landscapes needs to be adaptive, sustainable, and locally focused, to support our economy – especially through agriculture and tourism – and conserve and protect Australia's rich cultural, historical and natural value for future generations. Australia's forests also play an important role in capturing and storing carbon.[143]

Fire and flood are necessary for the health of Australia's landscapes. They are critical ecological processes that enable many of Australia's ecosystems to function, supporting regeneration and new growth. This important role of fire has been long understood by Indigenous peoples, who have used "rightway fire" to promote positive ecological and cultural outcomes for millennia.[144] Today, the increasing severity and frequency of fire and flood disasters threatens the delicate balance between the ability of fire and water to have a positive impact on the environment and the devastating ecological destruction they can cause.[145] Resilience-based active land management seeks to achieve this balance.

The Healthy Landscapes Mission aims to:

Landscape Knowledge
Work with others to build a national "living landscape" evidence base to better understand disaster risk and ecosystem needs before, during and after disaster events and develop interventions that target landscape and wildlife health and resilience.

Landscape Action
Implement locally adapted land practices which recognise both fuel load management and ecosystem needs and provide education, skill-building and job creation.

Landscape Investment
Support more standardised land measurement, monitoring and coordinated land management, making it economically viable and accessible.

Collaboration between landowners, Indigenous land management groups, governments, research organisations, conservation groups, financial institutions and investors will be pivotal and we will work to facilitate this.

LANDSCAPE KNOWLEDGE: KNOWLEDGE BASE

Our future in 2025: Individuals, communities and organisations understand their local landscapes, including their natural,cultural and economic value and how to live safely within them.

Insight

There is much we still must learn about Australia's landscapes. Landscapes are complex and unique. Many individuals and organisations are investing significant effort to better understand our local flora, fauna and ecosystems and their relationship to fire and flood. Despite this, we have an estimated knowledge base of just 25 per cent of Australian native species.[146] The various data sources that do exist are often fragmented, making it challenging to analyse and make decisions about different, complex ecosystems.

Different layers of information are required to inform decisions on resilience-focused land management practices and to support recovery after a hazard event.

These layers include:

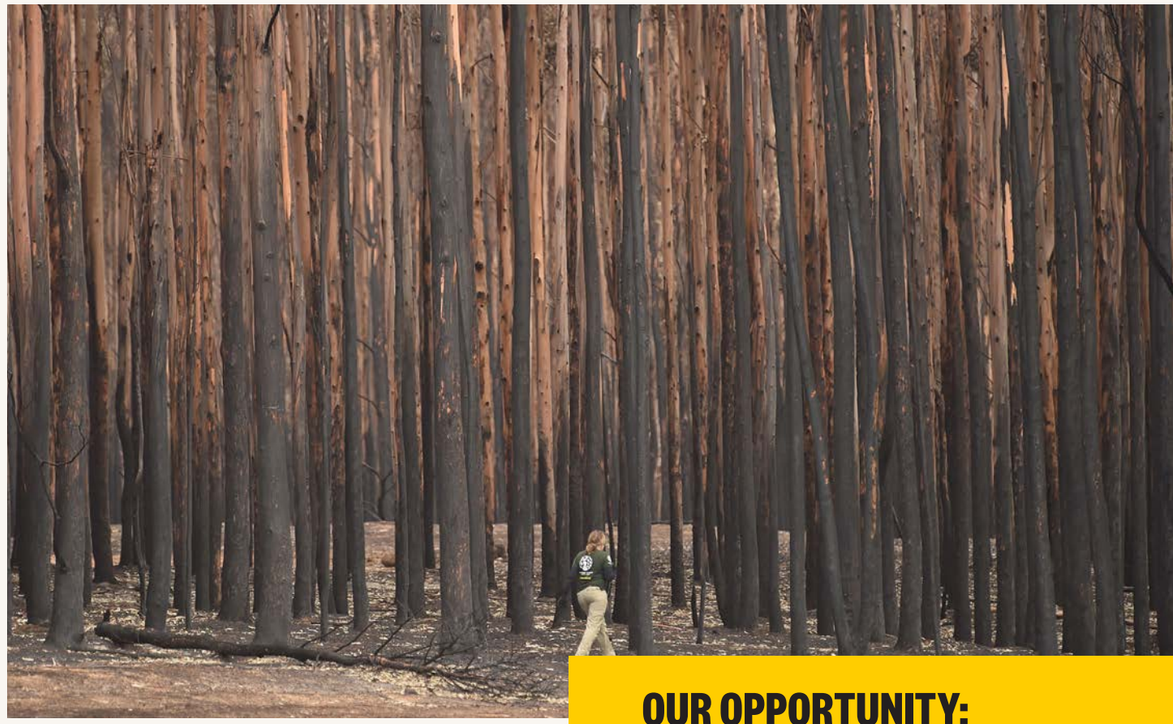
- The relationship of landscapes and species to surrounding communities and land uses.
- The characteristics of landscapes including their ecological value, economic value, cultural value, relationship to fire and flood, and the ecosystem services they provide.[147]
- History, including land and water management practices and previous damage from disaster events.
- Current condition, including soil characteristics and fuel load density that impact the likelihood and severity of fire and flood.[148]
- Methods to improve wildlife outcomes from fires through both preventionand recovery approaches.
- Current land management, water management and risk mitigation practices.

IMPROVING POST-DISASTER RECOVERY OF NATIVE SPECIES

With a commitment of AU$257,000, Minderoo Foundation is supporting research at The Australian National University Research School of Biology to understand the dietary needs of koalas as they are returned to the wild - and whether recovering landscapes will provide sufficient nutrition to sustain them on release.

The Australian National University research program, which is also supported by the NSW Government, has already established that koalas can digest new growth from some of the plants that form their usual diet. While helping koalas right now, it also builds our knowledge for long term resilience of our unique Australian wildlife and will improve the response to any future disasters.

Clinical Director Cheyne Flanagan tends to a koala named Paul from Lake Innes Nature Reserve as he recovers from burns at The Port Macquarie Koala Hospital in Port Macquarie, Australia – November 29, 2019. Photo credit: Nathan Edwards/Stringer



OUR OPPORTUNITY:

We can create a more comprehensive view of Australia's landscapes and wildlife and their relationship to fire and flood, through collaborative efforts that link existing data sources and add new sources. Information that is accessible, actionable and engaging will help to drive the widespread adoption of locally appropriate resilience-based land and wildlife management practices.

Technology will play an increasingly important role in our understanding of landscapes. Enhanced automated monitoring mechanisms provide new insights using AI-powered prediction and analysis, image capture and deep learning.[149] (e.g. Mayday.ai, CSIRO's Data61,[150] Global Forest Watch[151]).

Humane Society International Crisis Response Specialist, Kelly Donithan looks for injured wildlife in a burnt out eucalypt plantation on Kangaroo Island – January 15, 2020. On an island famed as Australia's "Galapagos" for its unique and abundant wildlife, rescuers raced to save rare animals in a bushfire-ravaged landscape. The charred forest floor on Kangaroo Island was reportedly littered with corpses of animals incinerated by the blazes that swept through two weeks prior. Photo credit: Peter Parks/Contributor via Getty Images

LANDSCAPE ACTION: LOCALLY ADAPTED

Our future in 2025: Land management takes a place based approach informed by a deep understanding of the local landscape and culture.

Communities are best placed to understand how to best manage local landscapes but require support to build knowledge and skills.

The dynamic nature of ecosystems means that each landscape is unique, complex and constantly evolving. Communities are best placed to understand their local landscape and share a vision and plan for the landscape in which they see themselves.

A recent independent inquiry following the 2019–2020 fires demonstrated the need to educate the community and organisations about their roles and responsibilities in managing vegetation to reduce hazards on public and private land.[152]

Valuing Indigenous knowledge, where there is a deep understanding and connection to the land, will promote better outcomes and strengthen the ties between our natural, social, economic and built environments.[153]

Insight

Cultural and prescribed burns could significantly reduce hazard levels.[154] Currently, over 70 per cent of Indigenous land management projects take place in the NT, Queensland or WA.[155] There is an opportunity to empower indigenous communities to apply their knowledge locally, particularly in southern states where hazard levels are expected to significantly increase in the coming decade. The benefits of improved land management through controlled burns, including cultural and prescribed burns, could be significant – preliminary analysis indicates that implementing controlled burns across Australia every year could reduce hazard levels by as much as 10 per cent on average and up to 18 per cent in south east Australia in the coming decade.[156] (Figure 2)

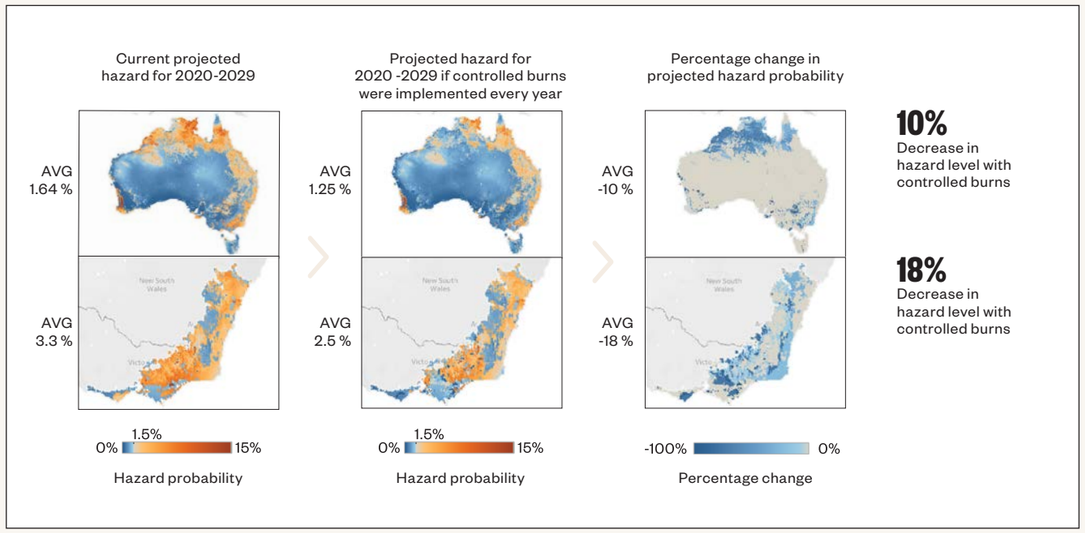


Figure 2: If controlled burns were implemented every year across south east Australia, hazard level could reduce by an average of 18% in 2020-2029[157]

High angle view of burning dry grass.
Photo Credit: Isabella Sthl via Getty Images

OUR OPPORTUNITY:

Locally adapted land management practices build sustainable landscapes. There is an opportunity to increase awareness and empower people, communities, industries and government to practice consistent and coordinated land management. Land management will reduce risk and make landscapes more sustainable.

KANGAROO ISLAND THREATENED SPECIES RECOVERY

Kangaroo Island Land for Wildlife is a conservation program that protects Australian threatened species most at risk of extinction, like the Endangered Kangaroo Island dunnart. With a commitment of AU$175,000, Minderoo Foundation has provided an accommodation pod for use as a field base in the remote North West of the Island; supported the purchase of specialised Felixer grooming traps which is new feral cat control technology used to reduce the biggest threat to Kangaroo Island's wildlife and has provided a purpose built all-terrain vehicle to conduct operations within the critical bushland habitats that support threatened species.

Kangaroo Island dunnart (Sminthopsis griseoventer aitkeni) taken by Brad Leue from Australian Wildlife Conservancy at the KI Western River Refuge where it has built a feral-free critical refuge. Photo credit: Brad Leue/AWC

LANDSCAPE INVESTMENT: ECONOMICALLY VIABLE AND ACCESSIBLE

Our future in 2025: Resilience-based land management is widely and consistently adopted because it is economically viable.

Financial viability is a challenge to widespread adoption of resilience-focused land management.

For publicly owned land, ongoing budget and resource pressures at state and federal levels limit the funding available to acquire[158] and manage ecologically valuable land.[159] Private landowners also need to make trade-offs between production conservation, and in the absence of financial incentives, conservation land management can appear to be a burden rather than an investment.

Innovative models and marketplaces will play a role in improving the viability of land management.

Government funding continues to be an important part of the solution to improving the economic viability of land management, and several governments have committed funds to private landholders to protect and conserve natural values on their land.[160] However, taking resilience-based land management to scale will require a longer-term co-investment approach in which economic, ecological and cultural outcomes are aligned and public good outcomes on private land are recognised and rewarded. The momentum behind sustainable and environmentally focused investing, such as forest resilience bonds and carbon farming, could be used to scale existing approaches and build innovative models and marketplaces.[161]

For example, the Carbon Farming initiative and emissions reduction fund in Australia's northern savannahs has contributed to Indigenous fire management becoming more economically viable and more widely adopted. This in turn has reduced the incidence of unplanned, out-of-control fires while also providing other secondary benefits to communities, such as reduced health costs, job creation, reduced welfare payments and increased community engagement.[162]

Encouraging investment in land and water management will require establishing consensus approaches to valuing the natural environment and the impact of damage to it, as well as being able to consistently measure baseline and changes due to efforts. The UN System of Environmental-Economic Accounting and the Natural Capital Coalition both provide decision making frameworks which integrate environmental and economic measures and dependencies.[163] These agreed standards offer consistent and comparable statistics and indicators for potential adoption on an international scale.

Insight

Increasing the extent of sustainable land management will require the creation and alignment of incentives through complimentary policy. Regulation will play an important role in creating and aligning incentives for land management, and maintaining the balance between empowering landowners to manage their land and protecting ecological values.[164] Examples in the current system suggest that private land owners may be unable to protect their properties due to insufficient fuel management on adjacent state-owned land.[165] In other examples, insufficient oversight has led to excessive land clearing, significantly reducing the resilience of the local landscape.[166]

While governance and regulatory mechanisms for land management exist across all Australian states, differences remain in the level of adoption and uptake of such practices and knowledge. Uptake of Indigenous land management practices is also influenced by regulation. For example, 73 per cent of Indigenous people recognise a homeland, but only 45 per cent can visit their homeland,[167] limiting their ability to manage lands that are not under native title.

OUR OPPORTUNITY:

Resilience-based land management practices have the potential to influence the risk of disasters. To encourage wider adoption, resilience-based land management practices will need to be economically viable, enabled through regulation, and supported with resourcing.

We can use technology to learn about the relationship between the Australian landscape, and fire and flood.

Ongoing, near-real-time monitoring, and analysis will improve the viability of land management and help us to understand the landscape's dynamic response to hazards. Making landscapes more resilient requires decisions based on a system view of evidence, and the ability to analyse how natural systems are responding in near-real time. This approach can be supported by integrating technology, including autonomous systems, imaging and sensors, with on-the-ground assessments.

Aerial view of Australia's bush fire destruction. Photo credit: Mikulas1

WHAT NEXT?

To reduce hazard exposure in Australia's 50 most fire and flood prone regions, we must first truly understand our landscape risk exposure and the nuanced needs of our unique flora, fauna and ecosystems.To this end, we will work closely with communities, government, conservation organisations and research and innovation communities to support new ways of measuring, building, sharing and standardising data which represents our collective knowledge of landscapes.

To reduce the exposure of our landscapes to disaster risk we must ensure that we are reducing fuel load while maintaining a healthy environment for our native species.

We will work closely with conservation organisations and Indigenous communities to support and build evidence for both new and traditional methods of landscape management for risk reduction and ecosystem health. In order to make land management economically viable we need to assess and monitor intervention outcomes in a consistent and automated way that will provide deeper insights and the foundation for new types of investment.

We will work with land managers and the innovation sector to incorporate new sensing technologies aimed at understanding and monitoring the landscape at an unprecedented level of detail. We will facilitate and encourage new investment in consistent, evidence based and locally led land and water management practices for risk reduction and ecosystem health.

Together, these elements of the Healthy Landscapes Mission will provide the evidence base and investment needed for long term disaster resilience of our unique ecosystems. We will know that we have achieved our goal when see a 50 per cent reduction in environmental exposure risk in the regions that we have worked in. This will be assessed using a hazard risk model which produces average fire and flood hazard probability metrics based on historical fire observations, temperature and rainfall projections, bioregion and land cover data and historical land management outcomes.[168]

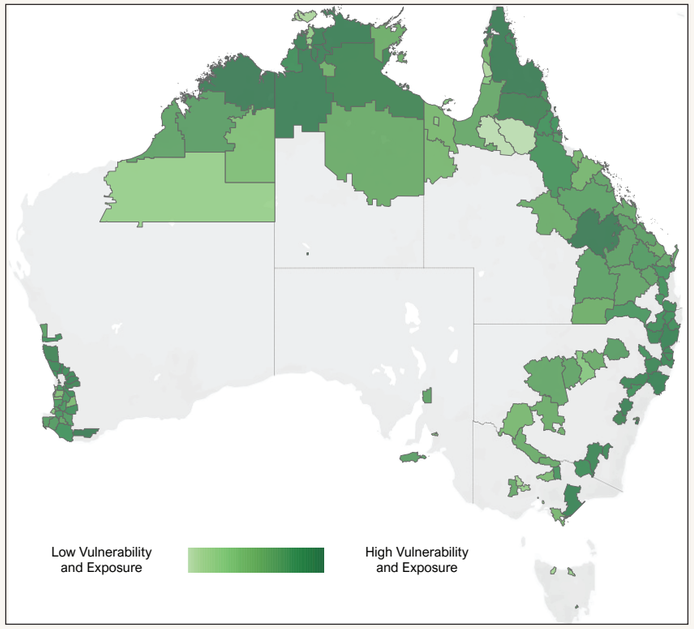


Figure 3: Based on modelling of projected weather patterns, over the next decade, approximately 30 per cent of Australia is expected to be exposed to increased fire hazard putting vulnerable flora and fauna at risk.

BUILDING A FIRE & FLOOD RESILIENCE DATA COLLECTIVE

Our future in 2025: We have a common trusted system for sharing significant national and global fire and flood resilience data to support decision making and action.

There is a wealth of data and knowledge available collectively across the disaster response, emergency management, research and public and private sectors of the ecosystem which is spread across multiple jurisdictions and private sector stakeholders. It creates a fragmented view of national capabilities and impact. It is imperative that we transform that data and knowledge into trusted information and insights that we can collectively leverage and act on to address future hazards.

Previous inquiries and Royal Commissions into natural disasters – including the Royal Commission after the Black Saturday Fires in 2009, the Royal Commission after the Black Summer fires in 2020, and work by the Productivity Commission, the Insurance Council of Australia, and the Department of Home Affairs in 2020 – have highlighted how disaggregated data leads to variation in how data is formatted and integrated. Addressing this challenge requires cooperation, agreed definitions, standards and sharing protocols and an investment of time, resources and capabilities.

Data-sharing models, such as those currently used by the Australian government, could be translated to facilitate information-sharing across private-public partnerships, through promoting the reuse of data, building trust and engaging communities, while increasing the availability and transparency of data.[169]

A data commons is a way to bring together disparate, but related data sets to enable stakeholders. There are notable examples where the concept of a data commons has created significant value such as the Australian Research Data Commons and the NIH National Cancer Institute Genomic Data Commons; both of which have enabled significant breakthroughs through the sharing of data for research and analysis.

However, no data commons currently exists for the purpose of investing in disaster resilience. Creating a public–private partnership to enable data sharing across jurisdictional boundaries while maintaining the commercial interests of industry stakeholders; and the privacy, security and integrity of public data is a high value opportunity. There is a tremendous amount of value potential to be created by bringing data custodians across the ecosystem together to combine related, but currently disparate datasets.

We are uniquely placed to enable the ecosystem in collaboration with a growing group of partners with on-the-ground experience working with fire and flood affected communities.

Our Resilience Data Collective program is focused on developing a framework for shared intelligence to build fire and flood resilience and will support creation of standards for interoperability, common measures and establishment of baselines; the commons will help create targeted and macro level outcomes that lift national resilience.

Our goal is to develop:

- An ecosystem of partners sharing standardised and relevant high value data into the commons.
- A community of data analysis and reporting capabilities to inform decision making for enhanced fire and flood preparedness, response, recovery, and overall resilience.
- A shared secure infrastructure that supports data collection and coordinated rapid response across organisations and jurisdictions.

Building the evidence base is a collaborative endeavour to guide resilience investments and measure their impact. The data, standardisation, analysis and measurement in this evidence base will guide the Resilience missions, allow partners to share information, and provide progress indicators on how the missions have contributed to a more disaster-resilient Australia.

STRATEGY

1. Establish an evidence base and data analysis tools to inform and support the Minderoo Foundation Fire and Flood Resilience Initiative missions and mission partners.
2. Create an open consortia for collaboration in a data common for the sharing of data to lift whole of ecosystem capabilities to enhance prediction, detection, response and overall resilience to fire and flood.
3. Establish standards for data sharing and trusted interoperability, creating progress measures that baseline current capabilities and validate macro level shifts.

This work will require an ability to scale and will build a critical mass as the number of partners and data availability increases.

We will activate and work with partners to contribute data sources and collaborate to build, operate or maintain technology platforms.

Our intent is to evangelise the need for a data commons for fire and flood resilience and work with the ecosystem to establish a shared framework across the key stakeholders to deliver the components necessary. We will leverage the Resilience Data Collective to provide the necessary insights and decision support to identify risks, exposures, vulnerabilities and provide insights to guide direction of investments to build resilience.

DATA AND ANALYSIS TOOLS

Our work in building this blueprint has created analysis tools that integrate data sets from over 20 public and private organisations, including the International Union for Conservation of Nature (IUCN), NASA, Climate Data Store, Bureau of Meteorology, Geoscience Australia and the Bushfire and Natural Hazards CRC as well as many contributing partners. The data relates to hazard, exposure, vulnerability and resilience to ensure mission priorities are grounded in data and an evidence base.

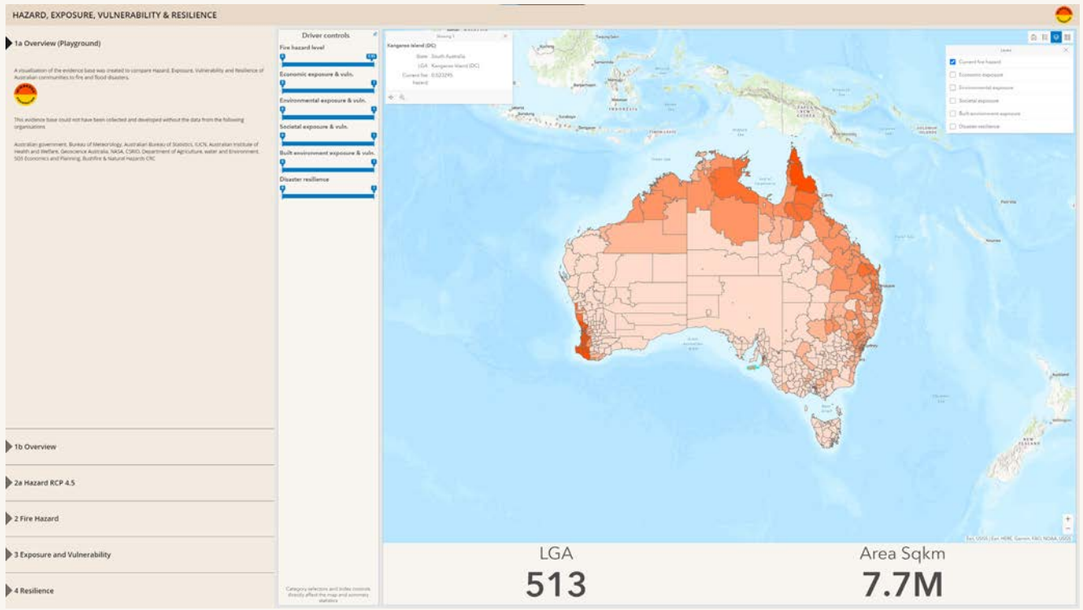


Figure 4: A model of hazard, exposure, vulnerability and resilience has been designed using data inputs from Australian Government, Bureau of Meteorology, Australian Bureau of Statistics, International Union for Conservation of Nature, Australian Institute of Health and Welfare, Geoscience Australia, NASA, CSIRO, Department of Agriculture, Water and Environment, SGS Economics and Planning, and the Bushfire and Natural Hazards CRC.

Case Study

INSURANCE COUNCIL OF AUSTRALIA DATAGLOBE

The ICA DataGlobe is an industry resource that collates together available hazard and mitigation information across Australia. The data is predominantly collected from local and state governments on a voluntary basis. Data can be visualised by approved users of the system to provide insights into the impacts of hazards in a particular location or to engage with communities concerned about hazards, insurance premiums and risk mitigation. Hazard information covered includes earthquake, cyclone, extreme rainfall, flood, storm surge and bushfires.

An example of the breadth of DataGlobe's data holdings is its records of identified flood risk for 14.1 million addresses in Australia – including addresses with no known flood exposure, addresses with known or mapped flooding and addresses that are flood exposed with unknown or unmapped severity.[170]

Smoke covering wide areas from fires around Shark Creek and the Yuraygir National Park by Bees Nest in Northern New South Wales, Australia – 8 September 2019.
Photo credit: Orbital Horizon/Copernicus Sentinel Data/Gallo Images via Getty Images

Case Study

THE AUSTRALIAN DISASTER RESILIENCE INDEX

The Bushfire and Natural Hazards CRC has developed The Australian Disaster Resilience Index in partnership with the University of New England. The index is the first national snapshot of disaster resilience to help governments, local organisations and emergency services improve their communities' resilience to natural hazards. It provides a nationally standardised index of resilience, drawing on 77 indicators from dozens of data sources.

The index was launched in July 2020 after six years of development. It is presented as an interactive website with navigable maps of regions across the country and is intended to provide input into macro-level policy, strategic planning and community engagement activities at national, state and local government levels.[171] Our insights for the Fire and Flood Resilience blueprint and our mission evidence base were built on the Bushfire and Natural Hazards CRC Australian Disaster Resilience Index in addition to other publicly available datasets.

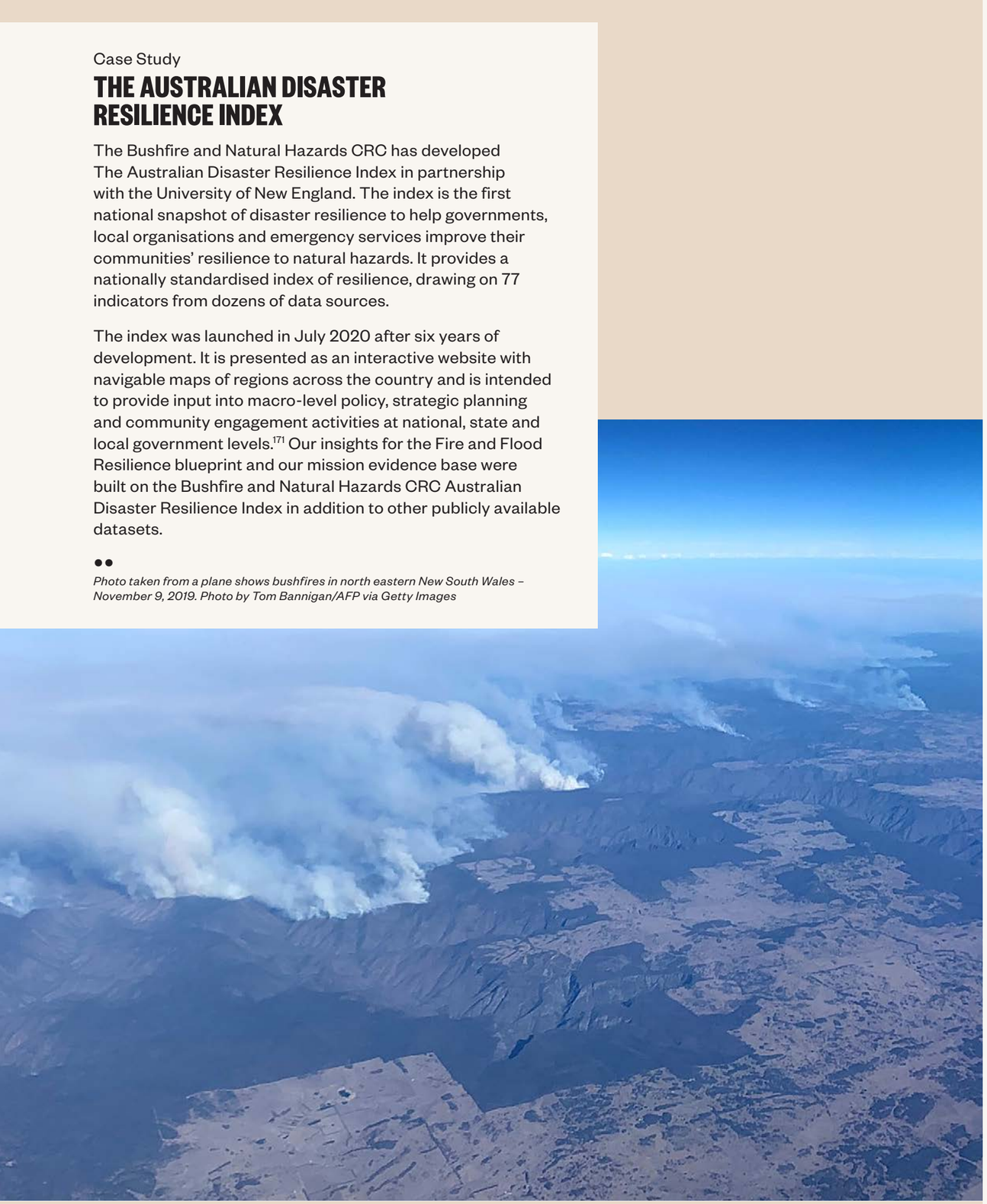


Photo taken from a plane shows bushfires in north eastern New South Wales – November 9, 2019. Photo by Tom Bannigan/AFP via Getty Images

MOBILISING FOR MISSION DELIVERY

There has never been a more important time to lift national and global resilience in the face of fire and flood disasters. It will take a national effort to make this happen. Minderoo Foundation is ready to be part of the solution. We are ready to work with partners across all parts of the ecosystem to deliver change for Australia.

We have defined an evidence based work plan to help Australia to become the global leader in fire and flood resilience by 2025, through national missions with global relevance. Minderoo Foundation's role in this is as an enabler to link activities and align with partners to build on work already underway while maintaining a clear focus on outcomes. Our priority is scaled impact.

The missions focus on ambitious quantifiable objectives that require a level of coordination with a wide range of actors in research, technology, government and not-for-profit organisations. We are applying a growth mindset and linking up with our partners to solve parts of the problem that we and they are each uniquely suited to solve.

Missions will be grounded in data, evidence and on the ground insights and will have clear milestones, stage gates for delivery and measures of success.

The Fire and Flood Initiative sits within the national innovation system, playing a pivotal role for lifting wildfire and disaster resilience. While parts of the missions will require new science and technology approaches, the end user and solution focus will mean that the missions will also seek off-the-shelf solutions where appropriate. Our key role is that of an enabler, bringing together capability and providing translation and development opportunities. Community-led activities and adjacent pools of capital will also be accessed, where possible, to speed response and scale impact. The Technology Readiness Level (TRL) scale, developed by NASA,[172] will be used to assess the readiness of individual technologies that may be required for the delivery of parts of missions.

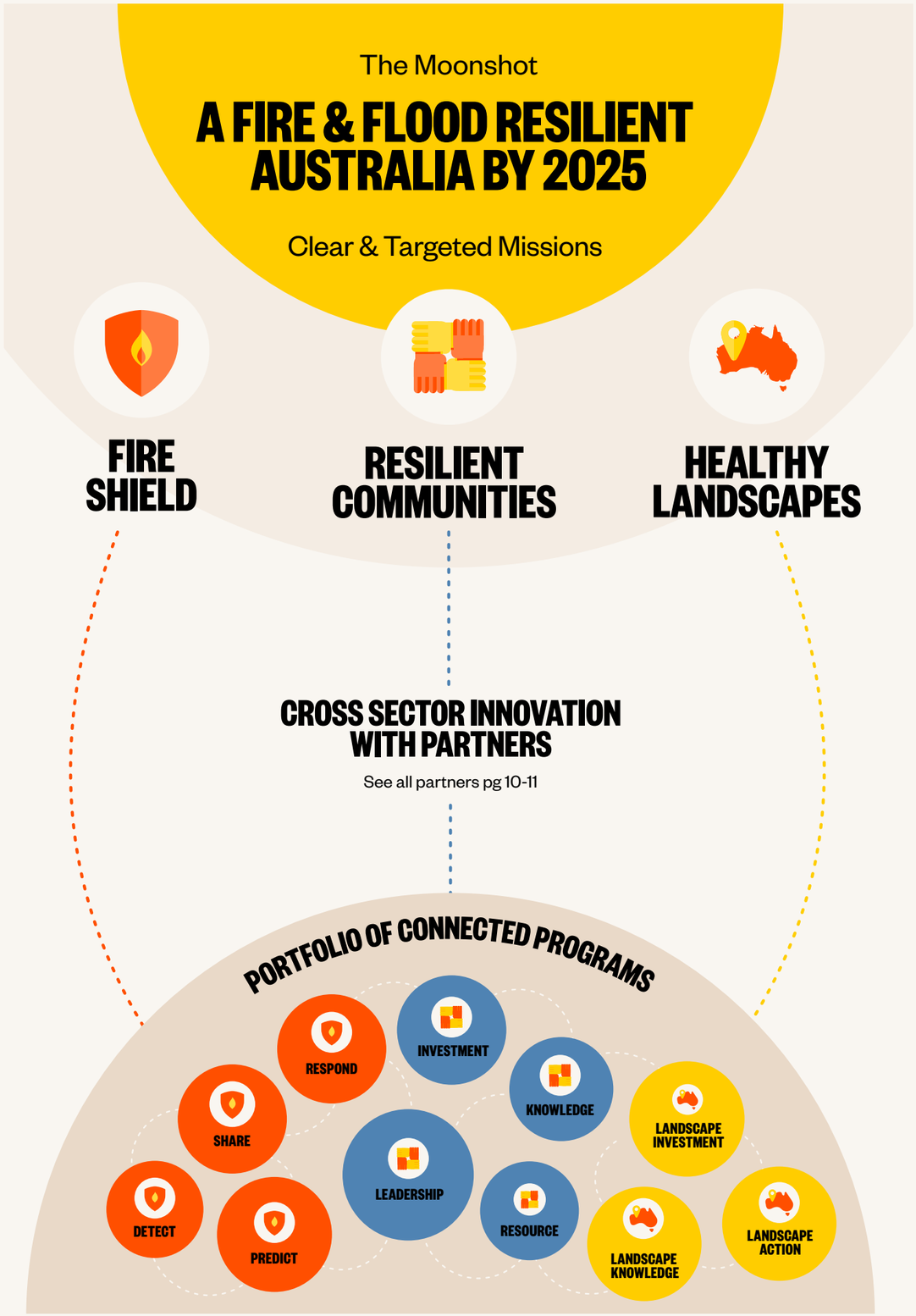
As we move toward the next phase of the program we will engage further with our partners representing communities, industry, government, non-profits and the research sector to:

- Refine and build on the evidence base for each mission.
- Identify the nature, scale and timing of additional partner engagement and input into missions.
- Determine additional project elements for mission delivery in consultation with partners.
- Implement, monitor and drive outcomes.

If you would like to get involved, please contact us at: resilience@minderoo.org

National Innovation System	TRL 1–4 Research & Feasibility Testing	TRL 4–7 Translation & Technology Development	TRL 8–9 Operationalisation and Scaling
Role	**R&D, science & tech** Primary research and technology developers	**Impact capital & missions** Concessional capital ready to take on project and technology risk, bringing together application providers and scaling them ready for public and private sector use	**Adjacent capital** Impact investing Use of data and proven applications for resilience-building in private organisations **Public good projects** Further roll-out of public good applications with high resilience impact
Example Parties	• Government-funded research programs (CSIRO, CRCs) • University research and incubators (eg: climate & biotech hubs) • Private sector hubs & start-ups (eg: Fire Tech Hubs)	• Philanthropy • NGOs • Industry • Government • Research organisations • Impact investors	• Funds management • Leading global investors • Industry • Government

Minderoo Foundation Fire & Flood Resilience target space



FIRE & FLOOD RESILENCE BLUEPRINT WORKING GROUP

Minderoo Foundation collaborated with Boston Consulting Group in the development of this blueprint.

We would like to thank them along with members of our blueprint working group for their contribution:

- Allianz
- Australasian Fire and Emergency Service Authorities Council
- Australian Academy of Science
- Australian Energy Market Operator
- Australian Red Cross
- Boston Consulting Group
- Bow Capital
- Bushfire and Natural Hazards Cooperative Research Centre
- Commonwealth Bank of Australia
- Conservation International
- Department of Agriculture, Water and the Environment
- Firesticks Alliance Indigenous Corporation
- Fortescue
- Geoscience Australia
- Insurance Australia Group
- Insurance Council Australia
- International Union for Conservation of Nature
- Movember Foundation
- Munich Re
- National Australia Bank
- National Bushfire Recovery Agency
- Optus
- Risk Frontiers
- Suncorp
- Telstra
- The B Team Australia
- The Nature Conservancy
- The Salvation Army
- Wesfarmers
- Westpac
- World Wide Fund for Nature-Australia

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Weather factors including maximum daily temperature and daily rainfall sourced from the Bureau of Meteorology (http://www.bom.gov.au/climate/data/) averaged monthly to establish consistency with average monthly weather projections sourced from the Climate Data Store (https://cds.climate.copernicus.eu/cdsapp#!/dataset/projections-cmip5-monthly-single-levels?tab=form)

Geographic factors including the land cover type and bioregion classification of each grid location, sourced from Geoscience Australia (http://www.ga.gov.au/scientific-topics/earth-obs/accessing-satellite-imagery/landcover) and the Australian Government respectively (https://www.environment.gov.au/land/nrs/science/ibra).

Historical fire occurrence observations sourced from MODIS and VIIRS satellite data from NASA (https://firms.modaps.eosdis.nasa.gov/download/)The Exposure & Vulnerability model incorporates data on:

Residential properties from the Australian Bureau of Statistics (https://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/2074.02016?OpenDocument) and Geoscience Australia NEXIS (https://data.gov.au/dataset/ds-ga-983acc5d-59b4-4c41-a1a7-660f32993aea/distribution/dist-ga-983acc5d-59b4-4c41-a1a7-660f32993aea-0/details?q=exposure)

GVA by industry from SGSEP (https://www.sgsep.com.au/publications/insights/gdp-report-economic-performance-of-australias-cities-and-regions)

Flora and fauna from IUCN (https://www.iucnredlist.org)

Land from the Department of Agriculture Water and Environment: CAPAD (http://www.environment.gov.au/fed/catalog/search/resource/details.page?uuid=%7B4448CACD-9DA8-43D1-A48F-48149FD5FCFD%7D)

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Built environment from Geoscience Australia: NEXIS (https://data.gov.au/dataset/ds-ga-983acc5d-59b4-4c41-a1a7-660f32993aea/distribution/dist-ga-983acc5d-59b4-4c41-a1a7-660f32993aea-0/details?q=exposure)

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