UNIVERSITY OF CANBERRA

CENTRE FOR APPLIED WATER SCIENCE

INSTITUTE FOR APPLIED ECOLOGY

CENTRE FOR APPLIED WATER SCIENCE

ANNUAL REPORT 2020–21

The Centre for Applied Water Science acknowledges the Ngunnawal people, traditional custodians of the lands where Bruce Campus is situated. We wish to acknowledge and respect their continuing culture and the contribution they make to the life of Canberra and the region. We also acknowledge all other First Nations Peoples on whose lands we gather.

Cover images: Top left, high school students sampling Lake Ginninderra as a part of the 2021 National Youth Science Forum with Professor Ross Thompson (Photo credit: Ross Thompson), top right Lachlan River wetlands the focus of a $2.9M research program led by Professor Fiona Dyer (Photo credit: Will Higgisson), bottom lake enclosures studying blue green algal blooms in Lake Tuggeranong in partnership with the ACT government (Photo credit: Ross Thompson).

Images throughout are as credited.

CONTENTS

RESPONDING TO THE GLOBAL WATER CRISIS

Globally, 2.1 billion people lack access to safe drinking water. Poor water quality due to pollution has direct health impacts on more than 5 million people. One in three people on Earth are affected by water scarcity, and more than one third of the world's cities are threatened by water shortages. In many parts of the world profound drying trends and altered patterns of rainfall are affecting agricultural productivity. Global demands for energy have resulted in a proliferation of major hydro-electric dam projects, with consequences for downstream flows, riverine productivity and nearshore marine fisheries. Collectively these trends are resulting in areas of geo-political instability.

Australia is the world's driest inhabited continent and is significantly challenged by global changes in patterns of rainfall and the frequency and intensity of drought. There is an emerging water crisis in Australia as a drying climate interacts with natural climatic variability climate and high consumptive water use. Median projections for water availability in the Murray-Darling Basin show a decline in mean annual runoff of 10% averaged across the Basin for 1oC global warming by about 2030, and twice that by about 2060 (see below).

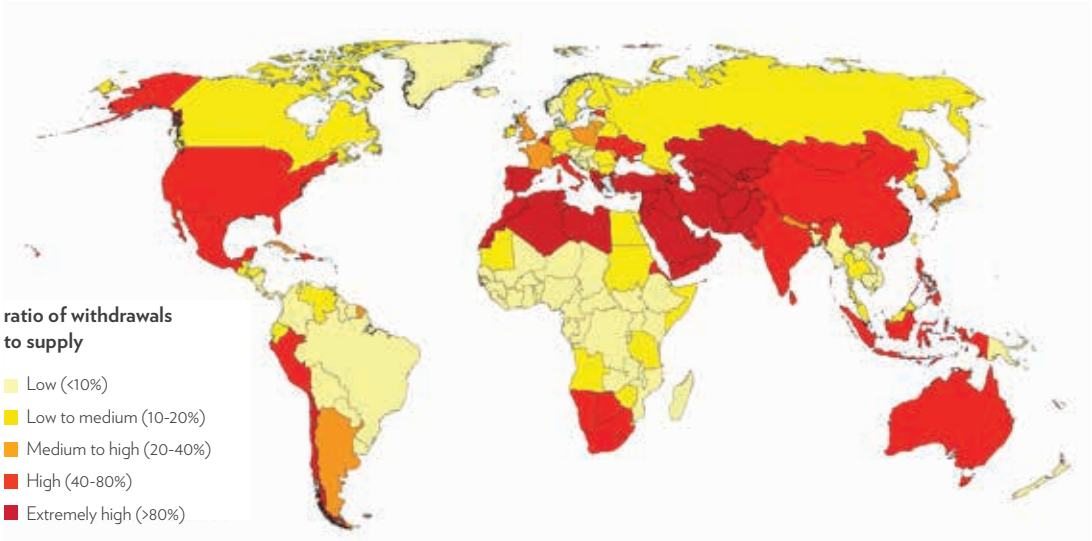
At least $30B has been spent on water reform and water management programs in Australia over the last decade. There needs to be policy-relevant science advice to inform the evaluation of those investments, and to guide water reform and policy in the coming decades. This need is particularly acute given the public focus on fish kills, drought management, water markets and bushfires.

(Photo credit: Mark Naftalin/UNDP — open source)

> “80% of the world's river systems are now profoundly impacted by human activities.”

(Photo credit: Getty Images)

Water Stress by Country: 2040

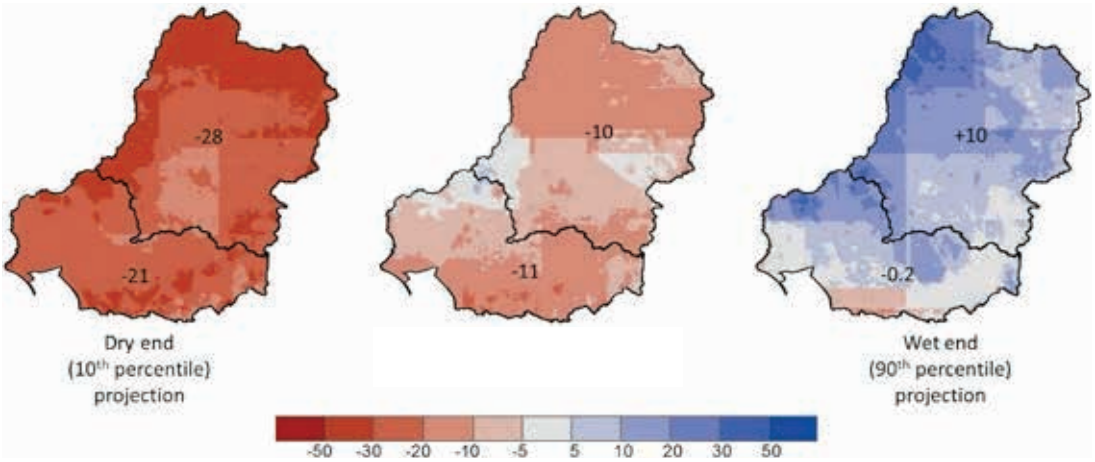


NOTE: Projections are based on a business-as-usual scenario using SSP2 and RCP8.5.

For more: ow.ly/RiWop

Predicted water stress by country in 2040 (Gassert et al. 2013)

Median Projection



Percentage change in mean annual runoff for 1°C global warming.

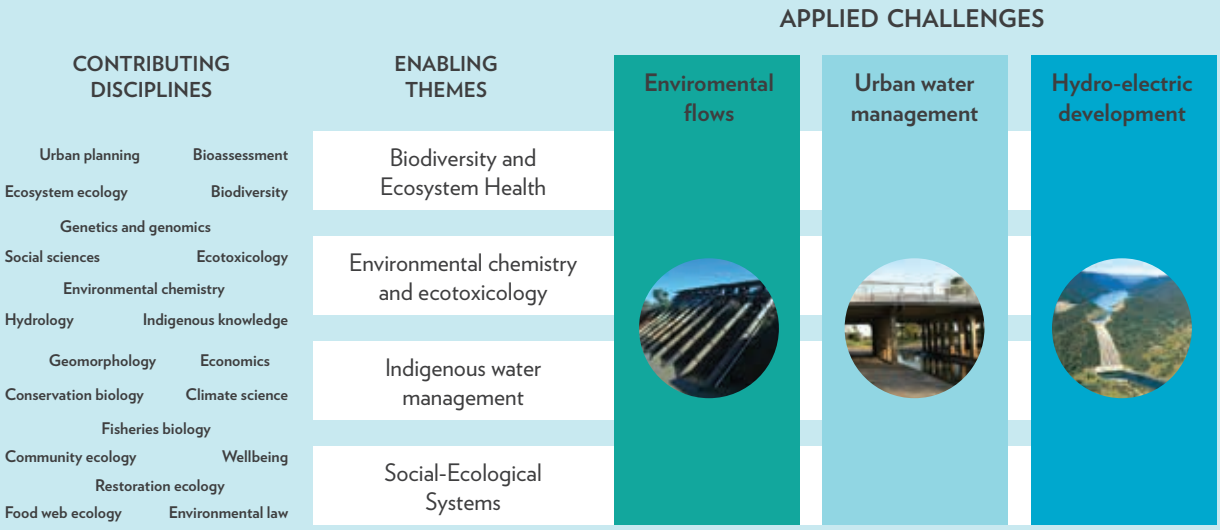
Median projected changes in mean annual runoff across the Murray Darling Basin by 2030 (South Eastern Australian Climate Initiative **www.seaci.org**; IPCC AR5 WG2 Australasia chapter, Reisinger et al.) 2015; Chiew et al 2009).

THE CENTRE FOR APPLIED WATER SCIENCE

The Centre for Applied Water Science (CAWS) is an international leader in research and knowledge-generation about 'managed waters'.

CAWS' water science core research strength is provided by academics with complementary expertise in environmental chemistry, eco-hydrology, community ecology, climate science, Indigenous knowledge and science, ecosystem ecology, geomorphology and ecotoxicology. The Centre also draws on personnel across the University, working across disciplinary boundaries to focus on integrated solutions to water management challenges. It has particularly strong connections with the Centre for Conservation Ecology and Genomics through the over-arching Institute for Applied Ecology, the Centre for Urban and Rural Futures, the Climate Change Adaptation and Resilience Research Network and the Institute for Governance and Policy Analysis.

CAWS focuses effort, reputation, and external engagement into areas of national and global significance. Four enabling themes focus diverse approaches to addressing water management challenges. This provides an opportunity to apply technologies in remote sensing and water quality assessment, eDNA, social-ecological systems, dispersed internet-of-things sensor networks and big data analysis and management.



RESEARCH EXCELLENCE

BUILDING KNOWLEDGE

CAWS researchers carry out fundamental and applied research in all areas of water science, publishing in peer-review journals and training the next generation of scientists.

POLICY RESPONSIVENESS

Recognising the urgent need for policy-relevant research, CAWS works closely with government and managers to ensure that research outcomes and scientific knowledge are provided in a timely way to ensure outcomes.

THOUGHT LEADERSHIP

CAWS leads efforts to develop consensus positions on issues of national relevance in water management based on the best available science.

A COLLABORATIVE APPROACH

CAWS leads and participates in major research consortia, seeking to bring the best expertise from around the Australia and the world and apply is to water management challenges.

(Photo credit: Ross Thompson)

EDUCATION AND TRAINING

UC has had an exceptional reputation for training water scientists for over two decades. A feature of UC has been the movement of public service staff into graduate programs and back into the public service. UC graduates are well regarded for their practical focus and 'work ready' nature. Working in partnership with the Faculty for Science and Technology and the Institute for Applied Ecology, CAWS contributes to excellence in education and training.

UNDERGRADUATE PROGRAMS

Research Placements and Honours. CAWS staff are actively engaged in teaching into the science and environmental science programs at UC. This includes working with partners outside the university to provide student work placements and research opportunities. The Honours program is integrated into the Centre's research activities and provides an opportunity to work with agencies and the private sector to develop and carry out short, focussed research projects.

PHD AND MASTERS BY RESEARCH

CAWS works closely with the Faculty and University Graduate Research Office in co-developing a graduate training program that emphasises relevant professional skills and research excellence. This includes Masters and PhD research programs that feature strong links to applied outcomes and include co-supervision, placements and co-development of projects with government agencies and the private sector.

GRADUATE TRAINING AND SHORT COURSES

CAWS works with colleagues inside the Faculty and the university to offer training in bioassessment (AUSRIVAS), evidence synthesis (EcoEvidence), water technologies, application of genetics and genomics, ecological modelling and hydrologic modelling. The emphasis is on providing a working knowledge in key areas, including emerging technologies

(Photo credit: Ross Thompson)

PARTNERSHIPS AND NETWORKS

CAWS maintains and seeks profound relationships with partners from the private sector, government and the research sector. CAWS researchers work closely with the ACT government, Commonwealth departments, the Murray Darling Basin Authority, Research and Development Corporations, water utilities, developers and technology providers.

CAWS benefits from working with a small group of international partners in key areas of research focus, allowing access to research funding and facilities not available in Australia, providing opportunities for graduate and staff training, and ensuring research excellence.

OUR STAFF

CAWS carries out research and graduate training in the following core areas:

- Water management in rural and urban environments including water sensitive urban design, water planning and law
- Aquatic bioassessment and ecosystem health assessment
- Native fish ecology, conservation and management
- Environmental flows management
- Indigenous water management
- Social economic and ecological perspectives on water
- Environmental chemistry and ecotoxicology
- Hydrology and geomorphology

PROFESSOR ROSS THOMPSON

Director, Centre for Applied Water Science

Professor Ross Thompson has research interests in biodiversity and restoration of landscapes, mainly in freshwater ecosystems. The fundamental part of his research program is in food-web ecology; seeking the rules that determine how natural communities assemble and persist. Ross' applied research addresses the ways in which food webs can be influenced by anthropogenic factors including urbanisation, land clearance, pharmaceutical contamination, invasion, and river flow management. He has an active research program on aquatic biodiversity and ecosystem function in urban and rural landscapes.

Over his 16y academic career to date he has published >110 papers, 11 book chapters and >150 scientific reports. He has attracted more than $10M of research funding and has been continuously funded by the Australian Research Council via Future Fellowship, Discovery and Linkage projects for the last 12 years. From 2015–2018 he occupied a Senior Management role as Director of the Institute for Applied Ecology. Ross has sat on the Australian Research Council College of Experts and is a past President of the Australian Freshwater Sciences Society. His work has strong links to government and industry, and Ross sits on advisory panels for local, state, and federal research programs.

In 2021 Ross was awarded the Hilary Jolly Medal for Research Excellence by the Australian Freshwater Sciences Society.

PROFESSOR FIONA DYER

Deputy Director, Centre for Applied Water Science

In 2021 Dr Fiona Dyer was promoted to full tenured Professor, representing her profound contributions to research, teaching, engagement, and service at the University of Canberra.

Professor Dyer has research interests in ecology and hydrology with a particularly strong focus on anthropogenic impacts on freshwater ecosystems. Over her 15-year academic career she has authored more than 100 publications including 53 peer reviewed papers, 2 research books and 1 book chapter. This includes 21 papers in the past 3 years with 75% of papers in the top quartile of journals. Fiona holds ministerially appointed positions on the Snowy Advisory Committee and the Lachlan Environmental Water Advisory Group and previous positions on the ACT & Region Catchment Management Coordination Group and the ACT NRM Committee. She leads multiple research projects including the Lachlan Selected Area Flow-MER program and major projects on urban lakes and wetlands with the ACT government.

ACADEMIC STAFF

Professor Ross Thompson (Director)
Food web ecology

Professor Fiona Dyer (Deputy Director)
Eco-hydrology

Associate Professor Simon Foster[2021]
Environmental chemistry and toxicology

Associate Professor Ben Kefford
Biodiversity and eco-toxicology

Associate Professor Duanne White
Geomorphology and climate change

AFFILIATE MEMBERS

Associate Professor Jurian Hoogewerff
Geochemistry, environmental chemistry

Professor Charles Lemckert
Water systems engineering/management

Professor Barbara Norman
Urban planning

Professor Murray Raff[2021]
Environmental law

Associate Professor Jacki Schirmer
Socio-economic dimensions of water

Professor Darren Sinclair
Environmental governance

Professor Rob Tanton
Micro-e*conomics*

RESEARCH FELLOWS

Dr Joanne Bennett*
Biodiversity and landscape ecology

Dr Jonathan Bray*[2020]
Ecotoxicology

Dr Andrew Brooks*[2021]
Biodiversity

Ben Broadhurst*
Fish ecology

Dr Steven Gao*
Spatial ecology and GIS (joint with CSIRO)

Dr Darren Giling*
Quantitative ecology (joint with CSIRO)

Enzo Guarino*
Hydrology

Dr Will Higgisson*
Plant ecology

Dr James Hitchcock*
Food web ecology and bioenergetics

Associate Professor Mark Lintermans*
Native fish biology and conservation

Associate Professor Bradley Moggridge
Indigenous water management

Dr Sue Nichols
Bioassessment and systematic review

Distinguished Professor LeRoy Poff
Environmental flow ecology

Dr Rod Ubrihien*
Urban lake management

Dr Peter Unmack
Genetics/genomics of Australian fishes

Legend: Staff marked with * are directly funded by external income. [2020] finished in 2020. [2021] finished in 2021.

TECHNICAL AND ADMINISTRATIVE STAFF

Dr Jill Bartlett
Contract management

Yasmin Cross
Laboratory and facilities manager

Rhian Clear*
Research technician

Ugyen Lhendup*
Research technician

Lea Knight*
Research technician

Alica Tchierschke*
Research technician

Hugh Allan*
Casual research technician

Ann Bennett*
Casual research technician

Dani Gutierrez*
Casual research technician

Jack Livingstone*
Casual research technician

Gus MacDonald*
Casual research technician

Joseph O'Connell*
Casual research technician

ADJUNCTS

Professor Peter Bridgewater

Professor Neil Byrom

Dr Brenda Dyack

Dr Rod Kennett

Dr Leah Moore

Dr Rob Rolls

Professor Brad Sherman

Professor Sue Briggs (1950–2020)

Dr Paul Downey

Professor John Hewson

Dr Ian Prosser

Dr Rob Richards

Professor Darren Ryder

Vale Professor Susan 'Sue' Briggs, AM
1950–2020

It is with great sadness that we note the passing of Professor Sue Briggs AM in late 2020, after a short illness. Sue was a wetland ecologist with a profound interest in science policy, education, and engagement. She completed her Bachelor of Science in Agriculture at Sydney University in 1972, her Masters of Natural Resources at University of New England in 1976, and her Doctor of Philosophy at the Australian National University in 1990.

Her career began in the NSW government in 1975 and she worked in several roles until her retirement in 2011 as Principal Research Scientist with the NSW Department of Environment and Climate Change based at CSIRO. At that time Sue moved into a role as Adjunct Professor in Ecosystem Management at the Institute for Applied Ecology at the University of Canberra. She was an active and much-loved teacher, collaborator and mentor, teaching courses in Environmental Planning and Assessment; Ecology and Biodiversity; Environmental Conflict Management; Conservation Biology and Professional Practice in Applied Science. Professor Briggs was made a Member of the Order of Australia in 2012 "For service to conservation and the environment through research and advisory roles supporting natural resources management and policy development" and was a Life Member of the Australasian Wildlife Management Society.

INTRODUCING OUR NEW STAFF

Dr Jill Bartlett (commenced 2021). Jill completed her PhD at UC in 2018 in environmental chemistry before moving into a post-doctoral position in urban stormwater management through CAWS' partnership with Riverview Ltd. In late 2020 Jill began to transition into her new role as managing external contracts and stakeholder engagement with CAWS, although she continues to be engaged in research and research supervision.

Dr Joanne Bennett (commenced 2020). Joanne is funded by the Commonwealth Environmental Water Office Flow-MER program and works on the role of environmental flows in supporting critical processes and flow refugia at whole of landscape scales. Jo was formerly a Postdoctoral research fellow at the Martin Luther University of Halle-Wittenberg and the German Centre for Integrative Biodiversity Research (iDiv), Leipzig. **In the past year Jo has published 2 high profile papers in the eminent journal Nature Communications.**

Dr Steven Gao (commenced 2020). Steve is a remote sensing specialist appointed as a joint position between CSIRO and UC. His research advances techniques to evaluate woody floodplain vegetation response to drought and environmental flows. The focus of his research is to integrate new approaches involving remote sensing of evapotranspiration to advance the understanding of floodplain ecosystem function across broad climatic zones and scales.

Dr Darren Giling (commenced 2019). Darren came to UC as a joint CSIRO-UC senior research fellow in environmental flows ecology. He was previously with the Department of Experimental Limnology Leibniz Institute of Freshwater Ecology and Inland Fisheries (IGB) in Stechlin, Germany. His interests are in quantitative ecology, particularly at landscape scales. **In 2020 Darren was successful in gaining a highly competitive Australian Research Council Discovery Early Career Research Award.**

Dr Will Higgisson (commenced 2019). Will completed his PhD with Fiona Dyer at UC in 2018 and has moved into a post-doctoral role supporting the Lachlan Selected Area Flow-MER program. His research interests are broad but include native plant ecology and biology, remote sensing of vegetation condition and the impacts of environmental watering on vegetation diversity, condition and distribution.

Dr James Hitchcock (commenced 2020). James moved to UC from UTC in 2020 to take up a role within the Basin-scale Flow-MER program. His research interests are wide-ranging but include food-web ecology, ecosystem energetics and micro-plastic pollution. He has worked on a wide range of aquatic habitats including streams, rivers, and estuaries. James has published extensively across those areas and is active in research supervision.

Associate Professor Brad Moggridge (commenced 2020). Brad Moggridge is a proud Murri from Kamilaroi Country in northern NSW. His research interests are in the area of hydro-geology and Indigenous reconciliation in water. Brad was awarded the ACT Tall Poppy Science Award in 2019 and a Lifetime Achievement Award by CSIRO in 2020. In 2020 Brad led a successful bid to the Australian Water Partnership addressing global issues around the engagement of indigenous peoples in water management.

OUR RESEARCH

There have been notable granting successes in 2020/21.

Darren Giling was successful with a highly prestigious Australian Research Council Discovery Early Researcher Award (DECRA). A team led by Ben Kefford and including LeRoy Poff, Ross Thompson, Jollene Reich and Beatrice Dewenter were successful with a Hermon Slade Grant ($170K), and a team led by Bradley Moggridge with Ross Thompson, Anne Poelina (CDU) and Phil Duncan (MQU) have been funded by the DFAT Australian Water Partnership. This is in addition to ongoing major research projects funded by the ARC, the Department of Agriculture, Water and Environment and the ACT Government.

RESEARCH SHOWCASE 2020/21

AUSTRALIAN RESEARCH COUNCIL DISCOVERY GRANT (DP180102016)

Project title: Does Climatic Thermal Variability matter?

Research team:
A/Prof Ben Kefford
Prof Ross Thompson
Prof LeRoy Poff
Prof Jane Hughes (Griffith)
Beatrice Dewenter (PhD student)
Jollene Reich (PhD student)

Summary: This project explores the ways in which climate change may influence biodiversity in the future. Working in northern Queensland and alpine NSW, linking with collaborators in Costa Rica and Colorado, the project seeks to understand the potential for aquatic invertebrates to adapt to changes in climate. Rather than focussing on mean changes in temperature alone, the project also investigates the effects of changes in temperature variability. Individual physiological assays are combined with community ecology and population genetics to understand how organisms may adapt or move in response to changing temperatures.

Aquatic habitats in the NSW alpine zone (top) and tropical Queensland (lower) are being used to better understand the effects of climate change on biodiversity. (Photo credits: Ross Thompson)

ACT GOVERNMENT URBAN LAKES PROJECT

Project title: Urban Stormwater Research: Lake Tuggeranong and Urban Ponds

Research team:
Prof Fiona Dyer
Dr Rod Ubrihien
Prof Ross Thompson
Joseph O'Connell (Honours student)

Summary: Algal blooms are an ongoing management challenge in urban lakes around the world, including in Canberra. Working in partnership with the ACT Government, a team led by Professor Fiona Dyer have been investigating the drivers of algal blooms in Lake Tuggeranong and other Canberra waterways. This research has involved the use of in-lake mesocosms to test different management approaches and extensive surveys of urban waterways to seek the sources of contaminants.

Aquatic mesocosms (experimental enclosures) in place in Lake Tuggeranong, investigating potential control measures for blue green algal blooms. (Photo credit: Ross Thompson)

COMMONWEALTH GOVERNMENT MONITORING, ECOLOGY AND RESEARCH PROGRAM: LACHLAN SELECTED AREA

Project title: The response of important native plant species to the use of environmental water

Research team:
Professor Fiona Dyer
Dr Will Higgisson
Jack Livingstone
And collaborators

Summary: The Flow Monitoring Evaluation and Research program (**www.flow-mer.org.au**) seeks to understand how the provision of environmental flows in the Murray Darling Basin may be used to manage key species, habitats and ecosystem functions. UC leads the monitoring of the Lachlan Selected Area (one of seven), led by Professor Fiona Dyer. The work described here is one of the many products of that program.

The Murray-Darling Basin is home to a large number of plant species known to have important uses for aboriginal people. While Commonwealth environmental watering actions to date have not deliberately targeted plant species because of their cultural significance or uses, watering actions that support groundcover vegetation have supported a range of native plant species that have a variety of uses by aboriginal people. In a case study of three native plant species, a UC led team demonstrated the role of environmental water in 2019–20 in supporting cover and abundance and highlight the potential to achieve benefits for these native plant species in the management of environmental water. This study demonstrates the important role environmental water can make in maintaining important native plant species in the landscape. There is opportunity to engage with Aboriginal communities across the Basin to identify plant species that are culturally important and can be supported with environmental water. This can help establish more specific objectives for vegetation outcomes in the Basin and help inform the design of watering actions.

Marsilea drumondii (Nardoo) during extensive flooding at Yanga National Park (2010–2012). Aboriginal communities used Nardoo in such large amounts that sets of grinding stones have been found in so-called 'Nardoo Mills'. These stones were used to grind the roasted sporocarps into a powder before mixing to make a dough which was baked to create bush bread or seedcakes high in protein and carbohydrates. The dough could also be eaten raw. (Photo credit: Tanya Doody, CSIRO)

RESEARCH INCOME

Category 1 (National Competitive Grants) funding — 2020/2021: $1,227,845

Category 2/3 (Government and Consultancy) funding — 2020/2021: $ 10,993,553

MAJOR PROJECTS (>$50,000 total value)

TITLE	LEAD INVESTIGATORS	FUNDER	TOTAL AMOUNT
CATEGORY 1 GRANTS			
Unravelling how ecosystems function through time and space	Darren Giling	Australian Research Council (DECRA program)	$456,645
Excellence in Antarctic Science	Duanne White	Australian Research Council (Special Research Initiative)	$300,000
Does Climatic Thermal Variability matter?	Ben Kefford Ross Thompson	Australian Research Council (Discovery program)	$299,600
Future proofing Australia's high country for climate change	Ben Kefford Duanne White	Australian Research Council (LIEF program)	$86,000
Developing a mechanistic impact of the effect of fires on stream macroinvertebrates.	Ben Kefford Ross Thompson	Hermon Slade Foundation	$85,600
CATEGORY 2/3 GRANTS			
Monitoring, Evaluation and Research Services: Basin Scale	Fiona Dyer	Commonwealth Environmental Water Office (Department of Agriculture, Water and Environment)	$2,935,800
Monitoring, Evaluation and Research Services: Basin Scale	Ross Thompson	Commonwealth Environmental Water Office (Department of Agriculture, Water and Environment)	$2,296,800
Urban Stormwater Research: Lake Tuggeranong and Urban Ponds	Fiona Dyer	ACT Government (Environment and Sustainable Development Directorate)	$1,317,600
Enlarged Cotter Reservoir ecological monitoring program	Ben Broadhurst	Icon Water	$1,012,170
Assessing fire impacts on spiny crayfish	Mark Lintermans	Commonwealth Wildlife and Habitat Bushfire Recovery Program	$629,500
Microbial conversion of kelp to high nitrogen plant and animal feeds	Simon Foster	NZ Ministry of Business, Innovation & Employment	$492,800
Evaluating woody floodplain vegetation	Fiona Dyer	CSIRO	$473,000
Below dams monitoring program	Ben Broadhurst	Icon Water	$343,686
Primary production responses to environmental flows	Ross Thompson	CSIRO	$300,000
Monitoring Flow and Water Quality: Ginninderry Development	Ross Thompson	Riverview Projects (ACT) Pty Limited	$256,200
Thredbo River bioassessment program	Ben Broadhurst	Kosciuszko Thredbo Pty. Ltd.	$214,191

TITLE	LEAD INVESTIGATORS	FUNDER	TOTAL AMOUNT
Murray River seasonal pulse productivity assessment	Darren Giling	Murray Darling Basin Authority	$168,574
AUSRIVAS river health assessment training	Sue Nichols	State governments	$150,000
ACT Water Quality assessment.	Ben Broadhurst	ACT Government (Environment and Sustainable Development Directorate)	$110,232
Giving a voice to Indigenous perspectives on Australian water management	Brad Moggridge Ross Thompson	Australian Water Partnership (Commonwealth Department of Foreign Affairs & Trade)	$97,000
eDNA methods to monitor native fish in the Lachlan catchment during 2018-19	Fiona Dyer	Commonwealth Environmental Water Office (Department of Agriculture, Water and Environment)	$71,800
Preparation of a cultural watering plan for the Mungindi Local Aboriginal Land Council	Brad Moggridge Ross Thompson	North West Local Land Services (NSW State Government)	$71,200
Rapid assessment of priority sites where weeds threaten biodiversity across the South East Local Land Services region.	Fiona Dyer	South East Local Land Services (NSW State Government)	$53,000

Category 1 Funding (Australian Competitive Grants).

There have been notable Category 1 granting successes in 2020/21. Darren Giling was successful with a highly prestigious Australian Research Council Discovery Early Researcher Award (DECRA). A team led by Ben Kefford and including LeRoy Poff, Ross Thompson, Jollene Reich and Beatrice Dewenter were successful with a Hermon Slade Grant ($170K). Major Category 1 funding proposals are currently either under consideration (ARC DECRA, ARC Discovery) or under development (ARC Future Fellowship, 2x ARC Linkage).

Category 2 Funding (Public Sector Funding).

Ongoing major projects with the Department for Agriculture, Water and Environment (totalling $5.2M) and the ACT government ($1.3M) are currently subject to re-bids which are due in late 2021. A team led by Bradley Moggridge with Ross Thompson, Anne Poelina (CDU) and Phil Duncan (MQU) have been funded by the DFAT Australian Water Partnership for research on Indigenous reconciliation and water. Major Category 2 bids were made in 2020 to the Terrestrial Ecosystem Research Network (>$40M) and the Water Environments Research Program ($20M) but were unsuccessful.

Category 3 Funding (Industry Funding).

Major research with industry is focussed on urban water science structured around ongoing relationships with Riverview Development Group and the Act Government. This work has recently been refunded for the next three years and will form the industry contribution to an ARC Linkage project going ahead in early 2022.

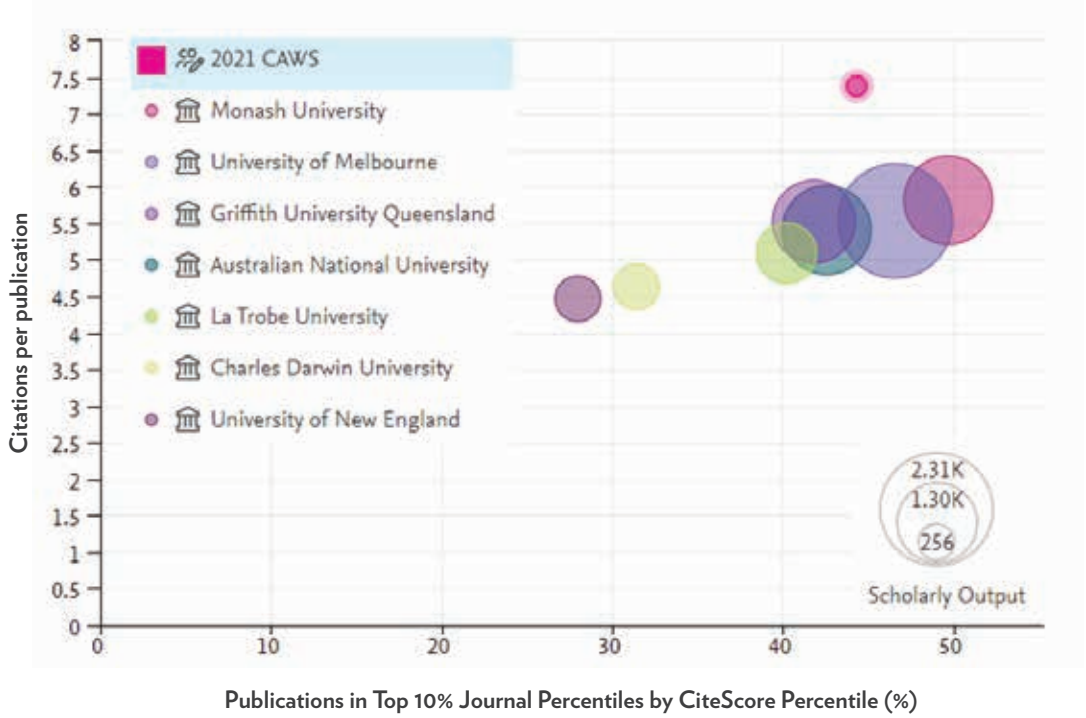
Category 4 Funding (Cooperative Research Centres).

Funding from CRCs is a relatively minor component of CAWS income, but the Centre is involved in two emerging CRC bids in the areas of regional water management and Indigenous engagement.

RESEARCH OUTPUTS

These metrics reflect the focus of CAWS on research excellence and impact. Despite being a small Centre by national standards CAWS has produced a substantive number of papers (3-year average 4.1 papers per full-time equivalent staff member). These papers have predominantly appeared in the top journals in environmental science (see Figure below). Published papers are heavily cited, with 7.48 citations per publication, more than 1.7x the average for the environmental science discipline. Despite the constraints of Covid-19, CAWS researchers continue to publish heavily with overseas collaborators — more than 50% of CAWS papers have an international co-author. More than 60% of CAWS papers have a government or industry co-author.

Publications in top quartile journals remain strong relative to the sector average and publications in the very top tier of journals (*Nature, Science*) have increased. CAWS staff remain heavily engaged with government and industry, reflected in the very high percentage of papers with industry co-authorship.



Centre for Applied Water Science (2021 CAWS) benchmarked against other environmental science groups in Australia, 2019–21. Ellipse size indicates number of papers, with the number of citations per paper and the percentage of papers in the top 10% of journals by citation shown.

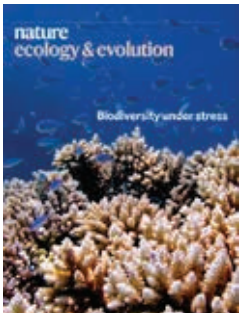
PUBLICATION HIGHLIGHTS 2020/21

THE EVOLUTION OF CRITICAL THERMAL LIMITS OF LIFE ON EARTH

Joanne M. Bennett et al. 2021, *Nature Communications* 12, 1198

Abstract. Understanding how species' thermal limits have evolved across the tree of life is central to predicting species' responses to climate change. Here, using experimentally derived estimates of thermal tolerance limits for over 2000 terrestrial and aquatic species, we show that most of the variation in thermal tolerance can be attributed to a combination of adaptation to current climatic extremes, and the existence of evolutionary 'attractors' that reflect either boundaries or optima in thermal tolerance limits. Our results also reveal deep-time climate legacies in ectotherms, whereby orders that originated in cold paleoclimates have presently lower cold tolerance limits than those with warm thermal ancestry. Conversely, heat tolerance appears unrelated to climate ancestry. Cold tolerance has evolved more quickly than heat tolerance in endotherms and ectotherms. If the past tempo of evolution for upper thermal limits continues, adaptive responses in thermal limits will have limited potential to rescue the large majority of species given the unprecedented rate of contemporary climate change.

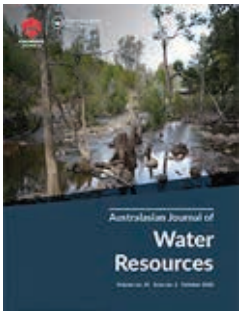
IMPACT OF 2019–2020 MEGA-FIRES ON AUSTRALIAN FAUNA HABITAT.



Ward, M. et al. including **Lintermans, M.**, 2020., *Nature Ecology & Evolution* 4: 1321-1326.

Abstract. Australia's 2019–2020 mega-fires were exacerbated by drought, anthropogenic climate change and existing land-use management. Here, using a combination of remotely sensed data and species distribution models, we found these fires burnt ~97,000 km2 of vegetation across southern and eastern Australia, which is considered habitat for 832 species of native vertebrate fauna. Seventy taxa had a substantial proportion (>30%) of habitat impacted; 21 of these were already listed as threatened with extinction. To avoid further species declines, Australia must urgently reassess the extinction vulnerability of fire-impacted species and assist the recovery of populations in both burnt and unburnt areas. Population recovery requires multipronged strategies aimed at ameliorating current and fire-induced threats, including proactively protecting unburnt habitats.

AUSTRALASIAN JOURNAL OF WATER RESOURCES SPECIAL ISSUE: INDIGENOUS WATER KNOWLEDGE



Edited by: **Bradley Moggridge** and Gail Tipa

Moggridge, B. J. 2021. Indigenous water knowledge and values in an Australasian context (2021): *Australasian Journal of Water Resources*

Moggridge, B.J. and **Thompson, R.M.,** 2021. Cultural value of water and western water management: an Australian indigenous perspective. *Australasian Journal of Water Resources*

Caron, V., Brim Box, J., Dobson, V.P., Dobson, V., **Richmond, L., Thompson, R.M.** and **Dyer, F.,** 2021. Restoring cultural plant communities at sacred water sites. *Australasian Journal of Water Resources*.

MARINE CONSERVATION: TOWARDS A MULTI-LAYERED NETWORK APPROACH

Jacob, U et al. including **Thompson, R.** 2020. *Philosophical Transactions of the Royal Society B,* 375(1814)

Abstract. Valuing, managing and conserving marine biodiversity and a full range of ecosystem services is at the forefront of research and policy agendas. However, biodiversity is being lost at up to a thousand times the average background rate. Traditional disciplinary and siloed conservation approaches are not able to tackle this massive loss of biodiversity because they generally ignore or overlook the interactive and dynamic nature of ecosystems processes, limiting their predictability. To conserve marine biodiversity, we must assess the interactions and impacts among biodiversity and ecosystem services (BD-ES). The scaling up in complexity from single species to entire communities is necessary, albeit challenging, for a deeper understanding of how ecosystem services relate to biodiversity and the roles species have in ecosystem service provision. These interactions are challenging to map, let alone fully assess, but network and system-based approaches provide a powerful way to progress beyond those limitations. Here, we introduce a conceptual multi-layered network approach to understanding how eco -system services supported by biodiversity drive the total service provision, how different stressors impact BD-ES and where conservation efforts should be placed to optimize the delivery of ecosystem services and protection of biodiversity.

LAND USE AND POLLINATOR DEPENDENCY DRIVES GLOBAL PATTERNS OF POLLEN LIMITATION IN THE ANTHROPOCENE

Joanne M Bennett et al. *Nature Communications 11*, 1 (2020)

Abstract. Land use change, by disrupting the co-evolved interactions between plants and their pollinators, could be causing plant reproduction to be limited by pollen supply. Using a phylogenetically controlled meta-analysis on over 2200 experimental studies and more than 1200 wild plants, we ask if land use intensification is causing plant reproduction to be pollen limited at global scales. Here we report that plants reliant on pollinators in urban settings are more pollen limited than similarly pollinator-reliant plants in other landscapes. Plants functionally specialized on bee pollinators are more pollen limited in natural than managed vegetation, but the reverse is true for plants pollinated exclusively by a non-bee functional group or those pollinated by multiple functional groups. Plants ecologically specialized on a single pollinator taxon were extremely pollen limited across land use types.

IMPACT

CAWS works closely with industry partners, government agencies and community groups to ensure that research is immediately relevant to solving water management challenges. In particular, CAWS staff sit on a number of influential working groups and committees to provide advice.

FEDERAL

Murray Darling Basin Sustainable Diversion Limit Review Working Group (Ross Thompson)

Threatened Species Recovery Hub Indigenous Liaison (Bradley Moggridge)

DAWE Committee on Aboriginal Water Interests (NWI Review) Bradley Moggridge Co-Chair

STATE AND TERRITORY

Snowy Advisory Committee (Fiona Dyer)

Lachlan Environmental Water Advisory Group (Fiona Dyer)

Board member of the ACT Landkeepers Trust (Fiona Dyer, Will Higgisson)

Executive member of the Upper Murrumbidgee Catchment Network (Fiona Dyer)

Chair of the NSW Fisheries Scientific Committee (Mark Lintermans)

ACT Environmental Flows Advisory Group (Ross Thompson)

Technical Committee, Alliance for Water Stewardship (AWS) Global Standard (Bradley Moggridge)

Vice President Australian Freshwater Science Society (Bradley Moggridge)

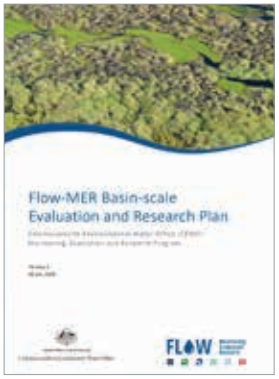
Expert Group, United Nations (UNECE) Transboundary Water Allocation Handbook (Bradley Moggridge)

IMPACT SHOWCASE 2020/21

Project title: FLOW Monitoring Evaluation and Research Project

Research team:
Professor Ross Thompson
Professor Fiona Dyer Dr Will Higgisson
Ben Broadhurst and collaborators

Pathway to impact: The Flow Monitoring Evaluation and Research program (**www.flow-mer.org.au**) seeks to understand how the provision of environmental flows in the Murray Darling Basin may be used to manage key species, habitats, and ecosystem functions. UC leads two components of this work, the monitoring of the Lachlan Selected Area (one of seven), led by Professor Fiona Dyer, and the Basin-scale synthesis of outcomes (co-led with CSIRO) led by Professor Ross Thompson. CAWS researchers are engaged in adaptive management of environmental water through advising water managers, informing development of watering plans and generating fundamental knowledge to support understanding of flow-ecology relationships.



EDUCATION AND TRAINING

While CAWS is primarily a research centre, it is important to recognise the important role the Centre has in supporting the teaching program, and the virtuous cycle that exists between engaging teaching and research excellence.

CONTRIBUTION TO UNDERGRADUATE TEACHING

All CAWS academic staff contribute substantively to the undergraduate teaching program. Over the 2020/2021 period CAWS staff have contributed on average a total of more than 1000 hours of face-to-face teaching into the Faculty of Science and Technology undergraduate program (shown below as an average in hours per annum).

LECTURES	PRACTICALS AND TUTORIALS	FIELD CLASSES
168	237.5	142

In addition, CAWS staff are unit convenors and the substantive contributors for a number of undergraduate subjects;

8101	Earth Systems Science	Duanne White
10231	Ecology	Ross Thompson
10232	Environmental Conflict and Engagement	Ben Kefford
10226	Freshwater Biology	Ben Kefford
10224	Integrated Catchment Science	Fiona Dyer
10225	Landscape Processes	Duanne White
9632	Research Project in Applied Science	Fiona Dyer
10228	Understanding Environmental Complexity	Ross Thompson

Additional significant teaching contributions are also made into;

10234	Conservation Ecology
6915	Ecochemistry
1809	Data Analysis in Science

CURRICULUM RENEWAL

In 2021 CAWS staff have been engaged in leadership of the redevelopment of the environmental science teaching program with a focus on delivering an excellent program in an efficient way.

Ross Thompson was Chair of the re-development committee for the *Environmental Science* degree, with Fiona Dyer, Simon Foster, Duanne White and Ben Kefford as committee members.

Ross Thompson is leading development of a new first year unit *Managing Environmental Challenges—Foundations*; Ben Kefford and Bradley Moggridge are members of that working group.

GRADUATE AND RESEARCH TRAINING

CAWS has an active program of supervising students in Honours, Masters and PhD programs. Students come from diverse backgrounds and countries of origin.

PHD AND MASTERS STUDENTS

Hugh Allan
Haysem Alhassen
Tracey Benson
Marcello Blaxell
Cherie Campbell
Beatrice Dewenter
Prue Haantjens
Matt Jeromson
Zaglul Khandkar
Mark Lintermans
Jack Livingstone
Brad Moggridge
Karl Moy
Anji Perera
Anju Rana
Jollene Reich
Munique Reid
Foyez Shams
Mark Shenton
Tuti Siregar
Simon Votto

HONOURS STUDENTS

Celine Anderson
Jack Livingstone
Britt McDonald
Joseph O'Connell
Breanna Reynolds
Sophie Rainbow
Jasmin Wells
Cody Woods

Honours student Breanna Reynolds was the recipient in 2021 of a National Landkeepers Trust scholarship for her work on vegetation recovery after repeated bushfires (Photo credit: Gus MacDonald)

Countries of origin for CAWS PhD and Masters students.

AUSRIVAS TRAINING

The AUSRIVAS (**www.ausrivas.ewater.org.au**) (Australian River Assessment System) is a prediction system used to assess the biological health of Australian rivers. AUSRIVAS was developed under the National River Health Program (NRHP) funded by the Federal Government in 1994. AUSRIVAS has two streams, Bioassessment and Physical assessment. These correspond with the biological assessment protocols and the geomorphic, physical, and chemical assessment protocols respectively. CAWS supplies an online course in the theory and techniques of AUSRIVAS which offers accreditation for water professionals from the private sector, universities, and government agencies. Annually CAWS trains approximately 30 water professionals in the AUSRIVAS course.

STUDENT SHOWCASE

BRITT MCDONALD

Honours student (2020–2021)

Project title: Developing population models for the Straw-necked Ibis and Royal Spoonbill in the Murray-Darling Basin

Supervisors:
Prof Fiona Dyer
Dr Heather McGinness (CSIRO)
Prof Ross Thompson

Brief summary of project: Britt's Honours project constructed population models for straw-necked ibis (*Threskiornis spinicollis*) and royal spoonbill (*Platalea regia*). The models were constructed using vital rates obtained from a synthesis of published and unpublished data and used to determine potential population trajectories for the study species in eastern Australia under various scenarios. The modelled results for straw-necked ibis indicate that the population in eastern Australia is in long-term decline, and that altering parameters such as breeding frequency had minimal effect on this trend. Population growth rates for straw-necked ibis and royal spoonbill were found to be most sensitive to adult survival rates. This suggests that management targeting adult survival (e.g. predator control protecting nesting birds) may be most effective in increasing population sizes. The results increase our understanding of potential waterbird population trajectories, and what factors are likely to have the greatest impact on populations.

Britt completed her Honours in early 2021 and has moved to a position at the Commonwealth Department of Agriculture, Water and Environment.

ENGAGEMENT

CAWS has maintained an active social media presence and has been heavily involved in stakeholder engagement through the year. CAWS staff have been featured in print and television media more than 50 times and have delivered more than 30 public seminars.

In June 2020 CAWS partnered with the Centre for Entrepreneurial Agri-Technology, a joint CSIRO-ANU venture to deliver a virtual Hackathon on technology to drought proof the agrifood sector.

Staff have been involved in outreach programs to primary and secondary schools and have once again led sessions for the National Youth Science Forum.

Students from the National Youth Science Forum program sampling Lake Ginninderra, January 2021. (Photo credit: Ross Thompson).

ENGAGEMENT SHOWCASE

'Up the Creek' with 'Down the Track'– Investing in the next generation of ecologists

Written by Adam Kereszy (Lachlan Selected Area Flow-MER team)

Research team:
Professor Fiona Dyer
Dr Will Higgisson
Ben Broadhurst
Professor Ross Thompson
And collaborators

(Reproduced from **www.flow-mer.org.au/up-the-creek-with-down-the-track** with permission).

The 'Down the Track' project at Lake Cargelligo has become one of the most important and high-profile youth initiatives over the last two years. Existing to support disengaged and at-risk youth, the project is run by Lana Masterson and Katy Quinn. Participants engage in a range of activities — everything from catering to shearing — that aim to promote engagement and self-esteem.

The 'Down the Track' project itself is an off-shoot of the original 'BackTrack' program founded and championed by jackaroo-turned-youth champion/advocate (not to mention Australian of the Year) Bernie Shakeshaft.

In Lake Cargelligo, 90% of 'Down the Track' participants are Indigenous, and all are teenagers from the local area — predominantly the lake itself and the nearby former Aboriginal mission Murrin Bridge.

In 2019, Lana first hinted at the idea of getting the 'Trackers' involved in some biological survey work, and in early 2020 we managed to pull it off — and not just a simple survey, but also incorporating a boat trip and an overnight camping trip to Robinson Crusoe Island.

Adam (pictured below) is part of the Flow-MER Program's Lachlan Selected Area team whose work is focusing on monitoring the outcomes of environmental water in the lower Lachlan river system, from Lake Brewster to the Great Cumbung Swamp.

(Photo credit: Flow-MER program)

RECONCILIATION

CAWS is committed to the principles of reconciliation, specifically with regard to Indigenous access to, and engagement with, water management and reform.

BRADLEY MOGGRIDGE

Kamilaroi man Bradley Moggridge was appointed in 2020 as an Associate Professor role in Indigenous Water Management. Brad has been with UC for the last four years, and this appointment is reflective of the profile and esteem Brad has in the Indigenous natural resource management space. That has been recognised in numerous ways in 2020 including through an Aboriginal and Torres Strait Islander STEM Professional Career Achievement Award.

JACK LIVINGSTONE

Wirradjuri man Jack Livingstone completed his Honours with CAWS in 2021 and has moved into a Research Assistant role before he commences his PhD in early 2022. Jack will be working on the application of cultural plants for managing contaminated sites, with a particular focus on Indigenous Protected Areas.

FUNDED RESEARCH

A number of CAWS researchers are actively engaged in co-design of research with Indigenous colleagues and working with Indigenous communities to empower them in participation in water management. Ongoing work led by Professor Fiona Dyer through the Flow-MER program is seeking to engage with Traditional Owners around managing environmental water for cultural outcomes.

Giving a voice to Indigenous perspectives on Australian water management

Research Team: Brad Moggridge, Ross Thompson, Phil Duncan, Anne Poelina

Funder: Australian Water Partnership (Department of Foreign Affairs & Trade)

Preparation of a cultural watering plan for the Mungindi Local Aboriginal Land Council

Research Team: Brad Moggridge, Ross Thompson

Funder: North West Local Land Services

Classrooms on Country

Research Team: Brad Moggridge, Ross Thompson,colleagues from Macquarie University

Funder: NSW Education Trust

CAWS is also an emerging centre for research focussed on understanding Indigenous attitudes to water and how to operationalise reconciliation around water.

SELECTED PUBLICATIONS

Caron, V., Brim Box, J., Dobson, V.P., Dobson, V., Richmond, L., **Thompson, R.M.** and **Dyer, F.,** (2021). Restoring cultural plant communities at sacred water sites. *Australasian Journal of Water Resources*, pp.1–10.

Moggridge, B.J. (2021) Indigenous water knowledge and values in an Australasian context. *Australasian Journal of Water Resources* 1–3.

Moggridge, B.J. and Thompson, R.M., (2021). Cultural value of water and western water management: an Australian indigenous perspective. *Australasian Journal of Water Resources,* pp.1–11.

Moggridge, B.J., (2020). Aboriginal people and groundwater. *Proceedings of the Royal Society of Queensland, The, 126,* pp.11–27.

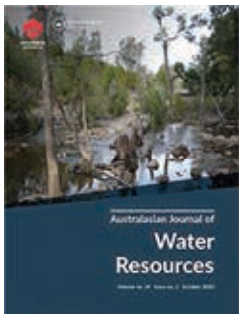
Moggridge, B. J. 2020 Aboriginal People and Groundwater. *Proceedings of The Royal Society of Queensland Vol. 126, pp.11–27 GAB Springs Special Edition*

Abstract: Aboriginal people have been part of the Australian landscape for 65,000 years or more, and in many areas, including the Great Artesian Basin, they have relied on groundwater for survival. Aboriginal people believe their story originated in the Dreamtime — the beginning, when Aboriginal cultural heroes created groundwater sites along with all other sacred sites. Their survival, particularly in a desert environment, has intrigued non-Aboriginal people for many years. While many studies have been conducted on how Aboriginal people survived at a local or regional level by accessing groundwater, no research has collated and reviewed the entire subject matter of 'Aboriginal People and Groundwater'. This paper, based on my 2005 Masters Thesis, endeavours to collate and review available research and provide an insight into the cultural relationships and dependence of Aboriginal people on groundwater. Since colonisation, the Australian continent, its landscape and the complex nature of Aboriginal society have changed. So too have human uses and reliance on groundwater, for it has become a favoured water supply for many communities and types of industry. In some cases, these uses have led to over-allocation and groundwater depletion or degradation. The future of groundwater use has to be managed sustainably, as Aboriginal people have done for thousands of years.

www.royalsocietyqld.org/2020-springs-special-issue-vol-126

Australasian Journal of Water Resources Special Issue: Indigenous Water Knowledge

Edited by: **Bradley Moggridge** and Gail Tipa



The University of Canberra's Centre for Applied Water Science is supported by the Faculty of Science and Technology and the Institute for Applied Ecology