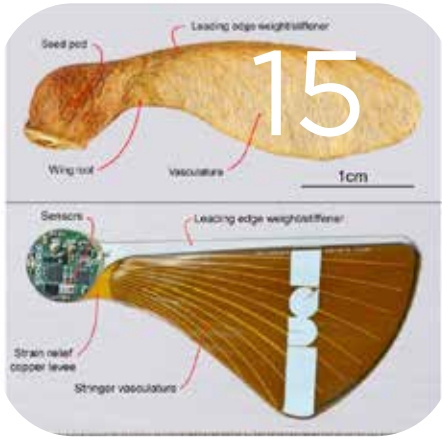
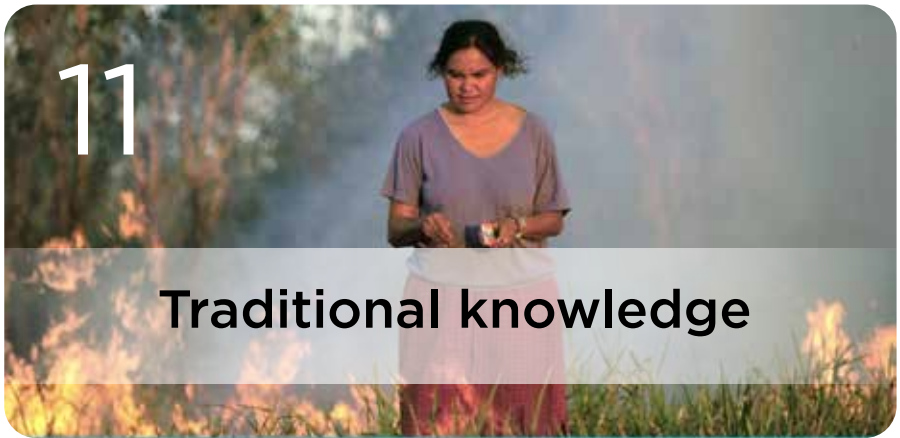




BUSHFIRE

RESEARCH CAPABILITY

November 2020



*Minimising the
devastating impact
of bushfires will
demand research
from a broad
spectrum of inter-
related disciplines.*

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**Deputy Vice-Chancellor
(Research and Innovation)
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.....
'Bushfire' by HighExposure, www.flickr.com/photos/imani/7819977934. Licence at creativecommons.org/licenses/by/2.0.



INTRODUCTION

The University of Queensland's unique **bushfire research** capability

World-class expertise in bushfire prediction, mitigation and recovery.

With the nation at high alert, Australia's record-breaking bushfire season continued well into 2020.

The University of Queensland has extensive research capability in the three important areas of bushfire research namely: prediction, mitigation and recovery.

As illustrated by the range of scientific expertise featured herein, responding to bushfires and their impact on both community and Country demands broad interdisciplinary research capability.

UQ's capability in this area ranges from advanced bushfire meteorology to fire-detection drones and planning large-scale recovery operations in the aftermath of fire events, including the psychological well being of survivors and fire fighters.

Our strengths in bushfire research capability are underpinned by our world-class expertise in civil and structural engineering that assists authorities to safeguard our infrastructure from the ravages of fire.

PREDICTION

UQ's School of Earth and Environmental Sciences (SEES) consistently ranks as a top performer in several of the world's most respected league tables – and is currently No. 11 in the world for **Environmental Sciences** and No. 30 in the world for **Geography**. SEES is also in the world's top 35 for Earth and Environmental Sciences in the latest Nature Index Tables. Research groups such as the SEES Remote Sensing Research Centre use remotely sensed data, fieldwork and spatial models to measure, map and monitor biophysical properties in terrestrial, atmospheric and aquatic environments to better understand and manage the Earth's environments and resources.

MITIGATION

Improving Australia's ability to respond to more intense bushfires will require coordinated mitigation strategies and improved disaster management/communications. Communication of risk and how to prepare and respond to natural hazards is usually seen as part of the solution. However, the effectiveness of communication often does not meet expectations, for example due to a lack of understanding of the effectiveness of various tools and methods.

RECOVERY

Loss of biodiversity is one of the greatest global challenges, and creating solutions to combat it is one of our research strengths. UQ is ranked No. 1 in the world for biodiversity conservation.¹ Our research group comprises multidisciplinary conservation scientists who have expertise in ecology, decision science, environmental policy, mathematics, social science, economics and spatial modelling. They lead the Centre for Biodiversity and Conservation Science and have key leadership roles in the National Environmental Science Programme Hub for Threatened Species Recovery and the ARC Centre of Excellence for Environmental Decisions. A significant strength is our ability to work with government, non-government and industry partners to influence national and international conservation policy.

¹ Center for World University Rankings by Subject 2017



UQ has established research capability in the three important areas of bushfire response namely: prediction, mitigation and recovery.

'Bushfire' by Red.Wolf, www.flickr.com/photos/redwolf/27909443518/. Licence at creativecommons.org/licenses/by/2.0.

School of Earth & Environmental Sciences

Jon Corcoran

Response management and spatial analytics

Hamish McGowan

Bushfire meteorology

Patrick Moss

Fire management

Stuart Phinn

Remote sensing

Noam Levin

Remote sensing

James Watson

Biodiversity; threatened and endangered species management

Civil Engineering

Joe Gattas

Bushfire recovery, low-cost housing

Alistair Grinham

Response management

David Lange

Structural fire engineering

Martyn McLaggan, Andres Osorio, Christian Zedan

Fire safety – civil engineering

Social Sciences

Suzanna Fay

Communicating in crises

Lynda Shevellar

Community development, post Natural disasters

School of Political Science and International Studies

Nicole George

Crisis management

Emma Hutchinson

Disaster imagery

David Cliff & Rickard Hansen

*Sustainable Minerals Institute
Fire safety, mining impacts*

Luke Knibbs

*School of Public Health
Air pollution and respiratory pathogens*

Jochen Mueller

*The Queensland Alliance for Environmental Health Sciences
Emerging Environmental Health Risks*

Pauline Pounds

*School of Information Technology and Electrical Engineering
Drone technology for bushfire prediction and management*

Rod Fensham

*Biological Sciences
Fire management*

UQ Business School

Sara Dolnicar & Judith Mair

Post-disaster resilience and tourism

Paula Jarzabkowski

Using insurance and reinsurance markets for disaster risk financing

Paul Spee

Individual behaviour and organisational characteristics influencing the prediction and mitigation of risks, such as bushfires.

Belinda Wade

Corporate responses to climate change

Jie Wang

Tourism preparedness, recovery and resilience

Gabby Walters

Disaster management strategies

Dongming Xu & Brent Ritchie

Disaster management strategies

'Backburning' by robdownunder, www.flickr.com/photos/aus_pics/3319080524/. Licence at creativecommons.org/licenses/by/2.0.



- *Severe bushfire meteorology*
- *Mountain and coastal meteorology*
- *Thunderstorm meteorology*
- *Earth surface – atmosphere interactions and energetics*
- *Design and application of observational platforms to research weather and climate*

PROF. HAMISH MCGOWAN

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Professor Hamish McGowan is Professor of Atmospheric Sciences at The University of Queensland.

He has more than 25 years of research and teaching experience in weather and climate, and is internationally recognised for expertise in: complex terrain meteorology and topographic modification of winds in mountain and coastal environments; transport of aerosols and air pollution meteorology; synoptic meteorology; earth surface – atmosphere energy and trace gas exchanges; paleoclimate; design and application of novel observation technologies to the study of atmospheric processes.

Hamish leads the Atmospheric Observations Research Group, which has the most extensive

meteorological observational research capability at an Australian university.

This includes Australia's only mobile weather radar, which has been deployed to develop understanding of bushfire-triggered thunderstorms in collaboration with the Bureau of Meteorology, Country Fire Authority (Victoria), and Queensland Parks and Wildlife.

Hamish has a track record of successful leadership of large multidisciplinary research projects and collaboration with industry and government agencies.

His research on which he has published widely, has led to paradigm changes in understanding of Australia's climate systems and causes of change in the continent's hydroclimate.

- *Wildlife Conservation*
- *Impact of fire on Australia's threatened species*

PROF. JAMES WATSON

School of Earth and
Environmental Sciences
Director, Centre for Biodiversity
and Conservation Science
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James Watson is a Professor of Conservation Science and Director of the Centre for Biodiversity and Conservation Science at UQ.

He leads the Green Fire Science research group, whose mission is to do applied research that is linked directly to the practice of conservation, and he is the Director of the Wildlife Conservation Society's Science and Research Initiative.

The Centre for Biodiversity and Conservation Science is pushing ahead with a national analysis of what the bushfires mean for Australia's threatened species as well as species that are not threatened but may become endangered due to the fires. This proactive work is part of the wider National Environmental Science Program threatened species hub work led by UQ.

Fire safety in underground mines

DR RICKARD HANSEN

Occupational Trainee
Adjunct Fellow
Sustainable Minerals Institute
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Rickard Hansen (PhD, MSc) is a researcher and a fire-protection engineer, specialising in fire behaviour and fire safety in underground hard rock mines.

During his doctoral studies, he conducted several full-scale fire experiments on mining vehicles in an underground mine.

He has published many papers and reports about the fire behaviour in underground hard rock mines.

His research interests include fire dynamics in underground mines, suppression of fires in underground mines, fire and rescue operations underground, smoke spread in underground mines and ignition of solid materials.

Aerial bushfire suppression, disposable drones

A/PROF. PAULINE POUNDS

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Associate Professor Pauline Pounds is developing small disposable drones that feature a built-in

miniature weather station, allowing them to detect local environmental conditions (on the ground, below the cloud layer), and offering early warning of moving firefronts.

Effectively a “fire alarm for the bush”, these drones have had limited field deployments in non-fire scenarios, but the technology holds much potential for aerial bushfire suppression.

Bushfire recovery, low-cost/temporary prefabricated housing systems, visualisation of Twitter and bushfire data

DR JOE GATTAS

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Joe Gattas is a civil engineer and lecturer at UQ. His research involves using origami design techniques to invent and improve thin-walled structures and devices.

There are numerous applications of origami shell structures, including deployable and modular housing; energy-absorbing packaging and barriers; and lightweight automobile and aircraft components.

He is also interested in all aspects of design, making, and coding, and pursues a large number of projects that relate to one or all of them.

With support of a John Monash Scholarship (2010), Joe completed his a PhD in Engineering Science at the University of Oxford in 2013.

Minimising power outages

DR MASHHUDA GLENCROSS

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The visualisation of Twitter and bushfire data is being used to reveal the stories of affected communities, and highlight the scale of bushfire impacts.

In parallel, the Centre for Energy Data Innovation is also working on an ARC grant application to research new methods for minimising power outages in severe weather events and bushfires.

While access to power is critical to evacuation efforts, the methods and technologies used to maintain power are equally important to storms, floods and any other climate-related emergencies.

We plan to build upon work we are doing with energy networks to support methods to allow communities at risk to access resources.

Tourism disaster management including planning, response, recovery marketing.

PROF. BRENT W RITCHIE

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Professor Ritchie's research interests include tourism disaster management, incorporating planning, response, and recovery marketing

His research has focused on understanding risk from an individual and organisational perspective.

His work on organisations explores risk attitudes and response strategies to effectively respond and recover from crises and disasters.

He also explores tourist attitudes to risk and their risk reduction behaviour, including beach goers, Australian outbound travellers and potential travellers to the Middle East and in Indonesia.

His research projects also examine the factors that influence the formation of risk attitudes and behaviour by using social and organisational psychology theory and concepts.

Exposure assessment for air pollution

A/PROF LUKE KNIBBS

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Associate Professor Luke Knibbs investigates the health effects of environmental risk factors, with a specific focus on air pollution and respiratory pathogens.

Since 2019, he has headed the Planetary Health & Health Protection Division, one of three academic divisions within the UQ School of Public Health (SPH).

Dr Knibbs completed his PhD on ultrafine particle exposure assessment in 2009, followed by three years' postdoctoral training at the International Laboratory for Air Quality and Health.

He has a special interest in understanding the burden of disease due to anthropogenic air pollution and transmission of bacterial respiratory pathogens via bio-aerosols. He and his team are interested in developing novel approaches to improve exposure assessment for both air pollution and bio-aerosols.

Remote sensing of bushfires

PROF. NOAM LEVIN

UQ School of Earth and Environmental Sciences
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Noam Levin studies geographical and environmental patterns and processes of land cover changes in the face of human and climate induced changes using remote sensing and Geographic Information Systems (GIS) tools. In his work he combines field work, remote sensing of satellite images, spatial analysis of GIS layers, statistical analyses and modelling.

Noam has a great interest in maps, and in exploring new methods to analyse spatial information, from historical maps, GIS layers, aerial photographs and satellite images. Noam is an Associate Professor at the Department of Geography at The Hebrew University of Jerusalem, and an international PI at the ARC Centre of Excellence for Environmental Decisions (CEED).

Remote sensing of bushfires

PROFESSOR STUART PHINN

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Professor Stuart Phinn's research interests are in measuring and monitoring environmental changes using earth observation data and publishing/sharing ecosystem data. Stuart is the Chair of the Committee that produced Australian Earth Observation Community Plan – 2026; he is also a professor of Geography at The University of Queensland, where he teaches remote sensing and directs the Remote Sensing Research Centre, which includes programs to support government agencies across Australia (Joint Remote Sensing Research Program) and enabling coordination across all government, industry and research groups collecting and using EO data (Earth Observation Australia). He was the founding director of Australia's Terrestrial Ecosystem Research Network and its Associate Science Director, 2009–2015.

The majority of Prof. Phinn's work uses images collected from satellite and aircraft, in combination with field measurements, to map and monitor the earth's environments and how they are changing over time.

The majority of his work uses images collected from satellite and aircraft, in combination with field measurements, to map and monitor the earth's environments and how they are changing over time. This work is done in collaboration with other environmental scientists, government environmental management agencies, NGO's and private companies.

He publishes extensively with his collaborators, and currently has 185 papers in refereed international journals, a book, an on-line textbook, and 12 book chapters. A large part of this work also involves training the next generation of scientists and managers who effectively use remote sensing, and has graduated 38 PhD students.

A growing part of this work now focuses on national coordination of earth observation activities and the collection, publishing and sharing of ecosystem data.

Dr Knibbs has a special interest in understanding the burden of disease due to anthropogenic air pollution and transmission of bacterial respiratory pathogens via bio-aerosols.

Bushfire Research Capability

Interdisciplinary research groups

The University of Queensland is uniquely placed to offer specialist professional advice and research across many bushfire-related disciplines. Queensland's own long history of adverse weather events has ensured the state's research infrastructure is well geared towards results-driven outcomes.

- Advanced **Water Management** Centre
- **Aquatic Systems** Research Group
- **Atmospheric Observations** Research Group
- Centre for **Energy Data** Innovation
- **Fire Safety** Engineering Research Group
- **Future Timber** Hub
- **Mental Health** Policy and Epidemiology group
- UQ **Structures** Lab
- UQ Business School capabilities in **disaster management**
- **Tissue culture** and **plant genetics**
- Queensland Alliance for **Environmental Health Sciences**

Image: 'Kangaroo Island fire' by robdownunder, www.flickr.com/photos/aus_pics/49330727998/ Licence at creativecommons.org/licenses/by/2.0



Bringing **traditional knowledge** into Australia's bushfire management

*The 'cultural burning'
by traditional owners' is
often in direct contrast
with prescribed 'hazard
reduction' fire regimes.*

The recent bushfire crisis has confirmed that current management practices are inadequate in preventing out-of-control wildfires in many parts of Australia.

Researchers at The University of Queensland have established a Translational Impact Research Network (TIRN) that aims to set up an interdisciplinary group to consider the future of Australia's flammable landscapes in a changing climate. Benefits of good fire management are obvious with reduced risk of wildfires, biodiversity gains and carbon credits.

Traditional owners in northern Australia have been implementing Indigenous fire regimes in some

areas of the Top End, but markedly fewer examples of these practices can be found elsewhere in Australia.

The 'cultural burning' by traditional owners' is often in direct contrast with prescribed 'hazard reduction' fire regimes.

This TIRN's focus is on Indigenous Knowledge and burning practices ('cultural burning').

The aim of this TIRN to position us for action under UQ's reorganised Global Change Institute for future opportunities to work across environmental, social, and economic realms.



*The 'cultural burning'
by traditional owners' is
often in direct contrast
with prescribed 'hazard
reduction' fire regimes.*

Photos: Indigenous fire management research project, UQ School of Earth & Environmental Sciences

Bringing **traditional knowledge** into Australia's bushfire management

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SOIL CARBON

Helen Ross
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COMMUNITY RESILIENCE

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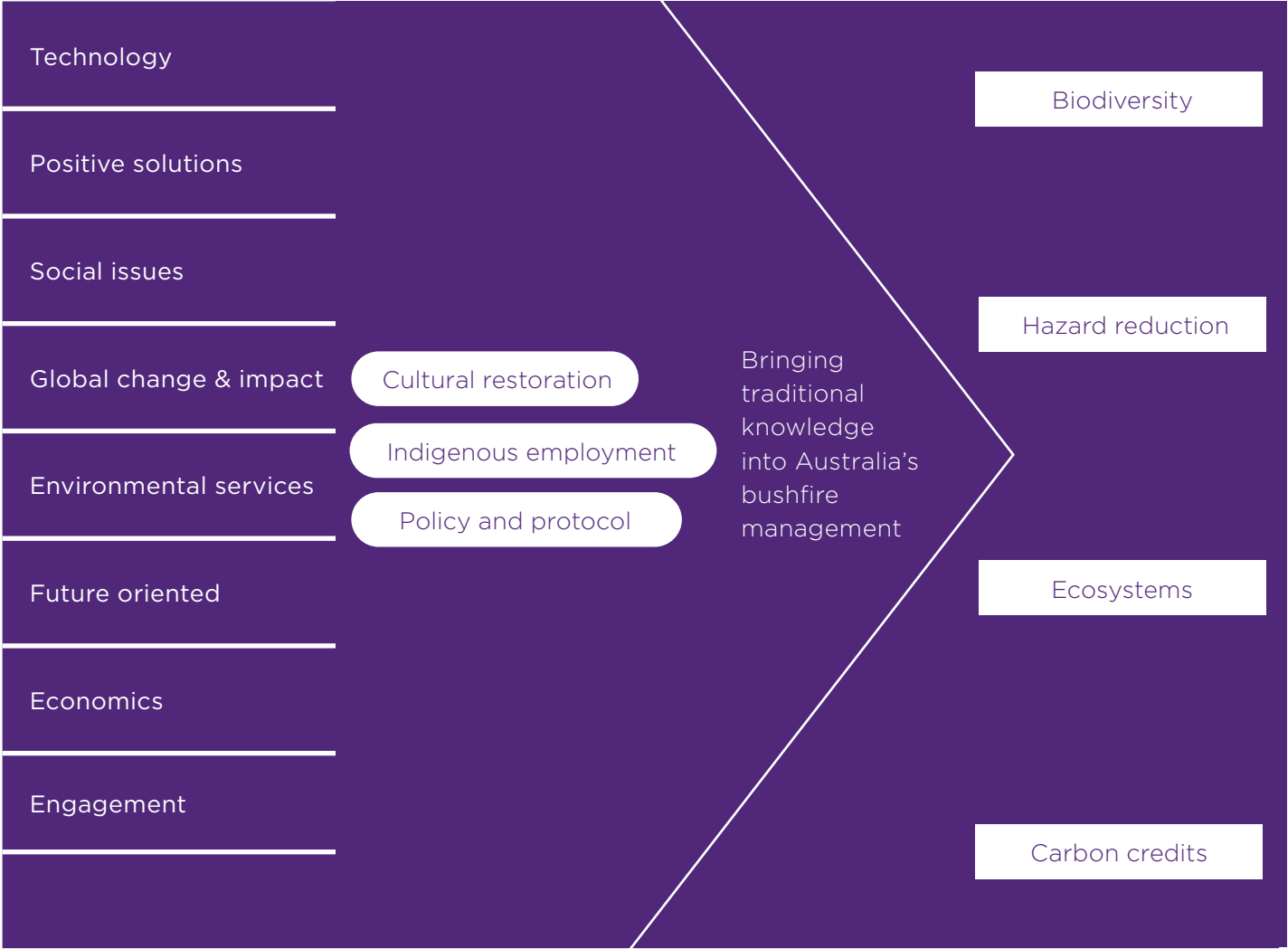
INDIGENOUS FIRE MANAGEMENT

Justine Bell
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ENVIRONMENTAL LAW

Melissa Fitzgerald
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BUSH FOOD



Cultural restoration

- Young traditional owner engagement with traditional knowledge
- Youth retained on Country
- Bushfood plants regenerated

Indigenous employment

- Jobs for young traditional owners due to policy changes
- Enacting to preserve native title

Policy and protocol

- Government communication
- Evidence-based policies
- Review current practice
- Decision-making tools

www.awmc.uq.edu.au

The Advanced Water Management Centre (AWMC) is an internationally recognised centre of excellence in innovative water technology and management.

An award winning multidisciplinary team and research portfolio covers the breadth of the urban industrial water cycle, achieving sustainable outcomes for the global water industry.

The millennial water and energy crisis has brought about a major change in many aspects of the water industry.

The shift towards a true urban water cycle, both at local and regional scale, poses numerous challenges and opportunities for the water industry as a whole.

We have a vast expertise base in our research team with more than 35 academic and research staff including three IWA Fellows, and more than 50 research students.

We have an outstanding track record of successful research, development, and application projects currently worth almost AU\$10 million per annum, many in close collaboration with industry and research collaborators.

We are partnered with more than 100 different utilities, industry groups, research institutions, and educational facilities around Australia and the world.

The combined efforts of the AWMC's programs are still achieving sustainable outcomes for the water industry.

We have challenged how the industry views greenhouse gas emissions, added value to our waste processes, and discovered how to protect our water resources and critical infrastructure.

Image: 'Lobethal in the Adelaide Hills' by denisbin, www.flickr.com/photos/82134796@N03/49335330933. Licence at <http://creativecommons.org/licenses/by/2.0>.



Advanced Water Management Centre

Environmental Biotechnology

In broad terms, biotechnology may be considered as any technology based on biology, for example technologies that harness microbiology and biomolecular processes to reduce or prevent environmental pollution (Environmental biotechnology) or generate new and sustainable value-add products (Industrial biotechnology).

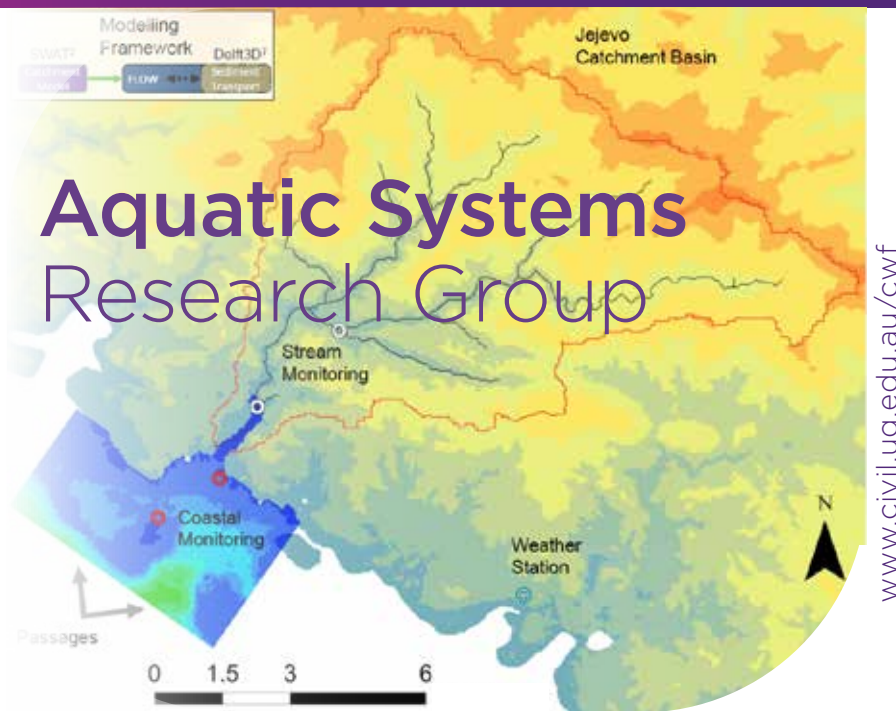
Environmental biotechnology is a strength at AWMC and has already had a long and successful history in wastewater treatment. Common technologies utilising microorganisms include biological nutrient removal, anaerobic digestion for removal of organic contaminants and biological filters for odour management.

While effective, these technologies can be energy intensive and tend

to focus on removal or stabilisation, rather than recovery.

AWMC researchers are advancing environmental biotechnology through development of more efficient operating strategies able to utilise existing infrastructure and alternative processes including high rate activated sludge, mainline anammox, anaerobic membrane bioreactors, and photobioreactors.

At the same time AWMC is driving a paradigm shift from waste treatment to resource recovery using the latest genomic and transcriptomic approaches to inform process design. This innovative approach combined with the latest research tools will enable the next generation of wastewater treatment for full resource recovery, including existing and emerging value-add products such as microbial protein, biopolymers, bioenergy, biofertilizers and commodity chemicals.



Aquatic Systems Research Group

The team is also exploring the use of autonomous vehicles (both UAVs or “drones” and autonomous boats) to access and collect samples from waterways during events such as bushfires.

Therefore, there is a particular need to understand how sediment and pollutants move from the landscape to water bodies immediately after bushfire events so that effective management practices can be put in place.

Through the application of adaptive real-time monitoring and forecasting systems this research team is developing new insights into these processes.

Innovative environmental monitoring systems that use an array of sensors to provide information on catchment and waterway condition in real-time allow the response of these systems to events such as fires to be measured in unprecedented detail.

These measurements are also vital for the development of advanced three-dimensional models that allow the flow pathways of sediments and pollutants through waterways to be understood.

These models can also be used by water managers to explore different bushfire scenarios to help better inform their planning and mitigation activities.

The team is also exploring the use of autonomous vehicles (both UAVs or “drones” and autonomous boats) to access and collect samples from waterways during events such as bushfires where traditional human sampling of these waterways is not feasible due to safety risks.

This technology has the potential to collect information to rapidly advance our knowledge of pre- and post-fire impacts on waterways as well as providing water managers with high quality, time critical information that has not been previously available.

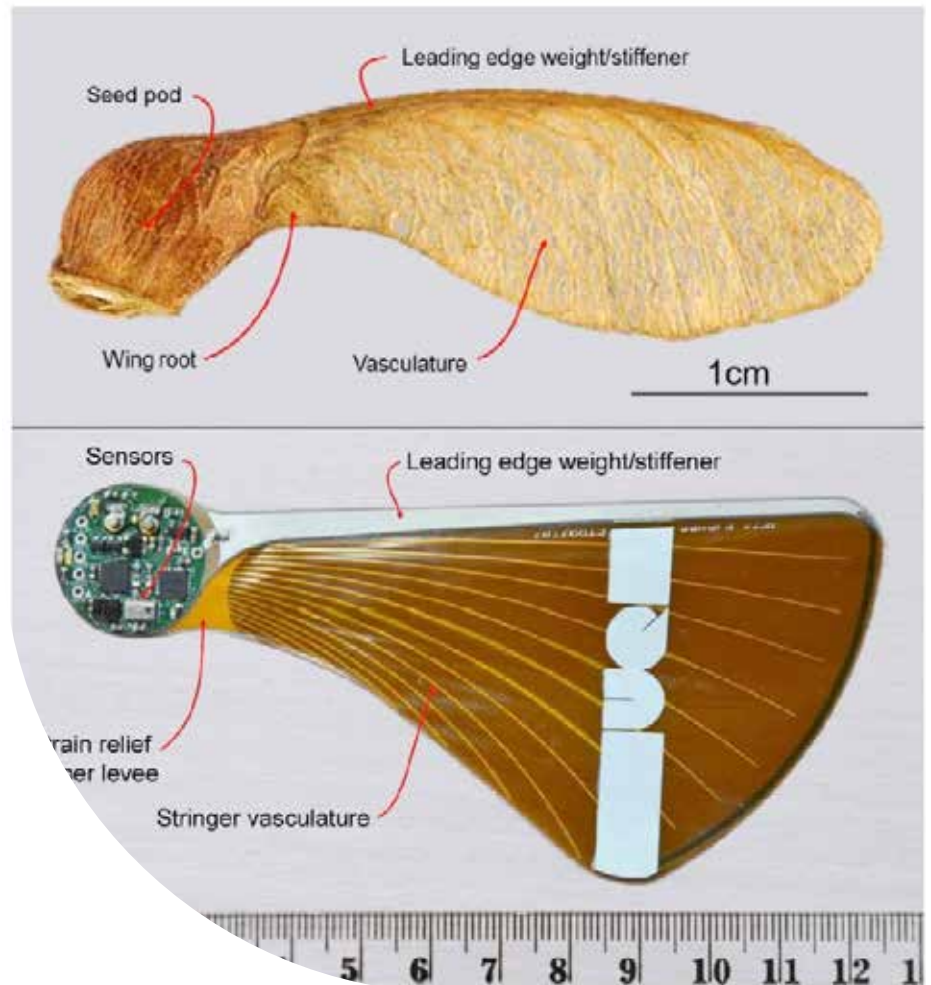


Understanding and predicting the post-bushfire impacts on water resources and aquatic ecosystems is an emerging area of activity for many water management organisations including local governments and water authorities.

Associate Professor Badin Gibbes and the team (Dr Alistair Grinham, Dr Simon Albert, Dr Remo Cossu) from the UQ School of Civil Engineering's Aquatic Systems Research Group are combining innovative catchment and water monitoring systems with advanced water-quality models to assist water management organisations to better understand the risks to water supplies from pollutants such as sediments, nutrients, pathogens and chemicals. Sediment inputs into lakes, rivers and water supply reservoirs have long been recognised as a key challenge for the sustainable management of these natural resources. Recent research indicates that bushfires can significantly alter sediment and pollutant transport pathways from catchments to waterways – particularly when rainfall closely follows bushfires.

Fighting fire from the air with the elegance of **nature**

See 'Automatic Distribution of Disposable Self-Deploying Sensor Modules', Paul Pounds, Timothy Potie, Farid Kendoul, Surya Singh, Raja Jurdak, and Jonathan Roberts, UQ, CSIRO. paul.pounds@uq.edu.au +61 (0) 426 238 326



UQ engineers are developing an innovative new system of biologically inspired fire sensors that can be safely delivered by low-altitude drones at or near a fire front.

Using a system that mimics the way nature disperses seed pods, researchers have designed a wing like sensor that can be mass-produced relatively cheaply.

The system will potentially allow fire fighters and other emergency personnel to monitor fire conditions without getting needlessly close to dangerous country or fire events.

Moreover, the sensors can be deployed in rugged or remote areas that are all but impossible to monitor with standard methods. While the engineers say there is

substantial work still to be done in making sensors practical for fire detection and monitoring, electro-aero-mechanical aircraft constitute a promising and cost-effective deployment mechanism for such systems.

In particular, their use of mature low-cost, mass-manufacturing processes make them eminently suitable for devices that are economically sensitive.

Early experiments have shown the integrated mono-wing system to be a very reliable descent arrest system, with no failed landings observed during any flight testing.

Similarly, the deployment automation elements of the technology have proven straightforward.

It's hoped that this technology will rapidly evolve, leading to effective large-scale field deployments.

Early experiments have shown the integrated monowing system to be a very reliable descent arrest system, with no failed landings observed during any flight testing.



Image by hellamilly, <https://www.flickr.com/photos/hellamilly/1395420480>. Licence at <http://creativecommons.org/licenses/by/2.0>.

Nature's **wildchild** — the fire-generated **thunderstorm**

Fire-generated thunderstorms can easily develop into destructive supercells, accompanied by extremely damaging winds, large hail and lightning

"It occurred in extreme conditions and was affected by the passage of a cold front over the wildfire," Professor McGowan said.

"We could show that the cold front's increase in atmospheric moisture, combined with changes in fire behaviour at that time, triggered the wildfire-induced thunderstorm.

With more extreme weather predicted to result from climate change, the team's findings highlighted the importance of combining weather radar and on-the-ground meteorological observations, providing insights into this fire-atmosphere coupling phenomenon.

"These observations are essential, helping us better build an understanding of extreme wildfire events, which could help improve fire behaviour predictions," Professor McGowan said.

Researchers used weather radar to investigate the dynamics of large plumes of heat, smoke and burning debris – known as pyrometeors – lofted above bushfires.

"These radar observations are then supported with a wide range of other meteorological data from weather stations, weather balloons and weather satellites," Professor McGowan said.

"We also used observations of a fire's behaviour made by firefighting personnel and local residents to further expand our understanding of fire-atmosphere interactions."

Professor McGowan said the analysis provided information to assist with bushfire management strategies.

The research is published in JGR Atmospheres (DOI: 10.1029/2018JD029986).

Professor Hamish McGowan

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Researchers say a better understanding of the dangerous yet surprisingly common phenomenon of wildfires triggering supercell thunderstorms could reduce risk to life and property.

A thunderstorm generated by a New South Wales wildfire reached a height of 12.7 kilometres, according to an analysis involving University of Queensland, Bureau of Meteorology and Monash University researchers.

UQ Atmospheric Observations Research Group leader Professor Hamish McGowan said the fire-generated thunderstorm also had a large core of rotating winds, indicating that it had indeed developed into a supercell thunderstorm.

"This is the most dangerous type of thunderstorms, generally associated with extremely damaging winds, large hail and lightning.

"Such a storm in proximity to a severe fire can pose a dire risk to firefighters and residents in the affected areas, and the ability to forecast such a risk could make a significant difference to safety."

The Sir Ivan Dougherty wildfire impacted 55,000 hectares of land in New South Wales in February 2017.

Access to reliable power is fundamental to most emergency response efforts, especially for maintaining communications. Research into power systems' resilience and effective communication of outage risk during bushfires and severe weather events is a cornerstone to improving bushfire readiness, response and damage mitigation efforts. The centre's world leading interdisciplinary expertise in power engineering, interaction design, visualisation and virtual/augmented reality technologies provide a strong existing competency for developing the new methods required to improve the resilience of power system during bushfire and severe weather emergencies.

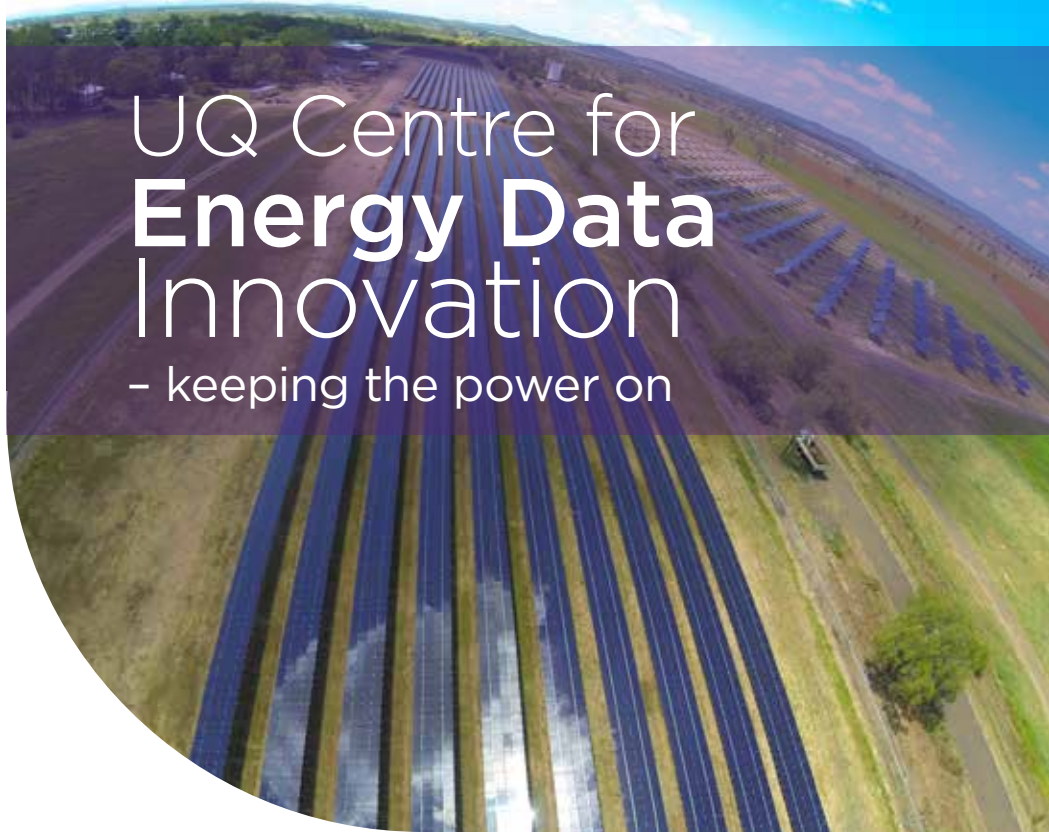
Working closely with key stakeholders in energy networks, energy consumers and the insurance industry we are developing a data driven approach to detailed monitoring of the digital energy grid

Highlights include:

- Power engineering and associated data analytics
- Modelling of power systems, networks and microgrids
- Integration of distributed generation and distributed storage devices
- Improve data power network operating state through sub-metering to better pinpoint sources of network outages
- Social media monitoring to identify information flows within and between communities during natural disasters
- Estimating power network operating state
- Condition assessments and rapid fault detection of critical power system assets
- Interaction design for rapid prototyping of computer-human interfaces
- Visualisation expertise and facilities to develop effective computer-human interfaces for energy flow and disaster preparedness
- Virtual Reality and Augmented reality expertise to prototype

- new human-data interactions
- Remote sensing techniques
- Strong links to Energy networks, energy consumer bodies and the insurance sector
- The ITEE Renewable Energy Laboratory
- UQ's own power assets (e.g. Gattin and Warwick solar farms, 2.2MWh engineering precinct battery, rooftop solar on all campuses)
- Recovery phase: designing resilient software infrastructures to enable affected communities share and learn one another's experiences and navigate through the crisis
- Recovery phase: design tools to enable stronger connections between affected communities, concerned authorities and service providers

The centre brings together experts in ITEE's Power and Energy Systems ITEE's Human Computer Interaction experts working on the following specific challenges for energy resilience during bushfire emergencies



UQ Centre for Energy Data Innovation

- keeping the power on

www.itee.uq.edu.au

- Prediction of outages during an ongoing bushfire emergency
- Mitigation strategies to support resilience of energy supply during a crisis
- Communication of risk for decision support to mitigate an emergency
- Planning and visualising evacuation during an ongoing bushfire crisis
- Communication technologies to support community before, during and after a crisis
- Human-centred crisis recovery solutions

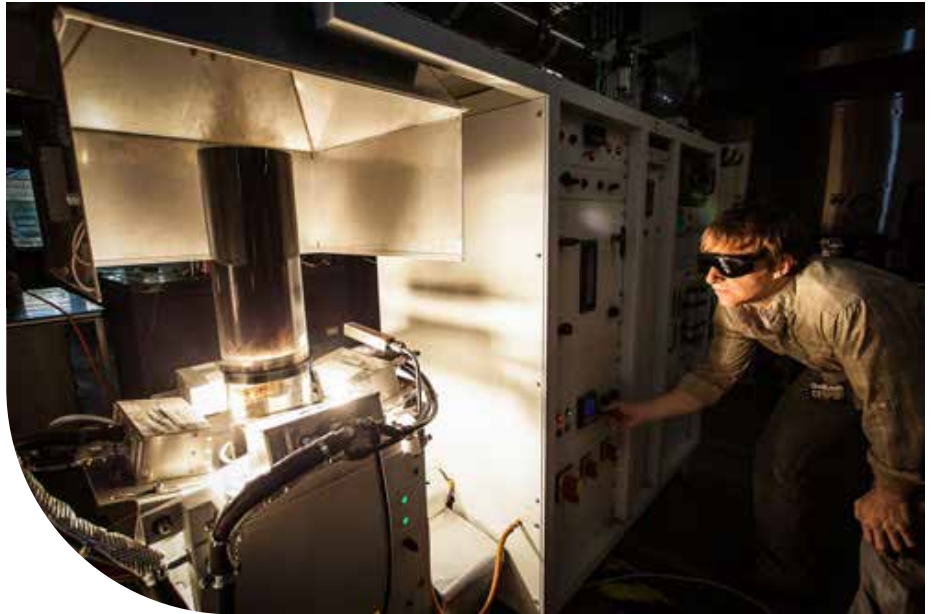
We have the right interdisciplinary team to build strategies for helping to keep people connected, informed, and safe during bushfire emergencies.

Dr Mashhuda Glencross

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Fire Safety Engineering Research Group

UQ's Fire Safety Engineering Research Group investigates a wide range of fire topics, from bushfires to fires in buildings, fires in transport infrastructure, and more. The group's combined research expertise covers problems directly or tangentially associated with the bushfires e.g. initiation and spread of bushfires, performance of structures affected by fires, recovery of affected communities.



www.civil.uq.edu.au/fire

Cladding Materials Library

The cladding materials library has recently been added to UQ's fire-fighting arsenal.

Designed to help give fire engineers the tools they need to tackle the cladding crisis, the library contains flammability data on a wide range of cladding materials, and is publicly and freely available.

UQ Fire Laboratory

Located in the Frank White Annex, UQ's spacious fire lab features a suite of state-of-the-art testing equipment designed to permit investigations ranging from small-scale testing to large-scale calorimetry.

The facility has multiple extraction hoods, including a demonstration hood that allows medium-scale experiments and classes to be conducted for students and visitors.

The larger-scale hood can accommodate a fire up to 2MW in size (roughly equivalent to a sofa fire). The exhaust for the large hood is equipped with a calorimetry system to allow the fire size to be measured as a function of time.

This allows larger-scale testing of composite materials to determine heat-release rates.

The library contains flammability data on a wide range of cladding materials, and is publicly and freely available.

Fire safety engineering research group

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Future Timber Hub



Australian Government
Australian Research Council

futuretimberhub.org

The Future Timber Hub is an industrial transformation research hub to transform future tall timber buildings.

Funded by the Australian Research Council, the Future Timber Hub is Australia's leading timber research collaboration bringing together experts from industry, government, and academia who are committed to the future development of tall timber buildings in the Pacific region.

The aim of the Hub is to transform the timber construction industry in Australia by generating the skills, knowledge and resources that will overcome current technological and social barriers limiting the application of timber to tall structures.

The Hub was founded as an interdisciplinary partnership between: The University of Queensland, the Queensland State Government Department of Agriculture and Fisheries, Arup, Hyne Timber, Lendlease, the Queensland Fire and Emergency Services (QFES), Scion NZ, Griffith University, the University of British Columbia and the University of Canterbury.

A key challenge in advancing timber-based construction in tall buildings is the need for an integrated approach

in manufacturing, design, and construction.

To ensure the Hub can meet this challenge, the interdisciplinary team includes product manufacturers, construction managers, fire safety engineers, architects, and structural engineers.

This team will advance tall timber construction at multiple levels, with projects including development of Engineered Wood Products (EWPs) appropriate for the Australian context; development of hybrid (e.g. concrete-timber) construction systems; development of prefabricated EWP construction systems; and holistic assessment of EWPs.

A second key challenge is the need to address environmental and fire safety considerations in timber construction, which are often more critical than structural and construction considerations.

The Hub leverages additional resources and partnerships to tackle these issues and has complete access to state-of-the-art facilities possessed by UQ Civil Engineering, UQ Architecture, and the Hub's industry partners.



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- **UQ Architecture Workshop**
- **UQ Fire Safety Facilities**
- **Hyne Timber Facilities**
- **Qld Government Salisbury Research Facility (DAF)**
- **UQ Structural Engineering Facilities**

Broader use of **timber** as a sustainable material in the Australian **built environment**



Dr Joe Gattas in the UQ Structures Lab, within the School of Civil Engineering

Using timber as a construction material has clear benefits – it's natural, making it a safe and healthy construction material; it's environmentally friendly as it can be sustainably farmed; it requires the lowest energy of almost all common building materials to produce; and it's a great insulator.

Advancing timber-based construction in tall buildings isn't easy, though. It requires an integrated approach across manufacturing, design and construction.

UQ's interdisciplinary team incorporates not just experts from the UQ School of Civil Engineering, but also product manufacturers, construction managers, fire safety engineers, architects and structural engineers. This range of experts are working towards the production of safe, strong and sustainable materials that can be used for rapid construction, while reducing the weight of material, enhancing

building quality and performance, and minimising waste on site.

The team works on projects including the development of Engineered Wood Products (EWPs) appropriate for the Australian context; the development of hybrid construction systems like concrete-timber; the development of prefabricated EWP construction systems; and holistic assessment of EWPs.

Less energy during extraction

EWPs provide one of the best potential means of reducing resource consumption and reducing the environmental impacts caused by the construction sector, which is estimated to contribute as much as one third of the total global greenhouse gas emissions.

Timber-based buildings require less energy from resource extraction through manufacturing, distribution, use and end-of-life disposal, and are responsible for producing far less greenhouse gas emissions,

air pollution and water pollution, going beyond the benefits of most renewable building materials.

The need to address fire safety considerations in timber construction is a major ongoing challenge for researchers.

Driven by the fear of large, destructive fires, current regulations impose severe restrictions on the use of timber. Timber structural elements are required to be covered by non-combustible materials, increasing the construction cost and embodied energy while also restricting the aesthetic exposure of timber surfaces. This is a key area that researchers are working on – how to properly address the inherent combustibility of timber and its structural performance during and after fire.

UQ fire engineering researcher Carmen Gorska Putynska (featured on the cover of this edition of *Ingenuity*), for example, is looking at how to best utilise the self-extinguishing nature of timber in engineered cross-laminated timber (CLT) structures, with the aim to improve fire safety in the use of this ultra-popular new product.

UQ's Fire Safety Engineering group are leading the discussion in Australia towards establishing clear guidelines for timber-based construction and achieving true optimisation of tall timber buildings.

With this research, the team hopes to usher in a new phase of tall timber building construction across Australia and across the world – and perhaps delivering a new 21st century timber Queensland style along the way.



Mental Health Policy and Epidemiology

The Mental Health Policy and Epidemiology group at the Queensland Centre for Mental Health Research (QCMHR) is a state-funded mental health research centre affiliated with our School.

The group is led by Professor Harvey Whiteford and comprises a wide range of research, technical and support staff.

The research of the Mental Health Policy and Epidemiology group aims to determine the burden of mental disorders and how services can be implemented to reduce their impact.

The group conduct studies that:

- determine the prevalence distribution and risk factors of mental disorders
- estimate the mortality and disability from mental disorders
- model and evaluate service system interventions for mental disorders
- develop measures of service performance
- analyse and inform mental health policy

Dr Fiona Charlson

Dr Fiona Charlson is a NHMRC Research Fellow at the Queensland Centre of Mental Health Research and School of Public Health, University of Queensland.

Dr Charlson is a psychiatric epidemiology and health services researcher with strong experience in addressing some of the most challenging global mental health research questions.

Dr Charlson has completed a Masters in International Public Health and a PhD on the epidemiological modelling of mental disorders in conflict-affected populations. Her research utilises a wide range of highly-specialised research skills from traditional qualitative and quantitative research methods, to new and innovative methods aimed at breaking down barriers to progress in the field.

She has been a core member of the Mental Disorders and Illicit Drug Use Research Group for the Global Burden of Disease Study since 2009.

Dr Charlson is at the leading edge of research into the mental health impacts of climate change and leads the Social and Emotional wellbeing group of UQ's Climate Change and Health Transdisciplinary Impact Research Network, and is part of the Research Working Group of the Climate and Health Alliance (CAHA).

Dr Charlson's technical expertise is highly sought after and has attracted collaboration requests and funding from a wide-range of national and international stakeholders, including; Queensland Health, the World Health Organization, the Institute for Health Metrics and Evaluation (University of Washington), US National Institutes of Health, Alan Flisher Centre for Public Mental Health (University of Cape Town) and various organisations in low- and middle-income countries.

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Tissue culture — from lab to bush



Dr Alice Hayward in QAAFI's Avocado tissue lab where the propagation takes place.

qaafi.uq.edu.au

In addition to tissue culture, we can provide capacity to inform conservation priorities or discover genes underlying traits of interest (e.g. disease tolerance, drought tolerance).

Innovations in plant tissue culture have the potential to secure a climate-resilient supply of key plant species for environmental or agricultural applications.

The Mitter Lab at the Queensland Alliance for Agriculture and Food Innovation (QAAFI) at The University of Queensland has critical research capability in tissue culture and plant genetics.

Working closely with key stakeholders the lab has developed tissue-culture pipelines for propagation and conservation of high-value plant species.

Highlights include:

- 10 years' experience in plant tissue culture
- IP developed for mass propagation of recalcitrant horticultural crops in tissue culture (Mitter Lab's proprietary meristem culture system).
- First team globally to develop cryopreservation for conservation of avocado germplasm.
- State-of-the-art plant tissue culture facility being built at UQ.

In addition we have:

- In-house customisable environmental sensors for real-time monitoring of field sites.
- Specialised expertise and work-flow at QAAFI for plant genomics and genetics supporting diversity assessments and genome sequencing.

With the unprecedented 2019-2020 fire season highlighting the devastating impacts of climate change on our native ecosystems and biodiversity, the Mitter Lab has been exploring the potential to translate their expertise to native Australian plants.

This is driven by a passion support recovery of our native species and ecosystems after fires or other impacts.

Speaking with stakeholders including nurseries, revegetation organisations and carbon-offset companies, tissue culture could assist with:

1. Seed rescue and propagation of threatened and endangered native species.
2. Improved propagation of difficult-to-propagate-species.

3. Propagation of key species for biodiverse plantings, where the total diversity of an original ecosystem must be restored.
4. Conservation of native germplasm using cryopreservation (where seed can not be stored).
5. Propagation and breeding of climate resilient or disease tolerant selections for future-proofed revegetation.

In all cases, tissue culture provides the advantage that plants produced are disease-free and supply is unaffected by season, climate or natural disaster events.

In addition to tissue culture, we can provide capacity to inform conservation priorities or discover genes underlying traits of interest (e.g. disease tolerance, drought tolerance).

We believe we have the team, capability and passion to deliver innovations in the propagation and conservation of key Australian native flora.

This could have multiple applications in ecosystem recovery and resilience to benefit the Australian environment and economy and work towards a sustainable low-carbon economy.

The Queensland Alliance for Environmental Health Sciences

The Queensland Alliance for Environmental Health Sciences (QAEHS) is a research centre, jointly funded by Queensland Health and The University of Queensland (UQ).

- Environmental aspects of toxicology
- Environmental epidemiology
- Environmental health microbiology
- Health risk assessment
- Health risk communication
- Climate change and health
- Identification and analysis of emerging environmental and public health risks
- State-of-the art monitoring and analytical techniques
- Methodologies and technologies for environmental hazards and exposures

QAEHS is a research centre within the Faculty of Health and Behavioural Sciences, which incorporates and replaces the former National Research Centre for Environmental Toxicology (Entox).

QAEHS aims to improve human health through environmental health science by addressing local, national and global environmental health science challenges and achieve first class outcomes in research, training and partnership engagement while meeting the needs of Queensland and the wider community.

As part of UQ's ongoing and successful environmental health partnership with Queensland Health,

QAEHS is committed to establishing and maintaining multidisciplinary research expertise across a range of environmental health sciences.

Catchment and drinking water micro pollutant water quality monitoring program

The QAEHS Catchment and Drinking Water Quality Micro Pollutant Monitoring Program was launched in mid-2014 with the aim of improving the characterisation and understanding of the micro-pollutant risk profile in source water reservoirs.

The monitoring program uses passive sampling techniques to measure a wide range of polar and non-polar organic contaminants in thirty five reservoirs in South East Queensland (SEQ).

The project aims to provide an insight into the water quality of the target reservoirs through comparison with drinking water quality guidelines.

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Bushfire mitigation policy and planning



This issue will gain increasing urgency at a time when predicted demographic changes will mean growing pressure to increase the availability of land.

The traditional approach to major disasters and emergencies has focussed on investments in response and recovery.

Recent experience, inquiries and the NSDR recognise that this approach is no longer adequate or sustainable.

The frequency, impacts and consequences of significant events are likely to continue increasing into the future along with community exposure and vulnerability.

This will result in greater impacts and higher demands on the emergency management sector.

A key component of increasing Australia's resilience to natural disasters is identifying options for mitigation.

Bushfire mitigation addresses three broad research areas:

- The planning of land use and the built environment, which includes building standards;
- The need to understand future risk and resilience posed by trends in demographics, population and climate change, and

- Planning risk communication and warnings.

Clearly, the work in this theme requires thorough understanding of the vulnerabilities that define potential impact, developed under the 'Disaster Resilience' research theme.

In parallel, the tools and processes developed under the 'Decision Support and Resource Investment' research theme can be directly applied to support the outputs developed.

In response to this, there is increased emphasis on identifying options for mitigation of disasters.

Planning of land use and the built environment

There are benefits to be gained from giving more consideration to the risk from natural hazards in the decisions around land use planning for residential and infrastructure construction.

This issue will gain increasing urgency at a time when predicted demographic changes will mean growing pressure to increase the availability of land.

While it is widely recognised that disaster resilience of communities and landscapes can be improved through better linkages between the emergency management sector and planning of land use and the built environment, this potential is not yet fully realised.

Apparent barriers include the inability to determine and articulate the cost of the transfer of risk for the protection of life and property on an all-hazards basis.

This applies to new development, extensions to existing

There are benefits to be gained from giving more consideration to the risk from natural hazards in the decisions around land use planning for residential and infrastructure construction.

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development including brown field, in-fill and retro-fitting existing development, and critical infrastructure. Potential research areas include:

- Assessment of the appropriateness of current standards and building codes, e.g. flood floor level, cyclone wind loadings, roof types, bushfire building codes etc.
- Assessment of whether there is adequate knowledge transfer between professionals within and between disciplines involved in land use planning
- Determining the level of knowledge represented within the emergency management sector around the options available for the protection of life and property, so that these can be assessed and articulated (e.g. community education, warning, evacuation, property protection, mitigation)
- Assessment whether there is good integration across all hazards in terms of emergency management input to land use planning, so as to avoid conflicting or contradictory requirements

- Assessment whether the public safety requirements being expressed by emergency management agencies are defensible in the legalistic environment of land use and building planning;
- Assessment of the evidence base to support the public safety standards being proposed by the emergency management sector e.g. loss of life, risk from isolation, access to and functioning of public infrastructure, risk exposure of high risk groups (aged care).

A growing challenge for residential planning

There is a growing need to incorporate consideration of the risk from natural hazards to a larger extent into decisions around land use planning for residential and infrastructure construction.

Greater understanding as to the most effective mechanisms to achieve this is required, at a time where predicted demographic change will mean growing pressure to increase the availability of land for settlement purposes.

Climate change and demographics, trends and impacts

There is a growing body of research looking at the impact of climate change on the frequency and severity of climate extremes, including natural hazards.

However, there is a lack of work being undertaken to translate this into changing requirements around preventing, preparing, responding to and recovering from severe natural disasters through changes in the hazard profile.

This should consider changes in land use planning, building codes, and resource allocation, but also assess whether the current preparedness and response paradigm is suited to the likely natural hazard future.

As much of our current planning and investment in infrastructure is based on historical risk profiles, we need assurance that these long-term decisions won't become a liability into the future.

Australia is a country with an evolving community that lives longer, is increasingly concentrated in high-risk areas, and suffers from first world issues.

These socio-economic trends alone make the nation increasingly vulnerable to disasters. Moreover, they interact with the changing natural disaster risk profile from climate change.

Potential research areas include:

- Investigating the (national) future risk profile in terms of impacts on communities and their infrastructure for a range of natural hazards. This should include scenarios for future events and their impacts and consequences
- Assessing how climate change affects bushfire fuels across the nation, and how this affects frequency and severity of bushfires and their potential impact on communities
- Investigating how climate change affects the correlation of natural disasters. For example, whether there will be an increasing/decreasing frequency of coincident events with compound impacts, such as cyclone, storm surge and flooding, or heatwaves and bushfires
- Determine of the interaction of socio-economic trends with the likely impacts of climate change on disaster risk
- Assess whether Australian building codes and planning practices are appropriate for our future risk profile, and investigate options for adaptation to a future risk profile;
- Understand whether the current response paradigm is adequate for an increasingly

uncertain climate future, including different types and duration of impact and different scale of impacts.

Climate change challenge

There is a lack of understanding of the impacts of climate change on the frequency and severity of severe natural hazard events, as it applies to their potential impact and consequences on urban and rural communities, ecosystems, institutions assets and infrastructure.

There is a need for the research to deliver outcomes in terms of likely future impacts of disasters on the community in such a way that this becomes directly useful for current practitioners across the PPRR spectrum.

Communication of risk and warnings

Many Australians are not well aware of the risks from natural hazards they are exposed to.

As a consequence, some individuals and communities do not take an active role in disaster prevention and management.

Communication of risk and how to prepare and respond to natural hazards is usually seen as (part of) the solution.

However, the effectiveness of communication often does not meet expectations, for example due to a lack of understanding of the effectiveness of various tools and methods.

Available communication models have become dated in a rapidly changing technological and demographic environment.

Some communities have by-passed governments and sought

These socio-economic trends alone make the nation increasingly vulnerable to disasters. Moreover, they interact with the changing natural disaster risk profile from climate change.



their own solutions to risk communication.

Research is needed to adapt the current understanding of effective communication to the new environment.

This includes a better grasp of how communication around risk and natural hazards can be tailored to the needs of different communities.

The provision of adequate warnings is a particular aspect of broader risk communication.

The warning communication paradigm is much more complex than it was a decade ago.

The community has higher expectations of warnings.

At the same time, technological advances mean there is scope for any individual to report on emerging events, to spread information and even to issue warnings.

As the warning paradigm evolves, research is needed that involves the users and practitioners of new technologies.

Potential research areas include:

- Further understanding of psychological and social aspects of risk awareness and behaviour in response to communication and warnings in the current (technological and social) environment;
- The potential impact of, and opportunities offered by, new technologies on the effectiveness and timeliness on risk communication and warnings;
- Methodologies and models for multi-dimensional engagement;
- Costs and benefits of delivering targeted warnings;
- Evaluation of the effectiveness of current warning mechanisms;
- Best practice approaches to creating and disseminating warnings

- Understanding expectations and shared responsibility around risk and response to natural disasters;
- Understanding the impact of changing demographics on the efficacy of risk communication and warnings.

Research is needed to adapt the current understanding of effective communication to the new environment.



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Insurance innovations for bushfire recovery and resilience

UQ brings significant expertise in developing insurance innovations to address protection gaps arising from extreme weather conditions, through Professor Paula Jarzabkowski, Associate Professor Paul Spee, and their research teams.

As Australia goes forward with the increased threat of extreme weather conditions and bushfire under climate change, insurance will be a key component in recovery and resilience in two ways.

Firstly, insurance payouts will continue to be important mechanisms in paying for losses and enabling the rebuilding communities in the aftermath of fires.

Secondly, insurance modelling and loss data will provide critical information on increases in risk from bushfire.

Insurance modelling can be used beyond pure price calculations of loss to plan for risk management and consider risk reduction measures that will increase resilience going forward. However, for insurance to continue in its role as a vital economic underpinning of Australian householders, businesses and policy makers, innovations will be needed.

UQ Business School capabilities in disaster management

Firstly, the increasing losses from and threat of bushfire, which has shown it may potentially affect a major urban conurbation, indicate increases in insurance pricing to accurately reflect the risk, which may make it unaffordable.

If we want those in fire risk areas to be able to afford insurance, we will need innovative collaborations between governments and insurance markets. Yet at the same time, we will need to ensure that such collaborations do not suppress critical pricing signals that indicate increased risk.

Rather, we will need collaborative action between government departments, insurance markets, and planning authorities to ensure that rebuilding and future building is fire resilient.

At the same time, subsidisation for those living in fire-exposed legacy assets will be a necessary short-to-medium term measure.

Collaborative action will be essential to ensure innovative schemes to cover protection gaps for those at risk, even as resilience measures are implemented to reduce those gaps.

Secondly, much of the damaged land will simply not have been insured. For example, key unique ecological sites, such as Kangaroo Island are in urgent need of funds to address whatever may be salvageable from an ecological perspective.

In addition, such rebuilding of unique Australian sites will be essential for the tourism industry and its ability to generate revenue.

We therefore need to lead on insurance innovations for financing disaster recovery, learning from other schemes around the world to tailor mechanisms for Australia.

For example, unique insurance products have been developed to

provide cash flow to reconstruct Mesoamerican coral reefs after the damage caused by hurricanes. Considerations of how to pay for such mechanisms will require multilateral agreements between tourism industries, government departments, nature conservancy organisations and insurance markets. Our research can provide both examples of schemes around the world and also work actively with Australian companies and policy-makers to tailor solutions that are specific to the threat of bushfire in Australia.

Executive education on climate change risk including natural disaster

UQ has expertise in developing and delivering executive education on climate change risk and opportunity through a program developed by Dr Belinda Wade and Associate Professor Tim Kastle with support from research teams within the Business School and School of Law.

The first stage of the program has been developed with Munich Re, a global reinsurance provider, and delivered to a major Australian banking and insurance provider.

Climate change will present both physical and transitional risks to organisations.

Physical changes will result in impacts including extreme weather events, sea level rise, and altered resource availability, directly impacting organisations along their value chain.

Transition risks are those risks that arise during the process of managing or avoiding the physical impacts of climate change.

These transitional changes emerge through the introduction of regulation, market changes, technology evolution, societal pressures and legal challenges. Each key sector of industry will be impacted to some degree by these changes.

For example, the Australian electricity sector is a lead indicator of the potential disruption through decarbonisation due to its reliance of aging emission intensive assets and inflexible transmission structure.

Other sectors will be impacted indirectly, for example, through the altered valuation of their investments or impacts on their supply chain.

In summary, all sectors and companies will be impacted whether directly or indirectly through the risks associated with climate change.

The introduction of reporting recommendations from the Task Force on Climate-related Financial Disclosures (TCFD) in 2016 together with the Huntley Opinion (2016 and 2019), which details director's responsibilities, have elevated the issue of climate management into the boardrooms of organisations across Australia.

Although the potential physical and transitional issue have been identified by many companies, there remains a gap between knowledge and practice.

This gap is significant given the rate of change required to avoid climatic change over 2°C and the potential disruption of the Australian economy.

Further research and education is needed to accelerate firm action on climate change.

This executive education program on climate risk has been developed

In summary, all sectors and companies will be impacted whether directly or indirectly through the risks associated with climate change.



Professor Jarzabkowski's current research examines how governments, reinsurance markets, development banks, donors, and humanitarian organisations around the world can better work together to address the growing gap in financial protection from catastrophic disaster in the face of climate change.

to enable companies to understand, measure, and manage the risks and opportunities posed by climate change.

These three key stages have been broken down as follows:

1. Understand the physical and transition risks arising from climate change and their potential impact on business.
2. Measure the risks posed by the physical and transitional change occurring on the path to a decarbonised economy.
3. Manage climate physical and transition risks within a business over the short-to-long term to protect, manage and build resilience within business operations.

Opportunities to evolve and differentiate are also included within the manage section of the course.

An online course on climate change is now in development within the UQ Business School to allow the education to be deployed to more individuals at different levels of an organisation.

It is anticipated that this course will be deployed later this year.

Key staff researching climate related disaster management at the UQ Business School

Paula Jarzabkowski is a Professor of Strategic Management at The University of Queensland Business School and Cass Business School, City, University of London.

Professor Jarzabkowski is an expert in using insurance and reinsurance markets for disaster-risk financing. Her extensive study of the global reinsurance industry has resulted in several papers in leading scientific journals, as well as industry reports and Masterclasses that are drawn upon by practitioners and policy makers around the world, and a widely acclaimed book "Making a

Market for Acts of God" with Oxford University Press.

Professor Jarzabkowski's current research examines how governments, reinsurance markets, development banks, donors, and humanitarian organisations around the world can better work together to address the growing gap in financial protection from catastrophic disaster in the face of climate change.

She studies schemes for closing the protection gap on multiple perils, including bushfire, flood, tropical storm, earthquake and terrorism. Most recently her work examines how financial protection can be more closely linked to physical resilience to disaster.

Her research has been funded by the Australian Reinsurance Pool Corporation, the Bank of England, the British Academy, the Economic & Social Research Council, the European Commission, the Insurance Intellectual Capital Initiative, the Lloyd's Tercentenary Foundation, and the Swiss Prevention Foundation.

Professor Jarzabkowski is Co-Chair of the Expert Advisory Group for the UK Centre for Disaster Protection, and on the OECD High-Level Advisory Board for the Financial Management of Catastrophic Risks.

Professor Jarzabkowski is a sought-after speaker at industry conferences and workshops, and her research frequently featured in industry and business media and is used to inform policy.

Her most recent industry reports are 'Between State and Market: Protection Gap Entities and Catastrophic Risk' and Insurance for Climate Adaptation: Opportunities and Limitations.

Paul Spee is Associate Professor of Strategic Management at The University of Queensland Business School.

Adapting a sociological perspective, Paul's research focuses on individual behaviour and organisational

characteristics influencing the prediction and mitigation of risks, such as bushfires.

Part of the reinsurance research team led by Prof Jarzabkowski, Paul's research investigates social influences shaping the calculation of risks, which inform organisational actions (or the lack thereof).

In addition, his research looks at the communication processes which shape responses and efforts of coordination.

The research on the prediction and mitigation in the context of reinsurance generated high visibility, featuring in various national and international media outlets, such as The Economist, the Financial Times or the Financial Times Magazine, including media appearances on ABC News 24 – The Business.

His research has been funded by the Australian Research Council, Telecommunications Regulatory Authority Bahrain as well as the Centre for the Business and Economics of Health and the Australian Institute for Business and Economics.

Dr Belinda Wade is a lecturer in sustainability and a leader of the Business Schools research area of sustainability.

Belinda's research examines corporate responses to climate change and avenues to progress an accelerated decarbonisation of the Australian economy. Specifically, Belinda has active research projects examining the strategic changes occurring for companies to decarbonise through investment in renewable energy and the divestment of fossil fuel based assets.

These research interests closely follow from Belinda's substantial industry experience in management level strategic positions within the trading departments of several dominant electricity utilities.

Belinda is a regular speaker at events on sustainability, a columnist for the *Entrepreneur Magazine*, and a committee member organising the upcoming Sustainability Research and Innovation 2020 (SRI2020) conference. Her most recent industry report is "Australia's Evolving Energy Future".

Tourism preparedness, recovery and resilience

Brent Ritchie, Gabby Walters, Judith Mair, Sara Dolnicar, Jie Wang

UQ brings significant expertise in disaster planning and management for tourism industries.

Tourism relies heavily on natural resources such as national parks and protected areas, which are prone to bushfire.

Tourism businesses are mainly micro and small businesses.

Due to their small size they face significant challenges to prepare and recover from bushfires.

Tourism destination marketing relies on positive and accurate information and imagery, which can be tarnished by bushfire media coverage, resulting in decline in visitation and flow on impacts on the regional economy. Staff have completed several research projects to inform the planning and management of natural disasters including bushfires.

Studies have examined disaster planning and preparedness in the accommodation sector as well as the factors that can increase planning and preparedness.

Tourists are at risk as they are often unfamiliar with the local area, warning systems and natural hazards, and may not be able to communicate in English.

Research has explored effective ways to communicate risks to tourists from China in particular. In regards to response and

recovery, staff have examined image restoration and recovery marketing for tourism destinations. Research has examined the impact of the 2009 Victorian Bushfires and the most effective recovery marketing messages.

Identifying and targeting resilient market segments, who may visit a soon after a disaster occurs, has also been undertaken.

Finally longitudinal studies have examined the how businesses manage disasters and provided insights into why some businesses thrive after a disaster when others fail.

Tourism relies heavily on natural resources such as national parks and protected areas, which are prone to bushfire.

APPENDIX 1

Research summary



Relevant topics identified

Topic	Terms
1	management/change/land/conservation/vegetation
2	chemical/air/fire/crisis/emission
3	drought/species/mortality/tree/rainfall
4	fire/species/habitat/landscape/disturbance
5	fire/flame/heat/thermal/insulation_material
6	fire/data/spatial/PFAS/event
7	fire/timber/steel/failure/thermal
8	fire/energy/water/climate/city
9	risk/disaster/community/social/event
10	seed/germination/exposure/health/policy
11	fire/concrete/specimen/column/fibre

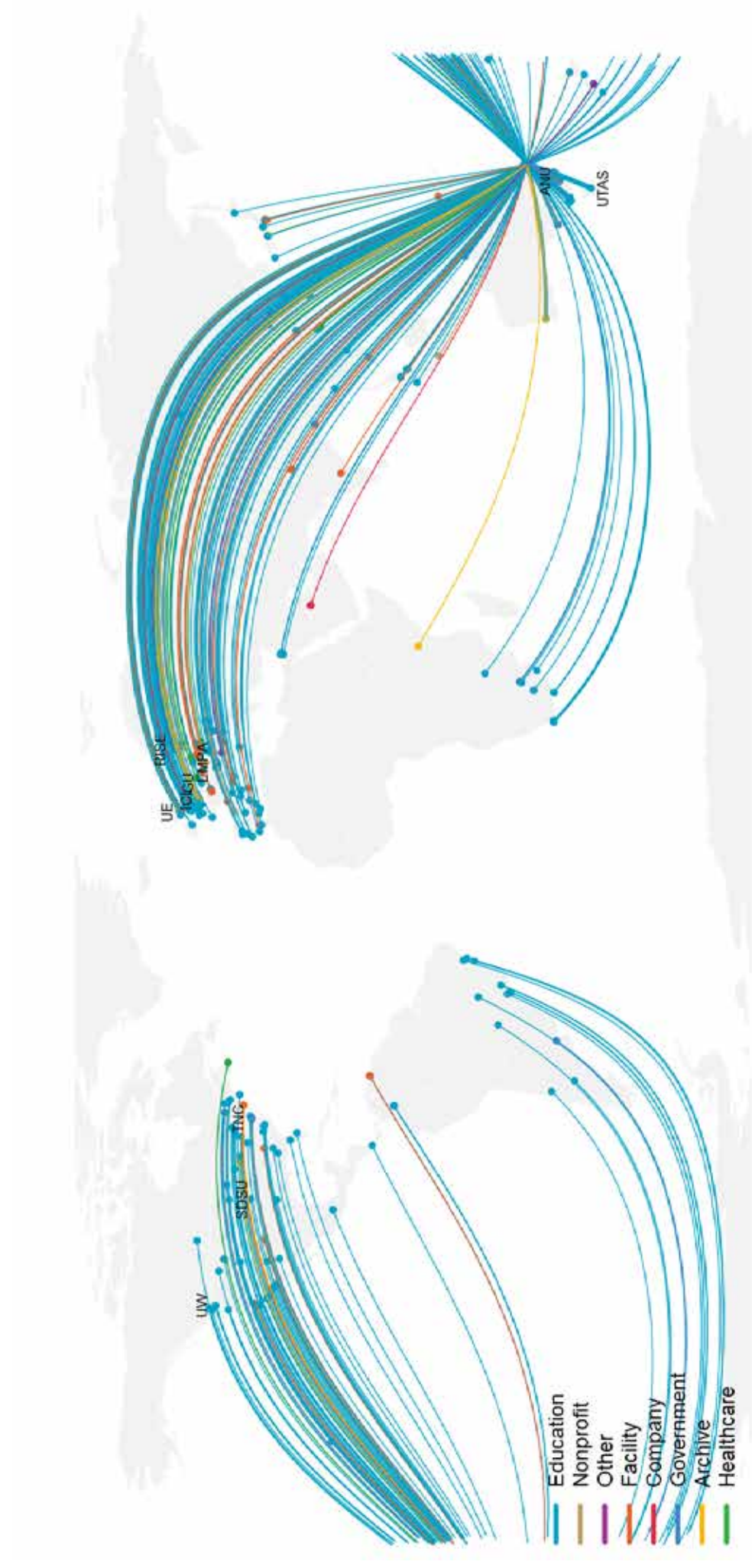
External collaborations	590
External collaborators	316
International collaborators	253
University collaborators	217
Research institute collaborators	37
Industry collaborators	16
Government collaborators	25

Publications	336
Mean CNCI	1.36
Grants	16
Research income	\$6,151,898
Relevant UQ staff (Continuing/Fixed/Industry Fellow; Level B & above)	67

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APPENDIX 2

External collaborations by organisation type map (>2 collaborations, 2013-2020)



APPENDIX 3

External collaborations: top collaborators in each organisation category (domestic & international)

Organisation	Country	Type	Collaborations
University of Edinburgh	United Kingdom	Education	27
Australian National University	Australia	Education	26
University of Tasmania	Australia	Education	18
University of Melbourne	Australia	Education	17
Australian Wildlife Conservancy	Australia	Not-for-profit	10
RISE Research Institutes of Sweden	Sweden	Other	8
Land and Water	Australia	Facility	6
Imperial College London	United Kingdom	Education	5
Arup Group (United Kingdom)	United Kingdom	Company	4
The Nature Conservancy	United States	Not-for-profit	3
University College London	United Kingdom	Education	3
Ghent University	Belgium	Education	3
South Dakota State University	United States	Education	3
CSIRO	Australia	Government	3
Swiss Federal Labs for Materials Science and Tech	Switzerland	Facility	3
University of Washington	United States	Education	3
University of Manchester	United States	Education	3
Dept of Biodiversity, Conservation and Attractions	Australia	Government	3

External grants

ID	Title	Amount (AUD)	Researchers
NE/NO11570/1	Do past fires explain current carbon dynamics of Amazonian forests?	993016.00	Ted R Feldpausch; Luiz Aragao; Oliver L Phillips; Claire Michelle Belcher
FT130101530	Real-time event detection, prediction and visualisation for emergency response	720320.00	Zehao Huang
LP140100504	A lightweight composite panel system for high speed modular construction	600000.00	Tuan Duc Ngo; David Visser; Hamid Reza Ronagh; Jay Gnananandan Sanjayan; Priyan A Mendis; Jose Torero Cullen; Hong-Xun Hao
LP170100557	Climate and health benefits of restoring tropical peat swamp forests	421000.00	Clive Alexander Mcalpine; Kelly Johnstone; Scott Lieske; Paul J Dargusch; Stuart R Phinn; Luke Knibbs; James Shulmeister
LE100100141	High-resolution ITRAX XRF core scanning facility for global change research	420000.00	Dennis Mather; John Dodson; Martin Thoms; Katherine Szabo; Helen McGregor; Allan Chivas; Grzegorz Skrzypek; Charles Skilbeck; David Bowman; Dan Penny; John Pandolfi; Jian-Xin Zhao; Massimo Gasparon; Scott Mooney; Russell Drysdale; Patrick Baker; Jonathan Woodhead; Ian D Goodwin; Kirstie A Fryirs; Paul P Hesse; Mark Warne; Peter Geli; Patrick De Deckker; Michael K Gagan; Simon G Haberle; John C Tibby
DP140102077	The consequences of drought-induced mortality for tree species in a changing climate	393000.00	Rod J Fensham; Craig D Allen; Don William Butler
DP160102806	Why Australian cycads are endangered: Pollinators, climate or humans?	388800.00	Lyn Cook; David Terrington Booth; Robert B Roemer; Lucy Irene Terry; Gimme H Walter
LP100100738	Impact of reforestation on the mitigation of climate extremes in eastern Australia resulting from global warming	385000.00	Clive Alexander Mcalpine; Jozef I Syktus
LP140100279	Rehabilitating a changing landscape: Using koala ecology to direct adaptive management	384853.00	Mathew S Crowther; Mark Howes; Brian Wilson; Clive Alexander Mcalpine; Mark B Krockenberger; Clare Mcarthur; Benjamin Moore; Daniel Lunney
DE160100289	Structural design and distributed fabrication of folded sandwich structures	375000.00	Joseph M Gattas
DP190102992	Core-shell nanofibrous bio-based flame retardants with reinforcement function	310000.00	Ping-An Song; Serge Bourbigot; Cristian Maluk; Qipeng Guo

APPENDIX 5

External grants (cont.)

DP150102354	Fire performance of concrete using fire testing	286300.00	Vinh T N Dao; Luke Alexander Bisby; Liza M O'Moore; Johnny Ho; Jose Torero Cullen
LE180100118	Sensor calibration facility for spectral and thermal remote sensing	159450.00	Arko Lucieer; Andrew McGrath; Stuart R Phinn; Sharon A Robinson; Christoph Rüdiger; Jonathan Roberts; Luis Gonzalez; Zbynek Malenovsky; Vanessa L Lucieer
NE/K000071/1	Dual-wavelength laser scanning for forest health monitoring.	127169.00	Rachel G Gaulton
LP120100172	Evaluating the effectiveness of fire safety programs in emergency services management	106000.00	Jonathan J Corcoran; Prem Chhetri
NE/102982X/1	Assessing the impacts of the 2010 drought on Amazon zone of transition	81990.00	Oliver L Phillips; Ted R Feldpausch

Current key UQ experts (fixed, continuing & industry Fellows: Level B and above)

Name	Unit	Interests	Publications
MALUK ZEDAN, Cristian	Civil Engineering	fire/concrete/specimen/column/fibre; fire/timber/steel/failure/thermal; fire/flame/heat/thermal/insulation_material	34
HIDALGO MEDINA, Juan P	Civil Engineering	fire/flame/heat/thermal/insulation_material; fire/timber/steel/failure/thermal; fire/concrete/specimen/column/fibre	26
LANG, David J	Civil Engineering	fire/timber/steel/failure/thermal; fire/concrete/specimen/column/fibre; risk/disaster/community/social/event	22
LEGGE, Sarah M	Earth and Environmental Sciences	fire/species/habitat/landscape/disturbance; management/change/land/conservation/vegetation; fire/energy/water/climate/city	17
FENSHAM, Rod	Biological Sciences	drought/species/mortality/tree/rainfall; fire/species/habitat/landscape/disturbance; fire/energy/water/climate/city; management/change/land/conservation/vegetation	17
SMITH, Annabel L	Agriculture and Food Sciences	fire/species/habitat/landscape/disturbance	12
MUELLER, Jochen	QAEHS	fire/data/spatial/PFAS/event; chemical/air/fire/crisis/emission	11

APPENDIX 6

Current key UQ experts (cont.)

POSSINGHAM, Hugh	Biological Sciences	management/change/land/conservation/vegetation; fire/species/habitat/landscape/disturbance	9
MOSS, Patrick T	Earth and Environmental Sciences	management/change/land/conservation/vegetation; fire/species/habitat/landscape/disturbance	8
CHAUHAN, Bhagirath	Centre for Crop Science	seed/germination/exposure/health/policy; drought/species/mortality/tree/rainfall	7
CORCORAN, Jonathan J	Earth and Environmental Sciences	fire/data/spatial/PFAS/event; chemical/air/fire/crisis/emission	7
PHINN, Stuart R	Earth and Environmental Sciences	drought/species/mortality/tree/rainfall; risk/disaster/community/social/event; fire/data/spatial/PFAS/event	6
MCLAGGAN, Martyn S	Civil Engineering	fire/flame/heat/thermal/insulation_material; fire/timber/steel/failure/thermal	5
SILCOCK, Jennifer	Biological Sciences	management/change/land/conservation/vegetation; fire/species/habitat/landscape/disturbance	5
MARON, Martine	Earth and Environmental Sciences	fire/species/habitat/landscape/disturbance; management/change/land/conservation/vegetation; drought/species/mortality/tree/rainfall	5
FERNANDO, Dilum	Civil Engineering	fire/timber/steel/failure/thermal	4
MCKENZIE, Simon F	Law	management/change/land/conservation/vegetation	4
DARGUSCH, Paul	Earth and Environmental Sciences	management/change/land/conservation/vegetation; risk/disaster/community/social/event; chemical/air/fire/crisis/emission	4
RHODES, Jonathan R	Earth and Environmental Sciences	management/change/land/conservation/vegetation; fire/species/habitat/landscape/disturbance; drought/species/mortality/tree/rainfall	4
FISHER, Diana O	Biological Sciences	fire/species/habitat/landscape/disturbance; management/change/land/conservation/vegetation; fire/data/spatial/PFAS/event	4
RITCHIE, Brent	Business, Economics and Law	risk/disaster/community/social/event	4
KENWAY, Steven J	Advanced Water Management Centre	fire/energy/water/climate/city	4
THAI, Phong	QAEHS	chemical/air/fire/crisis/emission; seed/germination/exposure/health/policy	4

APPENDIX 7

Current key UQ experts (cont.)

WANG, Xianyu	QAEHS	chemical/air/fire/crisis/emission	3
BRAEUNIG, Jennifer E	QAEHS	fire/data/spatial/PFAS/event	3
RESIDE, April E	Earth and Environmental Sciences	management/change/land/conservation/vegetation; fire/species/habitat/landscape/disturbance	3
WITT, Bradd	Earth and Environmental Sciences	management/change/land/conservation/vegetation; drought/species/mortality/tree/rainfall; fire/data/spatial/PFAS/event	3
LEUNG, Luke	Agriculture and Food Sciences	fire/species/habitat/landscape/disturbance; drought/species/mortality/tree/rainfall	3
LANT, Paul A	Chemical Engineering	fire/energy/water/climate/city	3
CLIFF, David I	Minerals Industry Safety and Health Centre	fire/data/spatial/PFAS/event	3
SHEVELLAR, Lynda J	Social Science	risk/disaster/community/social/event	3
KLIMENKO, Alexander Y	Mechanical and Mining Engineering	fire/flame/heat/thermal/insulation_material; fire/data/spatial/PFAS/event	3
COOK, Lyn	Biological Sciences	fire/species/habitat/landscape/disturbance	3
WATSON, James E	Earth and Environmental Sciences	management/change/land/conservation/vegetation; fire/species/habitat/landscape/disturbance	3
DAO, Vinh T N	Civil Engineering	fire/concrete/specimen/column/fibre	3
KARLOVSEK, Jurij	Civil Engineering	fire/timber/steel/failure/thermal; fire/concrete/specimen/column/fibre	3

APPENDIX 8

Featured publications (2013-2020)

Title	Journal	CNCI	Highly cited
Savanna vegetation-fire-climate relationships differ among continents	Science	13.02	1
Bibliometric visualisation: an application in tourism crisis and disaster management research	Current Issues in Tourism	10.79	1
A review of biomass burning: Emissions and impacts on air quality, health and climate in China	Science of the Total Environment	9.26	1
Tree mortality across biomes is promoted by drought intensity, lower wood density and higher specific leaf area	Ecology Letters	4.54	1
The need for hierarchies of acceptance criteria for probabilistic risk assessments in fire engineering	Fire Technology	7.7	0
Climate risk and state-contingent technology adoption: shocks, drought tolerance and preferences	European Review of Agricultural Economics	5.51	0
Leaching and bioavailability of selected perfluoroalkyl acids (PFAAs) from soil contaminated by firefighting activities	Science of the Total Environment	5.47	0
Landscape management of fire and grazing regimes alters the fine-scale habitat utilisation by feral cats	PLoS ONE	5.33	0
To what extent is drought-induced tree mortality a natural phenomenon?	Global Ecology and Biogeography	4.26	0
Discovery of novel per- and polyfluoroalkyl substances (PFASs) at a fire fighting training ground and preliminary investigation of their fate and mobility	Chemosphere	3.3	0
Structural capacity in fire of laminated timber elements in compartments with exposed timber surfaces	Engineering Structures	2.93	0
Novel fluorinated surfactants tentatively identified in firefighters using liquid chromatography quadrupole time-of-flight tandem mass spectrometry and a case-control approach	Environmental Science & Technology	2.69	0
Complex responses of birds to landscape-level fire extent, fire severity and environmental drivers	Diversity and Distributions	2.34	0

APPENDIX 9

Featured publications (2013-2020) cont.

Extraterritorial hunting expeditions to intense fire scars by feral cats	Scientific Reports	2.32	0
A Thin Skin Calorimeter (TSC) for quantifying irradiation during large-scale fire testing	International Journal of Thermal Sciences	2.21	0
Successional specialization in a reptile community cautions against widespread planned burning and complete fire suppression	Journal of Applied Ecology	2.09	0
Consumer-citizens mobilizing social capital following a natural disaster: Effects on well-being	Journal of Services Marketing	2.03	0
Dominant tree species are at risk from exaggerated drought under climate change	Global Change Biology	1.7	0
Measuring fire severity using UAV imagery in semi-arid central Queensland, Australia	International Journal of Remote Sensing	1.59	0
Perfluoroalkyl substances in a firefighting training ground (FTG), distribution and potential future release	Journal of Hazardous Materials	1.58	0

APPENDIX 10

UQ staff with two or more discipline-related publications

Name	Unit	Interests	Publications
MALUK ZEDAN, Cristian	Civil Engineering	fire/concrete/specimen/column/fibre; fire/timber/steel/failure/thermal; fire/flame/heat/thermal/insulation_material	34
HIDALGO MEDINA, Juan P	Civil Engineering	fire/flame/heat/thermal/insulation_material; fire/timber/steel/failure/thermal; fire/concrete/specimen/column/fibre	26
LANGE, David J	Civil Engineering	fire/timber/steel/failure/thermal; fire/concrete/specimen/column/fibre; risk/disaster/community/social/event	22
LEGGE, Sarah M	Earth and Environmental Sciences	fire/species/habitat/landscape/disturbance; management/change/land/conservation/vegetation; fire/energy/water/climate/city	17
FENSHAM, Rod	Biological Sciences	drought/species/mortality/tree/rainfall; fire/species/habitat/landscape/disturbance; fire/energy/water/climate/city; management/change/land/conservation/vegetation	17
SMITH, Annabel L	Agriculture and Food Sciences	fire/species/habitat/landscape/disturbance	12
MUELLER, Jochen	Queensland Alliance for Environmental Health Sciences	fire/data/spatial/PFAS/event; chemical/air/fire/crisis/emission	11
POSSINGHAM, Hugh	Biological Sciences	management/change/land/conservation/vegetation; fire/species/habitat/landscape/disturbance	9
MOSS, Patrick T	Earth and Environmental Sciences	management/change/land/conservation/vegetation; fire/species/habitat/landscape/disturbance	8
CHAUHAN, Bhagirath	Centre for Crop Science	seed/germination/exposure/health/policy; drought/species/mortality/tree/rainfall	7
CORCORAN, Jonathan J	Earth and Environmental Sciences	fire/data/spatial/PFAS/event; chemical/air/fire/crisis/emission	7
PHINN, Stuart R	Earth and Environmental Sciences	drought/species/mortality/tree/rainfall; risk/disaster/community/social/event; fire/data/spatial/PFAS/event	6
MCLAGGAN, Martyn S	Civil Engineering	fire/flame/heat/thermal/insulation_material; fire/timber/steel/failure/thermal	5
SILCOCK, Jennifer	Biological Sciences	management/change/land/conservation/vegetation; fire/species/habitat/landscape/disturbance	5
MARON, Martine	Earth and Environmental Sciences	fire/species/habitat/landscape/disturbance; management/change/land/conservation/vegetation; drought/species/mortality/tree/rainfall	5

APPENDIX 12

UQ staff with two or more discipline-related publications (cont.)

FERNANDO, Dilum	Civil Engineering	fire/timber/steel/failure/thermal	4
MCKENZIE, Simon F	Law	management/change/land/conservation/vegetation	4
DARGUSCH, Paul	Earth and Environmental Sciences	management/change/land/conservation/vegetation; risk/disaster/community/social/event; chemical/air/fire/crisis/emission	4
RHODES, Jonathan R	Earth and Environmental Sciences	management/change/land/conservation/vegetation; fire/species/habitat/landscape/disturbance; drought/species/mortality/tree/rainfall	4
FISHER, Diana O	Biological Sciences	fire/species/habitat/landscape/disturbance; management/change/land/conservation/vegetation; fire/data/spatial/PFAS/event	4
RITCHIE, Brent	Business, Economics and Law	risk/disaster/community/social/event	4
KENWAY, Steven J	Advanced Water Management Centre	fire/energy/water/climate/city	4
THAI, Phong	Queensland Alliance for Environmental Health Sciences	chemical/air/fire/crisis/emission; seed/germination/exposure/health/policy	4
WANG, Xianyu	Queensland Alliance for Environmental Health Sciences	chemical/air/fire/crisis/emission	3
BRAEUNIG, Jennifer E	Queensland Alliance for Environmental Health Sciences	fire/data/spatial/PFAS/event	3
RESIDE, April E	Earth and Environmental Sciences	management/change/land/conservation/vegetation; fire/species/habitat/landscape/disturbance	3
WITT, Bradd	Earth and Environmental Sciences	management/change/land/conservation/vegetation; drought/species/mortality/tree/rainfall; fire/data/spatial/PFAS/event	3
LEUNG, Luke	Agriculture and Food Sciences	fire/species/habitat/landscape/disturbance; drought/species/mortality/tree/rainfall	3
LANT, Paul A	Chemical Engineering	fire/energy/water/climate/city	3
CLIFF, David I	Minerals Industry Safety and Health Centre	fire/data/spatial/PFAS/event	3
SHEVELLAR, Lynda J	Social Science	risk/disaster/community/social/event	3
KLIMENKO, Alexander Y	Mechanical and Mining Engineering	fire/flame/heat/thermal/insulation_material; fire/data/spatial/PFAS/event	3

APPENDIX 13

UQ staff with two or more discipline-related publications (cont.)

COOK, Lyn	Biological Sciences	fire/species/habitat/landscape/disturbance	3
WATSON, James E	Earth and Environmental Sciences	management/change/land/conservation/vegetation; fire/species/habitat/landscape/disturbance	3
DAO, Vinh T N	Civil Engineering	fire/concrete/specimen/column/fibre	3
KARLOVSEK, Jurij	Civil Engineering	fire/timber/steel/failure/thermal; fire/concrete/specimen/column/fibre	3
ALI, Saleem H	Centre for Social Responsibility in Mining	risk/disaster/community/social/event	2
DOLNICAR, Sara	Business	risk/disaster/community/social/event	2
ERSKINE, Peter D	Sustainable Minerals Institute	fire/data/spatial/PFAS/event; fire/species/habitat/landscape/disturbance	2
ABDUL AZIZ, Ammar	Agriculture and Food Sciences	management/change/land/conservation/vegetation; chemical/air/fire/crisis/emission	2
NARAYAN, Edward	Agriculture and Food Sciences	drought/species/mortality/tree/rainfall; fire/species/habitat/landscape/disturbance	2
JONES, Malcolm K	Veterinary Science	fire/flame/heat/thermal/insulation_material; fire/species/habitat/landscape/disturbance; seed/germination/exposure/health/policy	2
RAUERT, Cassandra B	Queensland Alliance for Environmental Health Sciences	seed/germination/exposure/health/policy; chemical/air/fire/crisis/emission	2
ROELFSEMA, Christiaan M	Earth and Environmental Sciences	risk/disaster/community/social/event	2
ADKINS, Steve	Agriculture and Food Sciences	seed/germination/exposure/health/policy	2
Li, Xue	Information Technology and Electrical Engineering	risk/disaster/community/social/event; fire/data/spatial/PFAS/event; chemical/air/fire/crisis/emission	2
MCGOWAN, Hamish A	Earth and Environmental Sciences	fire/data/spatial/PFAS/event	2
MAZEROLLE, Lorraine A	Social Science	risk/disaster/community/social/event; seed/germination/exposure/health/policy	2
SCHMIDT, Susanne	Agriculture and Food Sciences	fire/energy/water/climate/city; fire/species/habitat/landscape/disturbance	2
HUME, David A	Mater Research Institute-UQ	fire/species/habitat/landscape/disturbance	2

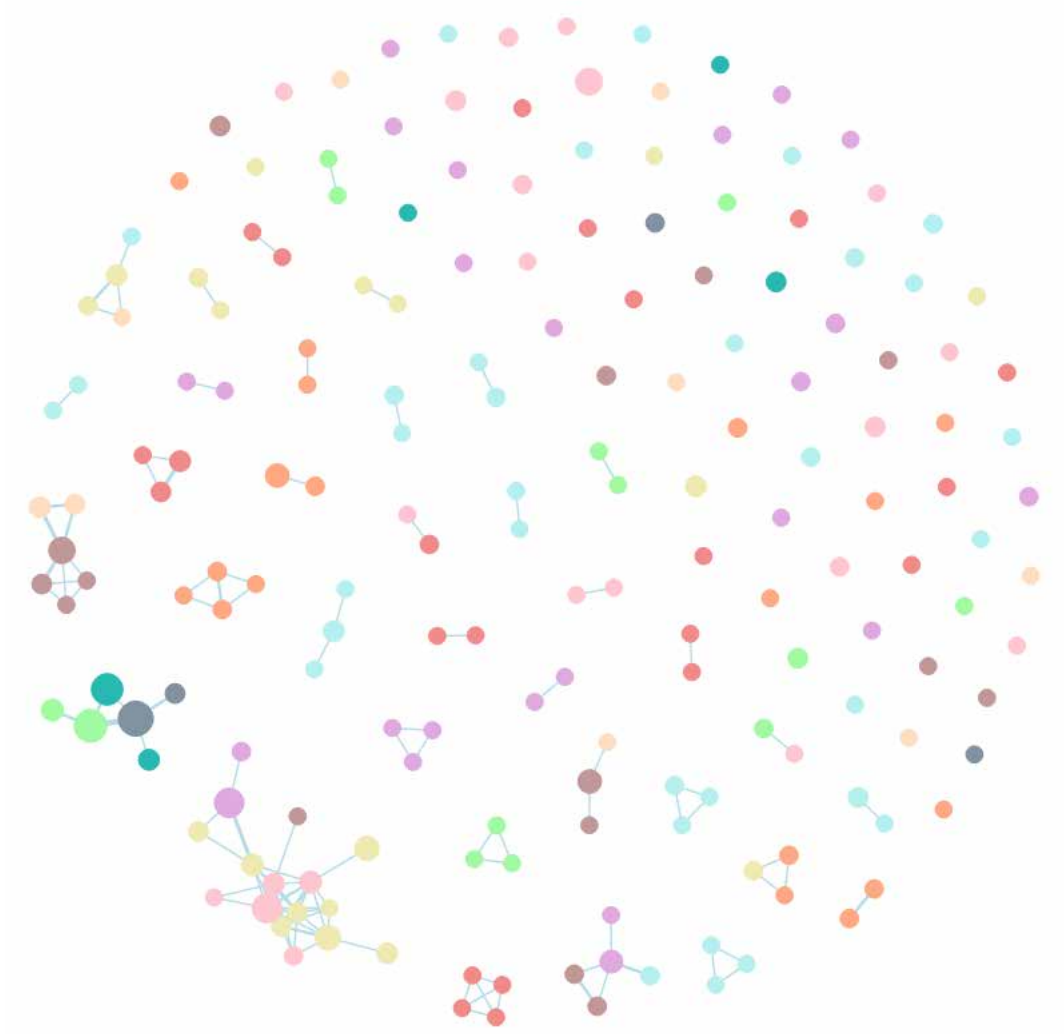
APPENDIX 14

UQ staff with two or more discipline-related publications (cont.)

QUIGGIN, John C	Economics	drought/species/mortality/tree/rainfall; management/change/land/conservation/vegetation; fire/data/spatial/PFAS/event	2
DWYER, John	Biological Sciences	drought/species/mortality/tree/rainfall; chemical/air/fire/crisis/emission; fire/species/habitat/landscape/disturbance	2
ZHAO, Jian-xin	Earth and Environmental Sciences	management/change/land/conservation/vegetation; drought/species/mortality/tree/rainfall	2
XU, Dongming	Business	risk/disaster/community/social/event	2
MARTIN-KHAN, Melinda G	Centre for Health Services Research	seed/germination/exposure/health/policy; risk/disaster/community/social/event	2
KARK, Salit	Biological Sciences	fire/species/habitat/landscape/disturbance; management/change/land/conservation/vegetation	2
MAYFIELD, Margaret M	Biological Sciences	drought/species/mortality/tree/rainfall; seed/germination/exposure/health/policy	2
MCKENNA, Phillip B	Centre for Mined Land Rehabilitation	fire/data/spatial/PFAS/event; fire/species/habitat/landscape/disturbance	2
WELSH, Kevin J	Earth and Environmental Sciences	management/change/land/conservation/vegetation; seed/germination/exposure/health/policy	2
SAHA, Tapan K	Information Technology and Electrical Engineering	seed/germination/exposure/health/policy	2
EKANAYAKE, Chandima M B	Information Technology and Electrical Engineering	seed/germination/exposure/health/policy	2
HEITZMANN, Michael T	Mechanical and Mining Engineering	fire/concrete/specimen/column/fibre; fire/flame/heat/thermal/insulation_material	2
KISELY, Stephen R	Clinical Medicine	seed/germination/exposure/health/policy; risk/disaster/community/social/event	2
LOWE, Kelsey	Social Science	seed/germination/exposure/health/policy; management/change/land/conservation/vegetation	2
LE BROCCQUE, Robyne M	Nursing, Midwifery and Social Work	risk/disaster/community/social/event	2
BEYER, Hawthorne	Biological Sciences	fire/species/habitat/landscape/disturbance; fire/data/spatial/PFAS/event	2
JANSE VAN RENSBURG, Berndt	Biological Sciences	fire/species/habitat/landscape/disturbance; chemical/air/fire/crisis/emission	2

APPENDIX 15

UQ community collaboration topic networks



seed/germination/exposure/health/policy

risk/disaster/community/social/event

management/change/land/conservation/vegetation

fire/timber/steel/failure/thermal

fire/species/habitat/landscape/disturbance

fire/flame/heat/thermal/insulation material

fire/energy/water/climate/city

fire/data/spatial/PFAS/event

fire/concrete/specimen/column/fibre

drought/species/mortality/tree/rainfall

chemical/air/fire/crisis/emission



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