



Australia's National  
Science Agency

# Preparing Australia for future extreme bushfire events

Delivering science and technology to reduce the impact  
of fire on Australia's people, environment and economy





CSIRO bushfire expert Justin Leonard conducts bushfire behaviour experiments in the field.

# Creating a bushfire ready nation

CSIRO is Australia's national science agency and a trusted advisor on fire prediction, management, behaviour and recovery.

For almost 70 years we have been working collaboratively in bushfire-research, from understanding and modelling impact of bushfires on the environment to post-fire assessments and improving infrastructure design.

Our scientists are developing reliable tools to predict bushfire behaviour, and advance fire spread prediction and bushfire suppression systems. We train all state fire agencies in fire behaviour and prediction and use world-class facilities and models to understand and manage fires under future climate conditions.

CSIRO was the first agency internationally to link an increase in bushfire weather severity to climate change in 1988. Our research and practical resilience measures in relation to bushfires and climate change are more important than ever before as Australia faces continued extreme fire weather into the future.

As a multidisciplinary science agency, CSIRO draws on a wide range of expertise to understand, predict, and manage fires and support recovery, rehabilitation and resilience.

Solving the nation's biggest challenges like increased extreme fire weather cannot be done alone.

CSIRO works with rural fire agencies and other research agencies so our scientists can apply knowledge of ecosystem and bushfire dynamics to real events. These partnerships enable CSIRO to share its bushfire research with the wider community.

We also work with state fire authorities to predict, manage and assess the impacts of bushfires. Predictions conducted using CSIRO research and expertise have been critical to timely identification of potential impacts and issue of emergency warnings.

Whether it's state fire agencies, Traditional Owners, government, business or a community in need, we are here to help. We apply cutting edge science and technology to deliver material benefit to Australian communities.



Working with other agencies to study bushfire behaviour at Ipswich in 2017.

# A proven record in bushfire research and providing expert advice

CSIRO is involved in a range of bushfire-related research, including:

- understanding and predicting bushfire behaviour
- developing prediction and fire data analysis tools
- impact of bushfires on infrastructure
- disaster management
- ecological responses to fire
- Indigenous fire knowledge and practice
- pollutants and greenhouse gases as a result of bushfires
- smoke forecasting for bushfires and prescribed burns
- building community resilience and risk management
- reducing impacts in the face of disasters
- preparing for climate change and extreme events
- investigating and reconstructing major wildfire events to aid learning and model development.

CSIRO has performed post-bushfire surveys since the 1940s. In addition to our array of other bushfire research, this in-the-field work provides invaluable information on how fires start, what influences their spread, how they impact buildings and how they can be stopped. Through this work, CSIRO developed the Forest Fire Danger Index in 1967, which, even today, forms the basis of Australia's fire-risk warning system.



Research Scientist with the CSIRO Land and Water Bushfire Behaviour and Risks group, Matt Plucinski, conducts out-door fire experiments.

We provide regular advice to governments to help with policy decisions

Following the 2019–20 Australian bushfire season, the Australian Government called on CSIRO for help to deliver practical resilience measures in relation to bushfires and climate change. We were tasked by the Prime Minister to deliver a report to Australian governments on climate and disaster resilience, working with an Expert Advisory Panel led by Australia's Chief Scientist Alan Finkel.



An abandoned car sits among the ash as a reminder of the Kosciuszko fire, Snowy Mountains. Pictured on the shores of Jounama Pondage, January 2020.

# National science agency delivering impact

Bushfire research involves working in partnership with different levels of government, the private sector and communities. Our research areas and bushfire-related projects are helping Australians better understand and respond to a changing climate and environment.

## Bushfire behaviour and risks

The Bushfire Behaviour and Risks team focuses on the study of the behaviour of bushfires and the development of systems to predict their spread and behaviour. CSIRO trains all state agencies in fire behaviour and prediction, and has world-class facilities and models to understand, predict, and manage fires under future climate conditions.

Predictions conducted by agencies using CSIRO's suite of models have been critical to the timely issue of emergency warnings.

## Spark

CSIRO is working on better detection methods, enhanced fire spread simulation models and suppression effectiveness models. When these are linked into a single modelling environment (Spark), they allow agencies to prioritise efforts to suppress new and running fires according to their potential to cause loss.

Spark, developed by CSIRO's Data61, is a state-of-the-art fire spread simulation framework for simulating the spread of fire across the landscape and is used by NSW, SA, QLD, VIC and Tas fire authorities.

## National bushfire life and house loss database

CSIRO has compiled a comprehensive dataset of the life and house loss during bushfires from 1900 to 2018. The database forms the basis of many advice guides and warning systems by the Australasian Fire Authorities Council (AFAC), the peak Australasian body for the fire and emergency services, and various fire agencies. It has influenced the timeliness and targeting of messaging in recent fire events.

## Emergency Situation Awareness

Data61's Emergency Situation Awareness (ESA) software provides situation awareness by using data mining techniques on Twitter to detect when disaster events, such as fires, are being broadcast on social media, and alerts users. ESA also stores complete Twitter stream information, allowing for post-event analysis.

Such useful and accessible information can provide timely situation awareness for disaster managers and emergency response agencies, allowing them to prepare their responses prior to receiving official confirmation of an event.



Our post-bushfire teams have used standard post-bushfire surveys since the 1983 Ash Wednesday fires in South Australia. Pictured right is CSIRO bushfire expert Justin Leonard.



CSIRO testing of firefighting vehicles to support development of crew protection systems.

## Sentinel Hotspots

Sentinel Hotspots is an internet-based satellite mapping system hosted by Geoscience Australia (GA) which provides emergency service managers access to the latest fire location information using satellite data collected up to three times a day. Since it was launched in 2003, firefighting organisations in all Australian states have used this tool to identify and zoom in on fire hotspots. This formed part of the early warning system for fire agencies and community during the 2019–2020 fires. The system was developed by CSIRO in collaboration with Department of Defence and Geoscience Australia.

## Fire tanker protection systems

Burnover-protection systems for Victorian crew-cabs have been developed in collaboration with CSIRO over 20 years and are now fitted as a standard requirement in all Victorian fire trucks. NSW and WA fire departments are also developing prototypes using this knowledge base.

The impact of these protective measures for fire trucks was demonstrated in the 2009 Black Saturday fires in Victoria when 12 fire trucks were impacted by fire and their crews emerged safely with no loss of life. These protection systems continued to provide crews with increased safety in subsequent fires including the 2019–2020 bushfires.

## Post-bushfire surveys

Our post-bushfire surveys and research provide invaluable information on how fires impact buildings and communities. Our bushfire scientists visit non-active fire zones to survey damage and gather data. This research effort has underpinned extensive policy and regulatory development and reform for building design, planning and education through various fire agencies and other state agencies.

## The CSIRO Pyrotron

This is a 25-m-long combustion wind tunnel designed, built and operated by CSIRO to enable the safe and repeatable study of the behaviour and spread of fires. This facility at the CSIRO Yarralumla site, Canberra allows statistically robust investigation of the processes of flame propagation in a range of bushfire fuels from grass, to forest litter, to small shrubs. Published results include analysis of greenhouse gas emission as a function of fire behaviour and spread mode and investigation of fire growth and acceleration.

## Full scale house burnover experimentation

CSIRO has conducted a series of full-scale house burnover experiments to assess the viability of conventional and novel building systems in a bushfire situation. This work has resulted in various building design innovations including an approved eco-house design and the development of a national bushfire building standard adopted by the National Construction Code in 2015. These codes have influenced a significant number of houses built since their adoption.

## Personal Bushfire Shelter (PBS) experimentation and advice

CSIRO has played a key role in providing technical support and scientific input to ensure the guidelines and regulatory systems for personal bushfire shelters are effective and reliable. Following the 2009 Victorian fires, the Victorian Building Authority engaged CSIRO to provide science input to support the development of policy guidelines around the use of personal bunkers for bushfire protection.



An example of an accredited bushfire bunker before being installed in the ground.



Experimental fire in CSIRO's Pyrotron. Scientists study ignition shrub fuels from surface fire.

## Protecting fire crews and assets

- *Training* – a firefighter safety training package was created by Western Australia's Fire and Emergency Services Authority, Department of Conservation and Land Management and CSIRO. CSIRO fire behaviour scientists helped to develop a training course for fire behaviour analysts and regularly trains first responders.
- *Firefighter health* – CSIRO has worked with state fire agencies to assess firefighter smoke and toxic air exposure while firefighting. This work has led to changes in the operating procedures and personal protective equipment specifications for firefighters across the nation.
- *Cars trapped in firestorms* – CSIRO evaluated the maximum heat load that a vehicle could face while remaining a safe haven for its occupants, in terms of both air temperature and air quality inside the vehicle. This research was used by AFAC (national council for fire and emergency services) to refine their policy documents on guidance for people caught in vehicles during bushfires.
- *Weather forecasting* – CSIRO has improved our ability to forecast bushfire weather that affects bushfire spread behaviour and this has been adopted in Bureau of Meteorology (BOM) operations.



## Smoke forecasting for bushfires and prescribed burns

CSIRO has worked with Victoria's Department of Environment, Land, Water and Planning (DELWP), the BOM, and the university sector to develop a tool that is being used to help manage smoke exposure from prescribed burns and bushfires.

AQF<sub>x</sub> (the air quality forecasting system) is run operationally by BOM and uses a fire spread model to calculate smoke emissions from ongoing fires and planned burns. Wind-blown dust and urban sources of pollution are also included in AQF<sub>x</sub>. The transport of smoke by the wind is forecast using the meteorology from BOM's ACCESS weather forecasting system.

Our research has led to the adoption of AQF<sub>x</sub> by land-use agencies in Victoria and NSW to aid in smoke management from prescribed burning and issue targeted health warnings when needed. AQF<sub>x</sub> has also been used to forecast smoke exposure from bushfires, with this information being made available to the emergency management centres and the state environment protection authorities. This capability has been extensively used since 2016. Forecasts provided by AQF<sub>x</sub> in 2019–20 were used in Victoria and NSW to anticipate hazards to health, aviation and Australian Defence Force operations. A national rollout of AQF<sub>x</sub> (endorsed by AFAC) is being planned to ensure that advanced warnings of community exposure to smoke from vegetation fires are available for all Australians. The smoke forecasts will also be applied to other industries such as agriculture (e.g. viticulture) and solar photo-voltaic systems.

**A suburb in a smoke haze. Sydney, 4 December 2019. Source: Shutterstock.**



## Fire safe material

Several fire safe materials have been developed, including pre-cast concrete panel technology (HySSIL) that is fire resistant for four hours. These new materials can be utilised as fire-proof insulative building materials in fire shelters, bunkers, sheds and panic rooms.

Fire resistant coatings based on inorganic polymers have also been trialled to provide improved fire protection for timber products used for construction and furniture.

## Testing and evaluation of construction products

We conduct laboratory testing and assessment of materials, elements of construction and systems in accordance with Australian requirements for the construction of buildings in bushfire prone areas. We also provide large scale evaluations for buildings exposed to radiant heat and large flaming sources for bushfire attack levels up to the flame zone.



Testing on a small scale for radiant heat exposure for building materials. CSIRO, Clayton site, Victoria.



Large scale AS1530.8 test for buildings exposed to bushfire attack (radiant heat) at CSIRO, North Ryde site, NSW.

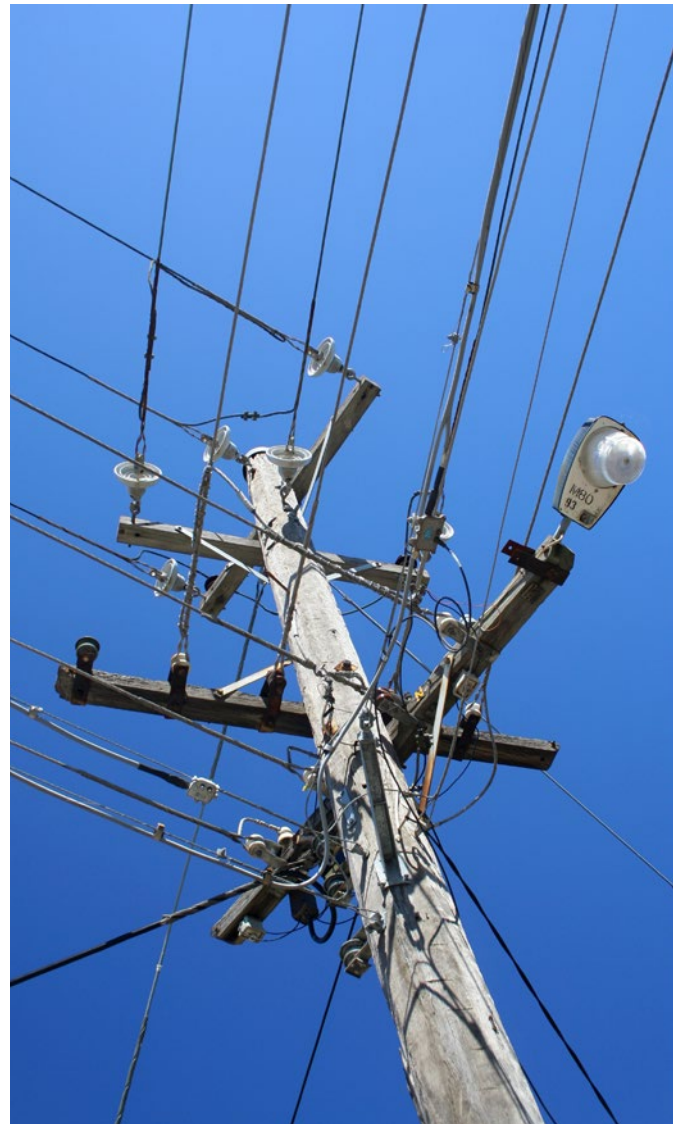
## Building resilient communities

To support improved bushfire resilience, CSIRO has researched the root causes of our vulnerabilities, rather than focussing only on managing the hazards. This requires understanding of the interdependent systems that our society depends on to deliver essential goods and services, such as energy, water, food, health, education and other social services, transport, and communications. CSIRO has used this approach in aiding the development of the federal government's National Disaster Risk Reduction Framework, and in developing Climate Compass. This is a framework designed to help Australian public servants manage the risks from the changing climate and incorporate this into developing policies, programs and asset management approaches.

CSIRO was a partner of the Australian Government's National Resilience Taskforce, established in 2018 and led the national engagement process to build understanding of the causes of disaster vulnerability. We also worked on scenarios to understand disaster risk, reduce vulnerability, and deliver better outcomes by focusing on governance and communities.

## Data

- *Big Data used to decrease fire risk* – following the 2009 Victorian Bushfires Royal Commission the State Government established a 10-year, \$750 million Powerline Bushfire Safety Program (PBSP). Using data on electrical infrastructure and ignitions starting from 2007, CSIRO was able to show that by carefully targeting PBSP investment, a large percentage of the bushfire risk from powerlines could be removed across the state.
- *Victoria wide evacuability hotspots* – CSIRO's Data61 is working with agencies to develop a tool that will allow state-wide assessment of evacuability for given fire weather conditions. Following validation and benchmarking, this tool is expected to be used on an operational basis at the state control centre in Victoria from the 2020–21 fire season.
- *Data and infrastructure for wildlife and environment impact assessment and recovery monitoring* – The Atlas of Living Australia provided the most comprehensive biodiversity data available for modelling of the 2019–20 fire season's impacts on biodiversity and ecology. This facility also supports and integrates the extensive national citizen science community into the data ecosystem underpinning CSIRO's fire-related activities.



Using big data to reduce the risk of fires from powerlines.

## Understanding the link between climate, emissions and bushfires

- *State of the Climate* – CSIRO and the Bureau of Meteorology have regularly reported on climate variability and change in Australia including bushfire weather via the biennial State of the Climate report since 2010.
- *Greenhouse gas accounting of forest fires* – CSIRO continues working closely with the Australian government to develop national greenhouse gas accounting methods for use in the Australian National Greenhouse Gas Inventory. This will lead to improved confidence in estimates of fire impacts on carbon stocks and emissions. We are also developing novel modelling approaches to understand the consequences of both wildfires and prescribed burning on carbon budgets.

## Understanding land management and wildlife impacts

- *Indigenous fire regimes* – CSIRO has a growing track record of working in collaborative partnerships with indigenous groups in the application of traditional knowledge to bushfire management. This includes the development of protocols for indigenous fire management partnerships through the Northern Australia Environmental Research Portal. CSIRO recognises that indigenous cultural fire management or ‘cultural burning’ practices have been crucial to the successful management of Australian landscapes for thousands of years.
- *Revegetation* – The ACT government used CSIRO revegetation options for burnt catchments following the 2003 ACT fires to plan rehabilitation efforts. The options developed drew on previous work on the impacts of bushfire on the long-term quantity of water in rivers and reservoirs, and the impacts following bushfires on water quality, sediment movement and vegetation rehabilitation.

- *Biodiversity and Ecology* – CSIRO’s in-depth research on the dynamics of Australian ecosystems enables impacts of fire on biodiversity and ecosystem processes to be monitored and predicted. This enables effective design and testing of response and adaptation pathways and informs development of carbon methodologies such as the widely applied savanna burning methodology. By utilising its world-renowned capability in macroecological modelling, CSIRO adds significant value to existing efforts to estimate the impact of the 2019-20 fires on biodiversity, and to identify priority areas of habitat to maintain as fire refugia. Our approach allows estimation of potential extinction levels, and priority habitat mapping, to be extended well beyond better-known vertebrate species, to consider overall biodiversity across a much broader range of biological groups, including plants and invertebrates. Post-fire initiatives include using heat-mapping satellite data to reveal the extent and intensity of the fires, and overlaying records of plant occurrence to discover the plant species and ecosystems impacted.
- *National Research Collections Australia* – We are custodians of collections of plant and animal species that contribute to our national biological knowledge, providing a key resource to support rehabilitation efforts post fire. This vast storehouse of information grounds our regeneration efforts by confirming what species existed, and where, in the landscape.



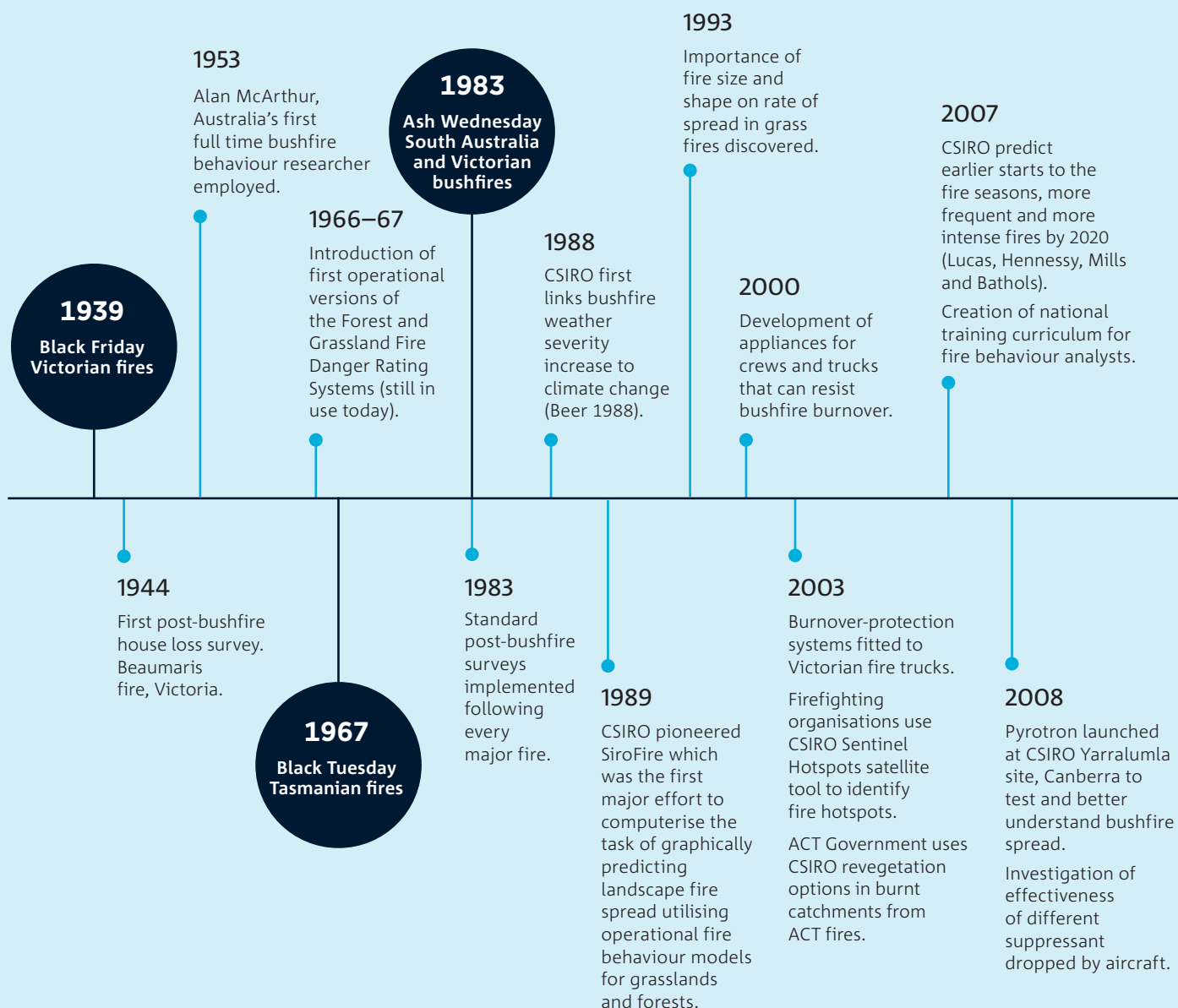
Tree ferns sprouting three weeks after fire at Martins Creek in NSW, 19 January 2020.

# Looking to the future

The impact of climate change has led to longer, more intense fire seasons and an increase in the average number of elevated fire weather days. So preparing for and managing bushfires is critical to minimise the risk and potential damage of bushfires.

In the same way we have solved some of Australia's greatest challenges for more than 100 years CSIRO continues to apply scientific and technological solutions to help Australia face the challenges and opportunities of a variable and changing climate.

## CSIRO's bushfire research science outputs





Burnt hills are featured in the background following the Kosciuszko National Park fire in NSW, February 2020.

### 2009

First fully digital post bushfire survey following 2009 Black Saturday Fires.

Work with Victorian Government to rebuild houses using best practice sustainability principles.

CSIRO support 10-year, \$750 million Powerline Bushfire Safety Program (PBSP) established in Victoria.

Inform the Victorian Royal Commission on design and construction standard for bunkers.

### 2012

Bushfire hazard mapping methodology incorporates climate change projections into Queensland bushfire planning (Leonard, Blanche 2012).

CSIRO and Melbourne University develop nationally recognised bushfire course.

### 2016

AQFx air quality forecasting system to measure smoke exposure from bushfires. Development of protocols for indigenous fire management partnerships.

### 2017

State-wide mapping of annual bushfire fuel loads introduced in Queensland (Newham, Opie, Leonard, 2017).

### 2019-20

South Eastern Australian bushfires

### 2021-22

AQFx air quality forecasting rolls out nationally for warnings of community exposure to smoke.

**2009**  
Black Saturday Victorian fires

### 2011

CSIRO supports development of Community fire refuges across Victoria.

### 2010

A 'fire-proof' house is tested at the Rural Fire Services Hot Test Fire Facility at Mogo, NSW.

Evaluation of DC-10 air tanker for aerial firefighting.

### 2015

National bushfire building standard is adopted by the National Construction Code in 2015.

Publication of A Guide to Rate of Fire Spread Models for Australian Vegetation.

### 2013

Bushfire life and house loss database underpins national policy reform (Blanche, Leonard 2013).

Commencement of development of Spark wildfire spread simulation framework (completed in 2015).

### 2018

CSIRO named the official project partner for the Australian Government's National Resilience Taskforce.

### 2019-20

Australian Government calls on CSIRO to help deliver practical resilience measures in relation to bushfires and climate change.



As Australia's national science agency and innovation catalyst, CSIRO is solving the greatest challenges through innovative science and technology.

CSIRO. Unlocking a better future for everyone.

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Cover: New post fire regrowth in the Adelaide Hills. February 2020.  
Above: Resprouts of blady grass (*Imperata cylindrica*) and pink bloodwood (*Corymbia intermedia*) on the foothills of the Great Dividing Range on the Atherton Tablelands in September 2009.