ARI

Australian Rivers Institute

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CONTENTS

DIRECTOR'S PERSPECTIVE

From the Director, Professor Stuart Bunn

Delivering tangible results for stakeholders

I am pleased to say that 2018 was another successful year for our Institute with major projects taking form and new capabilities added to our portfolio, with the appointment of an impressive cohort of early and midcareer researchers.

In this second edition of the ARI Magazine we continue the conversation about our research and outline how engagement with a broad range of stakeholders not only can lead to environmental benefits, but positive economic and social outcomes as well.

Several of the major projects covered in this issue of the magazine highlight our Institute's broad-ranging expertise and our commitment to developing strategic partnerships. The Ian Potter project on Catchment Resilience aims to demonstrate how we can optimise public and industry investment to restore degraded rivers and floodplains, using a case study in the upper Lockyer Valley. The tools developed in this project can ultimately be used to reduce the costs of water treatment, reduce the costs of damaging flooding, address the build-up of sediment in Moreton Bay, and provide additional environmental benefits from catchment to coast.

The second major project show-cased in this issue is the Global Wetlands Project (GLOW). GLOW aims to help prioritise conservation efforts of coastal wetlands by developing measurements of the health of these systems. The project will build a new index of coastal wetland health which can be used to better inform global conservation projects and efforts.

We also explore an ACIAR-funded collaborative project on rice-shrimp farming in the Mekong Delta. Dr Ben Stuart-Koster and Professor Michele Burford are helping build rice-shrimp farm resilience to combat the impacts of rising sea levels due to climate change and restricted river flows as a result of urbanisation and water resource development. Building resilience in these farming areas is vital to food production in the region and to avoid a potential human migration crisis in the Mekong Delta. The Vietnamese Government has considered the findings of this project in future planning for the region.

We look at the incredible new fish identification software being developed by members of ARI – making it easier to identify and count species from underwater footage, leading to faster generation and provision of data for fisheries management. The potential of this project is vast, as it can support coastal conservation efforts and key fisheries information.

Dr Simon Linke and his team have also developed a new system to continuously and remotely monitor wildlife activity in wetland regions. The study uncovers the effects on ecosystem health of environmental water allocations along the Murray Darling Basin.

In this issue we have featured opinion pieces from some of our senior staff at ARI. Professor Jon Olley, who joined ARI in 2008 after a long career in CSIRO, is now Professor Emeritus in the Institute. He shares his experiences in the quest to identify the major sources of land-based pollution, and the difficulties in implementing actions at the appropriate scale to address them. Professor Michele Burford highlights the need for research that is interdisciplinary and large-scale, and draws on projects in the Gulf of Carpentaria and the Mekong Delta as examples of this approach. Important international collaborations to address the rise of Harmfull Algal Blooms (HABs) in a warming world are also highlighted.

These project summaries and commentary showcase how we operate and what we can deliver as a world leader in coastal, catchment and river research. The Magazine is one of the ways we aim to broaden our engagement with stakeholders and work with them to address these pressing environmental challenges. I hope you enjoy this edition.

Stuart Bunn

'...2018 was yet another successful year for our Institute with major projects taking form.'

NATURE PAPER PUBLICATION

The Great Barrier Reef and the missing fish—what happened?

Ecosystems are changing across the world as temperatures increase due to climate change, and areas rich in biodiversity like the Great Barrier Reef (GBR) will be seriously impacted. New research in the journal Nature - the world's leading science journal - looks at the effects of the 2016 heatwave on the GBR and Coral Sea fish communities.

ARI member Dr Brown, Dr Rick Stuart Smith and Dr Graham Edgar from the University of Tasmania and Dr Daniela Ceccarelli from the ARC Centre of Excellence for Coral Reef Studies have looked at the effects of the 2016 heatwave that adversely affected the GBR. This group of researchers found that the temperature increases that occurred during the 2016 heatwave created significant changes for more than 1,000 fish and invertebrate species that live on the GBR. After the event, fish populations in the GBR's southern region became similar to those in the warmer waters in the northern regions of the GBR.

It is likely that many fish species in warmer waters died out, as it became too hot. Whereas, in the south warmer water species became more active and increased in abundance. Dr Brown and the team found that many fish species responded directly to coral bleaching, but numerous other species were affected, even where coral cover remained intact.

Of note was the decline of fish that scrape algae from reef surfaces in the northern regions of the GBR. Importantly, these fish are regarded as being significant in reef recovery after a bleaching event.

Due to the loss of diversity in fish populations along sections of the GBR, Dr Brown predicts that reef recovery could slow. This factor highlights that although efforts are being made to increase reef resilience to climate change through the introduction of stress tolerant corals, conservation efforts may struggle to stop the impacts of warming seas on fish populations.

However, Dr Brown and the team highlight there is still hope and the positive response from many fish species in the cooler tropical regions may continue to support healthy coral reef ecosystems, although these may vary from the ecosystems we see today.

This research was made possible thanks to data collected by the Reef Life Survey program, an organisation that trains volunteers in the specialized skill of surveying fish and invertebrate communities. The approach of recruiting volunteer experts meant that the team had access to data over a much broader region than would otherwise have been available.

'It is likely that many fish species in warmer waters died out, as it became too hot.'

Photo Courtesy of Dr Rick Stuart-Smith

'Dr Brown and the team found that many fish species responded directly to coral bleaching, but numerous other species were affected, even where coral cover remained intact.'

Photo Courtesy of Dr Rick Stuart-Smith

NEWS

New book helps fight global algal blooms

Algal blooms can lead to mass fish kills and degraded water quality that impact on the value and services of aquatic ecosystems. Harmful algal blooms appear to be on the rise globally, aligned with rising temperatures due to climate change.

ARI's Professor Michele Burford is part of a team of editors behind *Global Ecology and Oceanography of Harmful Algal Blooms (GEOHAB)*, a new book published by Springer, now available online. The book features input from several experts from around the world and collates their research from the past 10 years, covering causes, impacts on the economy and environments and management options for harmful algal blooms.

The book highlights the challenges faced by water managers around the globe, including increased nutrient inputs from human activity and increasing temperatures due to climate change. Bloom-forming algae grow faster in warmer water, so in future we can expect a higher frequency of blooms.

GEOHAB will be a valuable resource for water managers, academics and policymakers as it collates critical information on algal blooms in one source. Water managers can also use the book as a guide to develop mitigation strategies to reduce or prevent the occurrence of blooms.

EU-AUSTRALIA LEADERSHIP FORUM SUCCESS

Dr Ryan Burrows —an emerging leader

Recently, Dr Ryan Burrows attended the EU-Australia Leadership Forum as an Emerging Leader in his field of freshwater ecology. He was selected as a candidate for this role for having a global world view and displaying advanced knowledge in his field. Previous work in the EU, as well as in the public and private sectors in Australia, enabled him to bring a unique perspective on the future of the EU-Australia relationship.

Dr Burrows said the opportunity provided a truly unique experience that focused on global issues, that nation states must overcome together to reach an ecologically sustainable and economically prosperous future.

'The Leadership Forum was a great opportunity to network with leaders in the EU and Australia across many sectors. A key theme throughout the forum was the importance of protecting and maintaining multilateral approaches when solving global issues, including for climate change and regional water security. Without multilateral approaches, issues such as water security can easily lead to regional and international conflicts that have negative ramifications for the environment, society and economies,' said Dr Burrows.

He believes that with better integration of expert knowledge and global partnerships such as the EU- Australia Leadership Forum, positive outcomes can be achieved especially in the area of global freshwater security and conservation.

'We need to ensure that human activities do not negatively impact the essential services that freshwater ecosystems provide humanity. The protection of our freshwater ecosystems is an important challenge for society that partnerships like the EU-Australia Leadership Forum can help address,' said Dr Burrows.

LAST YEARS RED TIDE EVENT IN FLORIDA IS THE TIP OF THE ICEBERG

Deputy Director David Hamilton

In the last northern hemisphere summer, the state of Florida experienced a massive red tide bloom along its coastline and major blue-green algal blooms inland. These events brought attention globally to the future health of aquatic ecosystems. Increases in nutrients exported from land to water are fuelling blooms.

Increasingly, these nutrients arise from diffuse pollution, which is sourced broadly across the landscape from increasing intensity of land use and food production, even through point source pollution declines from improved regulation and treatment of waste streams.

Increasing nutrient levels are acting synergistically with warming surface waters of inland and marine waters that bring greater stability to the water column to produce algal blooms. Many of these blooms, particularly in freshwater, are produced by cyanobacteria and are referred to as 'CyanoHABs'. The HABs refers to 'harmful algal blooms' because not only are blooms unsightly and symptomatic of declining aquatic ecosystem health, but they can also be toxic. Many other blooms are referred to as 'red tides' because of their distinctive red colour. They can also be toxic, as evidenced by the vast number of deaths of manatees, eels, fish and other mammalian species in the recent bloom in coastal waters of Florida. Many of these issues are explored in the book Global Ecology and Oceanography of Harmful Algal Blooms (GEOHAB) co-edited by Professor Michele Burford.

A particular feature of many bloom-forming algae is that they are buoyant and they can aggregate at the water surface. Buoyancy in many of the cyanobacteria is due to the presence of gas vesicles —air pockets contained within the cells. By contrast, many of the species that form red tides aggregate by actively swimming using flagella. They are commonly phototactic, meaning that they will swim upwards towards light. So why would climate change affect these surface aggregations?

As water above four degrees celsius warms, it becomes increasingly buoyant forming a layer above cooler denser water. This layering creates stability that allows buoyant algae to easily float and aggregate together in a bloom. Climate warming is also warming surface waters and creating more stability of the water column that is leading to more intense and frequent algal blooms.

This coalescence of more nutrients and climate warming is becoming evident in massive algal blooms around the world. Examples include the CyanoHAB bloom in the Murray Darling River system which was 1,600 kilometres long in 2016; the Florida coastal bloom, due to a red tide species (Karenia brevis) as well as washout of a CyanoHAB species (Microcystis) from inland waters into the coastal zone; Microcystis blooms in Lake Taihu (2,400 square kilometres) that shut down water treatment plants and necessitated authorities in China to seek alternative water supplies; and, in what is now known as the Toledo Water Crisis, issuance of a 'do not drink' water advisory for three days in 2014, when there was a major Microcystis bloom in Lake Erie where water was being sourced for supply to the city of Toledo.

What can we do about this increasing frequency of harmful algal blooms? Climate change is already upon us and even with the most optimistic of projections, temperatures will continue to rise for some time. It is clear that we need to become more efficient at retaining nutrients on the land to reduce levels in waterways. This will require some hard decisions to be made—re-thinking and re-engineering inefficient practices that are producing nutrients and leading to diffuse source pollution. It will mean targeting discrete areas of the landscape that are most commonly producing the bulk of the nutrient runoff.

ARI's Catchment Resilience project, will help to prioritise where investment should be targeted to reduce diffuse source pollution. Reduced nutrient pollution will help to reduce the frequency and severity of algal blooms, even as expected increases in temperature from climate warming take place.

'Increases in nutrients exported from the land to water are fuelling algae blooms'

MAJOR PROJECTS


Photo Courtesy of Tom Raynar

Going global to protect coastal wetlands

Coastal wetlands are disappearing. We know they need help, but what's the best way to provide that help? The Global Wetlands Project at ARI is planning to answer this question.

Seagrass meadows, mangrove forests and saltmarshes are important places. These coastal wetland habitats support rich biodiversity, underpin human livelihoods and protect coastal communities.

Unfortunately, over 50% of the world's coastal wetlands have already been lost. The remainder are at risk from a range of serious threats, from deforestation and urbanisation, to pollution and rising sea levels.

There is an urgent need to protect and restore coastal wetlands to halt further decline. However, to inspire action and prioritise conservation efforts, we first need to measure the health of these systems.

Various indices of health have been used to date, but these have been specific to particular locations or particular groups of organisms. There is no single, stable, accurate and efficient way to measure and track wetland health that works across different habitat types. Simply put, it means global wetland conservation isn't as effective as it could be.

The Global Wetlands Project (GLOW) is a new scientific endeavour to meet this challenge. The aim is to build a new index of coastal wetland health, which can be applied on a global scale and used to inform conservation.

In March 2018, Professor Rod Connolly established GLOW at ARI in collaboration with Dr Chris Brown and Professor Brendan Mackey (from Griffith University's Climate Change Response Program). Since then, they have recruited a team with expertise in ecology, conservation planning, ecological modelling, environmental policy, software development and communications.

'This is a truly global project' said Professor Connolly.

'In addition to the team here at Griffith University, we've established collaborations with researchers at trial locations worldwide including China, India, Portugal, South Africa and Vanuatu.'

'within a given budget, which actions will be most effective at protecting or rehabilitating wetlands? What is most feasible?'

Dr Brown, as Research Leader, will be guiding research under the three GLOW themes: measuring wetland health, improving conservation and engaging authentically.

'We want to use the index to create a map showing how coastal wetland health varies around the world, across regions and countries. This will let us identify the most threatened sites and most urgent conservation needs,' said Dr Brown.

Then we want to take the index into action, by building a web-based scenario modelling tool to help answer questions of, 'What if?'. For example, within a given budget, which actions will be most effective at protecting or rehabilitating wetlands? What is most feasible?"

Professor Connolly hopes GLOW can guide strategic investment and action towards better protection and restoration of coastal wetlands worldwide.

'We need to work together to meet the challenge. That means scientists, managers, communities, industries, politicians and other stakeholders collaborating to build and maintain conservation capacity.'

Project Partners

Ms. Mahua Roy Chowdhury, University of Calcutta, India.

Dr. Ana Sousa, University of Aveiro, Portugal

Dr Anusha Rajkaran, University of Western Cape, South Africa

Professor Shing-Yip (Joe) Lee, Chinese University of Hong Kong, China

Dr Paul Maxwell, Healthy Land & Water Queensland, Australia

For more information on GLOW head to the official project website: **globalwetlandsproject.org/**

Key Elements:

- Over 50% of the world's coastal wetlands have already been lost. The remainder are at risk from a range of serious threats from deforestation and urbanisation, to pollution and rising sea levels.
- The project aims to build a new index of coastal wetland health, which can be applied at the global scale and used to inform conservation.
- A set goal of the project is to build a web-based scenario modelling tool to help answer questions of, 'What if?'. This will help guide which actions will be most effective at protecting or rehabilitating wetlands within a given budget.

Photo Courtesy of Tom Raynar

CATCHMENT RESILIENCE PROJECT

Catchment Resilience Solutions—saving rivers and prioritising industry investment

The Problem

Our catchments are no longer resilient to extreme weather events and, in a changing climate, the frequency of damaging events is increasing, but ARI is developing a tool that will identify potential solutions.

The Causes

Extreme rain events cause rivers and streams to overflow, destroying homes, public infrastructure and devastating productive agricultural land when thousands of tonnes of high quality topsoil get washed away. Sediment mobilised in floods affects the operation of water treatment plants and can threaten drinking water supplies. It also settles in reservoirs, which reduces their capacity to hold water, and in downstream harbours and bays, which obstructs shipping channels. Dredging shipping channels is costly and ecosystem-wide impacts may also occur when sensitive sea grass meadows are smothered in sediment.

Catchments have also become more sensitive to extreme weather events as increased human activity has modified runoff and the stability of riverbanks. Clearing of vegetation along the riparian zone, changes to stream channels, frequent burning and overgrazing in catchment areas has increased the volume and speed of flooding. Natural river structures that slowed flooding are often removed.

Our Project

ARI, in partnership with The Ian Potter Foundation, has launched the 'Catchment Resilience' project. It aims to rebuild catchment resilience against extreme weather events and provide analytical tools that can help direct resources to critical areas in a catchment where investments will be most effective.

Targeted investment will help minimise the effects of extreme weather on our catchments, reduce sediment dispersion throughout rivers and bays, reduce nutrient loss of agricultural farmland and decrease flood risks that damage public and private infrastructure.

Major industries and public utilities that operate downstream to catchment areas are beginning to see the benefits of investing in projects upstream that aim to reduce sediment and nutrient load, and lower costs to their operations.

The 'Catchment Resilience' project aims to showcase how to tackle the problems at their source in the upper catchment where the greatest impacts can be achieved. These benefits can extend to protection of public assets and can even save lives.

'The 'Catchment Resilience' project aims to showcase how to tackle the problems at their source in the upper catchment where the greatest impacts can be achieved. These benefits can extend to protection of public assets and can even save lives.'

The Solution

For 15 years ARI's research projects have been building knowledge to identify the cause of the problem, what actions are effective and where they will have the greatest benefit. This knowledge can now be adapted into an evidence-based, spatial investment tool to support deliberative engagement and negotiation between the community, other stakeholders and investors. Building stakeholder confidence through this process is key to mobilising investment, and to overcome remaining institutional barriers to address this problem at the scale required. The tool is being designed with an advanced visualisation interface designed by our partner QUT to facilitate engagement across a range of stakeholders.

Project outcomes

Catchment issues caused by extreme weather events affect water security, farm productivity and the health of freshwater and coastal waterways across Australia. The tool being developed by this project will be designed to be transferable to other catchment settings, across Australia and overseas.

Collaboration List

- **The Ian Potter Foundation**
- **Australian Rivers Institute, Griffith University**
- **Queensland University of Technology (QUT)**
- **Queensland Government**
- **Water Technology**
- **Queensland Urban Utilities**
- **SeqWater**
- **Port of Brisbane**
- **Healthy Land and Water**
- **SEQ Council of Mayors**
- **Lockyer Valley Regional Council**

Key Elements:

- The Ian Potter 'Catchment resilience' Project is a coordinated, catchment-scale initiative to guide and optimise investment in restoration for multiple benefits.
- The benefits arise from reduced flood risk, sediment and nutrient reduction, increased carbon storage, and improved aquatic ecosystem health.
- Associated economic benefits extend to downstream industry and government that rely on the provision of ecosystem services from healthy catchments upstream, and include the reduced costs for water supply and treatment, and harbour dredging.
- Project partners QUT are developing a state-of-the-art visualisation tool to facilitate engagement with stakeholders and explore different management scenarios.
- There is great potential for global uptake of the tools built and lessons learned from this project.

'For 15 years ARI's research projects have been building knowledge to identify the cause of the problem, what actions are effective and where they will have the greatest benefit.'

The issue: Greater frequency of extreme weather events is leading to loss of productive agricultural land, damage to urban infrastructure and requires dredging to maintain shipping channels. These issues are being addressed through tools developed by the 'Catchment Resilience' project.

RESEARCH IN FOCUS

Let there be light: Maintaining healthy seagrass in Moreton Bay

A healthy seagrass meadow habitat helps support ecosystem sustainability, which is key to protecting the Gold Coast's reputation as an ecotourism hub. In coastal wetlands, plants form a critical habitat for a diverse range of animals. For example, seagrass is a key food source for iconic species like dugongs and sea turtles.

Light is critical for photosynthesis, enabling plants to thrive and support higher levels of the food chain. Sand and mud can reduce the light available to support plant communities while pollution, boat wake and dredging may directly impact plants.

Seagrasses become stressed by low light conditions. Loss of seagrass meadows means less habitat for fish, less food for dugongs and turtles and less carbon sequestered from the atmosphere.

Dr Ryan Pearson is investigating these issues in Broadwater in Moreton Bay where he has recently installed sensors that continuously measure how much light reaches seagrass. The sensors are deployed in numerous areas with varying depths and boat traffic volumes.

'This information is critical. It will help us untangle the role of weather events, boat traffic and other impacts in regulating seagrass health,' says Dr Pearson.

Project leader Professor Rod Connolly said that the funding partner, Gold Coast Waterways Authority, is eager to see the results.

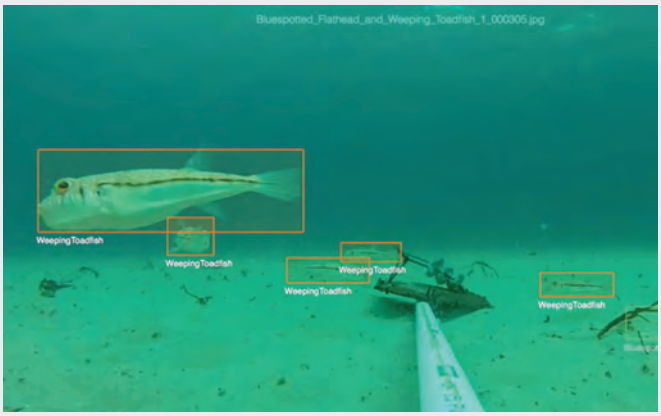
'The reality is the Authority needs to dredge channels to keep them open for boat traffic. A better understanding of these dynamics means they can make better decisions. For example, the timing and duration of dredging can be aligned to optimise seagrass health,' said Professor Rod Connolly.

This research collaboration is between James Cook University and GLOW – the Global Wetlands Project – at Griffith University.

Key Elements:

- The project can help inform waterways managers of the best time and duration to dredge waterways that will also optimise seagrass health.
- Seagrass meadows are at risk and this can impact local wildlife which tourism depends on.
- Actions can be taken to increase protection of the local biodiversity and businesses that depend on the Gold Coast waterways.

Photo Courtesy of Tom Raynar



Finding Nemo—using artificial intelligence to improve fish surveys

ARI ecologists and software developers have developed cloud-based machine learning for faster processing of underwater video footage.

Marine fish stocks are overexploited globally to the tune of 30%. They need to be better utilised, protected and restored. For that to happen, fisheries managers need accurate information on fish location and numbers.

A standard method that scientists use to provide this data is Remote Underwater Video. This involves recording what swims past an underwater camera each hour. However, watching hundreds of hours of footage is too time consuming.

One of ARI's research teams is solving this problem by making it easier to identify and count species in underwater footage, leading to faster generation and provision of data for fisheries management.

Development

The FishID system uses 'object detection deep neural networks'. These are artificial intelligence (AI) algorithms that help a computer learn how to see patterns in pixels – for example an eye or a fin – that is ultimately linked to different sizes and species of fish. To train the system, the team has used video footage collected along the sandy beaches of south east Queensland, using a dataset of 13,000 fish from 40 species which have already been identified by humans.

The project's Senior Software Engineer, Eric Jinks, has been comparing the performance of state-of-the-art object detection models on the dataset.

'We use a model that offers a good balance between efficiency and accuracy, run through Griffith University's collaboration with Microsoft Azure,' says Jinks.

'Our best-performing model is achieving a precision of 83% on the validation dataset,' wrote Jinks in a recent blog post featured in *Catchment to Coast*.

'This is really good, but the results also highlight some challenges.'

The visualisations of predictions made by the algorithm, on videos it had never seen before, provide some valuable lessons.

'Identifying fish from videos is particularly demanding,' he added.

'Other image identification sites for wildlife only upload photos with the animal of interest. Our monitoring algorithm firstly determines if there is one fish or many fish present. It also has to manage low light, bubbles and fish swimming at different orientations, to identify and count them.'

Applications

Professor Rod Connolly, a member of ARI and Director of the Global Wetlands Project (GLOW), said that automated monitoring is a new dawn for conservation. The FishID system can be trained for any aquatic ecosystem with clear water. In addition to the beach dataset, the team has tested it on footage from rivers, estuaries and the Great Barrier Reef.

FishID is a collaborative effort between GLOW and Professor Bela Stantic, Head of the School of Information and Communication Technology, Griffith University and Professor Susanne Becken, Director, Institute for Tourism, Griffith University, along with Professor Thomas Schlacher, Dr Andrew Olds, Dr Ben Gilby and Dr Chris Henderson from the University of the Sunshine Coast.

Example Footage: youtube.com/watch?v=2RDVKs7pfp8&feature=youtu.be

'The potential applications and implications are huge for fisheries and coastal habitat conservation.'

Key Elements:

- The problem fisheries managers face is that 30% of marine fishstocks are overexploited globally, so they need better information about fish populations and species.
- ARI's team has developed a FishID software system that can identify and count fish species in underwater footage.
- This AI system will ultimately lead to faster generation and provision of data for fisheries management.
- The FishID system can help guide conservation efforts in regions by closely monitoring fish populations.

RESEARCH UPDATE

Southern Mekong Delta, the beginning of a global story

The implications of a changing climate are starting to be felt and increasing global temperatures are directly impacting current sea levels. Such changes have dire consequences for not only global ecosystems but human populations that live at sea level on major river deltas like the Mekong Delta in Vietnam.

Major parts of the Vietnamese farming population are directly affected by sea level increases as they depend on freshwater in low-lying areas for rice production. Major changes in sea levels will cause a significant change in the Mekong Delta area, and negatively impact tens of thousands of farmers.

Coinciding with temperature changes is additional pressure from development and urbanisation upstream that reduces fresh water flows to downstream regions that mix with saline water. Salty water can now flood 'excessively' into upstream areas, changing salinity levels. This change means that farmers have converted farms to grow rice and shrimp together because of higher levels of salinity.

The ability of millions of Vietnamese farmers to feed themselves and large parts of their population requires adaptation to the pressures of climate change and reduced freshwater flows. Without change a significant crisis could be ahead for Vietnam.

The Project and Research impacts

Professor Michele Burford and Dr Ben Stewart-Koster have been busy in the Southern Mekong Delta, working with local farmers to increase their farming practices' resilience against climate change and decreasing river flow from the upstream water resource development.

The focus of the research is identifying new on-farm agricultural practices for combined rice-shrimp farmers to overcome these two main challenges and increase agricultural sustainability. The project has the potential to help tens of thousands of small-scale farmers in Vietnam.

'The rice grown on the Mekong Delta accounts for half of the total production in Vietnam, which is one of the largest producers globally,' said Dr Stewart-Koster.

The importance of the research is highlighted by how many farmers can be aided by the project. While not completed, the research has already begun to have an immediate influence on future planning for the region and how they manage water resources.

'Recently the Vietnamese government has been revising their master plan for the region and this research was able to contribute to that,' said Dr Stewart-Koster.

'The importance of the research is highlighted by how many farmers can be aided by the project. While not completed, the research has already begun to have an immediate influence on future planning for the region and how they manage water resources.'

Once finalised, the new farming system practices will be accessible via a smartphone app available to farmers and government extension officers in the region. The project has seen integration of local knowledge, government support and scientific insight to produce on-the-ground results that will improve strategies to increase agricultural sustainability.

'The project offers a model of how researchers from universities and government can engage directly with research users, in this case agricultural producers, to achieve positive outcomes for all concerned,' said Dr Stewart-Koster.

Project Partners

- Funded by Australian Centre for International Agricultural Research (ARIAR)
- Vietnamese partners
  - Research Institute for Aquaculture 2 (RIA2)
  - Can Tho University
  - Cú'u Long Rice Research Institute
  - Collaborating farmers from 21 farms
- Australian partners
  - University of New South Wales
  - Charles Sturt University

Key Messages:

- Integration of farmers' knowledge with scientific expertise can advance research programs quickly.
- Involving and engaging local farmers and government early in the project helped ensure scientists' research had a measurable and meaningful impact/uptake by all stakeholders.
- Vietnam faces considerable challenges from climate change and upstream water resource development that could cause a potential migrant crisis in the Mekong Delta region.
- Climate Change will have major impact on ecosystems, food supplies, economies and trading ability of nations such as Vietnam. Preparing for the changes is paramount to mitigating the effects on communities and ecosystems.

RESEARCH HIGHLIGHTS

To fix the reef we need to fix the land—but where do we start?

Protecting the Great Barrier Reef starts with protecting the riverbanks.

Algal blooms are problematic for tourism, agriculture and for general human use of water. We also know that these blooms can damage the Great Barrier Reef (GBR). Algal blooms may form after a flooding event when too much nutrient-rich sediment is delivered into receiving water. Algae are fuelled by nutrients released from sediments. When floods erode riverbanks loaded with nutrients, algal problems often occur downstream.

We know, restoring vegetation in catchment areas will limit sediment loads endangering the reef, but catchment managers need to know which areas deliver the most sediment and nutrients into the water.

Recently, Dr Hannah Franklin was part of an ARI team in collaboration with the Department of Environment and Science from the Queensland Government that developed a new scientific technique to rapidly identify nutrient-rich sediment sources in reef catchments. They measured how quickly algae grow in the laboratory in response to additions of sediment sources from two GBR catchments, the Johnstone and Bowen Rivers.

Adding sediment sources to flasks of algae growing in the laboratory was designed to simulate sediment delivery during floods and the biological response. These results and techniques will allow researchers to make predictions in other catchments with similar sediment properties. Catchment managers can use this information in their local area to understand which types of sediment are likely to stimulate algal blooms that will ultimately damage the river ecosystem and reefs. The method can also help catchment managers to target areas for sediment erosion control.

Recommendations for Reducing Erosion:

- Re-establishing riparian vegetation, such as trees, to bind sediment with plant roots.
- Large-scale engineering solutions, using earth moving machinery to stabilize gullies which produce large amounts of sediment.
- Reducing grazing intensity on erosion-prone soils.

This new screening technique could be used elsewhere in Australia and around the world as an important first step to identify the location of high-risk areas that are major nutrient sources and to guide targeted catchment restoration. This method will also improve the cost-effectiveness of management actions.

Key Points:

- This new technique is able to help identify sediment sources which may cause damaging algal blooms.
- The findings will aid catchment managers in protecting the Great Barrier Reef and its associated tourism/ fishery industries and lead to better targeted catchment management.
- Around 40% of sediments tested from the Johnstone and Bowen catchments were found to have the potential to contribute to algal blooms in this study.
- Within three days researchers can determine problematic sediments in catchment areas that may contribute to algal blooms.

This work has been published in Science of the Total Environment:

Franklin, H. M., Garzon-Garcia, A., Burton, J., Moody, P. W., De Hayr, R. W., & Burford, M. A. (2018). A novel bioassay to assess phytoplankton responses to soil-derived particulate nutrients. *Science of the Total Environment*, 636, 1470–1479. https://doi.org/10.1016/j.scitotenv.2018.04.195

Garzon-Garcia, A., Burton, J., Franklin, H. M., Moody, P. W., De Hayr, R. W., & Burford, M. A. (2018). Indicators of phytoplankton response to particulate nutrient bioavailability in fresh and marine waters of the Great Barrier Reef. *Science of the Total Environment*, 636, 1416–1427. https://doi.org/10.1016/j.scitotenv.2018.04.334

Murray Darling environmental water allocations—how do we measure their impact effectively?

The Situation:

In 2012, the Federal Government adopted the Murray Darling Basin Plan which included $13 Billion worth of investment to recover water from agricultural use and improve river health and help monitor change in conditions along the basin.

Each year, close to half of the Murray Darling Basin's (MDB) total water is diverted to support human and industry needs (especially agriculture irrigation). The result of this is that only 40% of the original amount of water reaches the mouth of the Murray and the impact of withdrawals negatively affects native fish, frogs and birds.

Recent fish kills in the lower Darling River due to low flows and poor water quality have highlighted the need for better monitoring of the ecosystem's health.

Improving methods:

Dr Simon Linke, in collaboration with Ms Jo Deretic from the Goulburn Broken Catchment Management Authority, has been monitoring the effect of environmental water allocations on the MDB through a newly-developed eco-acoustic monitoring system. The new system is a world-first method of continuously and autonomously monitoring wildlife activity in the wetlands.

Previous methods of measuring ecosystem health have been performed by sporadic spot checks throughout the year, but this fails to capture the dynamic picture of wildlife activity. These methods also don't allow water managers to clearly capture incremental increases of species arriving and returning to restored wetland ecosystems, especially during water allocation periods —increased activity in wetlands is used as a proxy for species numbers.

The ecosystem health of Reedy Swamp, north of Shepparton, Victoria, was monitored by analysing bird and frog activity via the autonomous recording system that can be used year-round, as batteries for the system only need to be changed once a year.

Increased activity in the wetland region is an ecosystem health marker in determining the outcomes of environmental watering. Researchers can assume that the higher the activity in the area the greater the ecosystem health.

Research Benefits:

This new system lowers costs of monitoring the health of wetlands ecosystems and gives managers a dynamic picture of what is actually occurring. The new monitoring system allows managers to watch how the effects of their actions impact the ecosystem, whether their actions improve the system's health or not, and then reassess the management approaches.

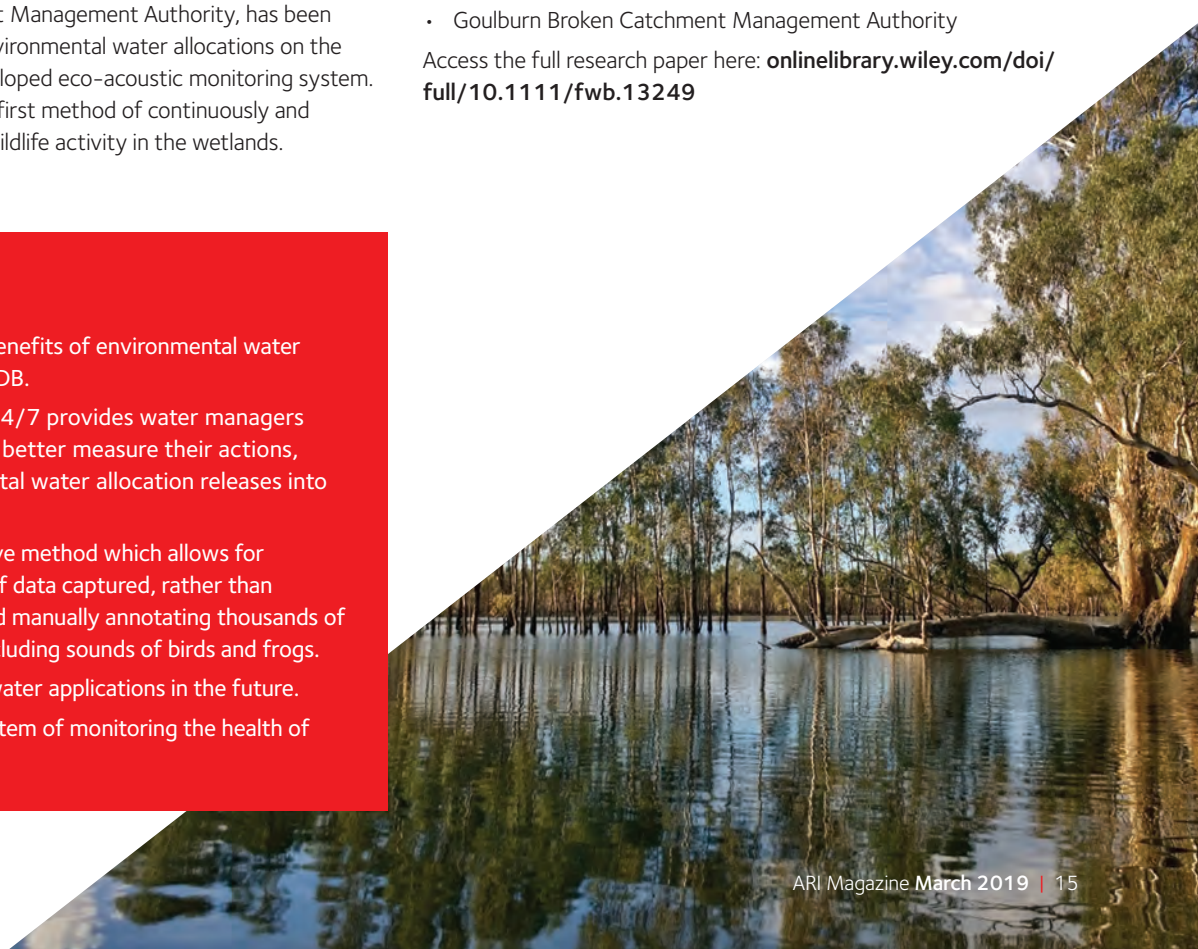
Partners

- Goulburn Broken Catchment Management Authority

Access the full research paper here: **onlinelibrary.wiley.com/doi/full/10.1111/fwb.13249**

Key Points:

- Demonstrates the benefits of environmental water allocations to the MDB.
- Recording of data 24/7 provides water managers with information to better measure their actions, such as environmental water allocation releases into the river system.
- A new, cost-effective method which allows for automatic analysis of data captured, rather than through listening and manually annotating thousands of soundscape files, including sounds of birds and frogs.
- Potential for underwater applications in the future.
- A more accurate system of monitoring the health of river systems.



OPINION, PEOPLE AND PERSPECTIVE

Emeritus Professor Jon Olley

Riparian health: eighteen years on but the message stays the same.

If I could go back in time and put in place one policy before European settlement began in Australia it would be that riparian vegetation should be protected and enhanced. Protection should be part and parcel of any development or farming enterprise. The kind of riparian clearing that destabilised channel networks across much of Queensland is probably also the single biggest cause of fine sediment pollution in agriculturally developed parts of Australia.

For the moment let us focus on the South East Queensland region and Moreton Bay, a Ramsar wetland of international significance. A decline in the ecosystem health of the Bay has been attributed to sediments and nutrients derived from terrestrial sources. Much of my time at the Australian Rivers Institute has been focused on identifying those sources.

I joined Griffith University and the Australian Rivers Institute in 2008 after 24 years in CSIRO's Division of Land and Water. My first ARI project was the Healthy Country Project. This was a Queensland Government funded 'proof of concept' initiative to demonstrate that bringing together the best science, planning and on-ground implementation can significantly reduce non-urban diffuse source pollutants entering the waterways. It started in January 2008 with an $8 million investment, most of which was for on-ground works. Project partners included the SEQ Healthy Waterways Partnership (SEQ HWP), SEQ Catchments Ltd, Queensland Primary Industries and Fisheries (QPIF), Department of Employment and Economic Development and the SEQ Traditional Owners Alliance (SEQTOA).

As part of the project, three small focal catchments were selected to develop appropriate rehabilitation techniques for the region. These techniques included (i) the development of methods to target the primary sediment and associated nutrient sources; (ii) designing tools that could be used to specify what works should occur where; (iii) trialling different rehabilitation methods; and (iv) developing methods to monitor, evaluate and adapt land and waterways management actions. Our focus was primarily on the question, 'where do the sediment and associated nutrients come from?'.

The answer was that most of the sediments and nutrients come from a small proportion of the catchment (<30% of the catchment area) and are predominantly supplied by channel erosion.

This meant that fixing the problem of excess sediment required re-afforestation of the riparian zones. This major finding was consistent with project work I had been involved in eight years earlier on some of the same catchments. This project found that the sediments in Central Moreton Bay were derived primarily from channel erosion in the Lockyer and Bremer River catchments, both major sub-catchments which ultimately drain to the Bay.

Another 10 years of effort in the South-East produced five PhDs, 16 major reports and 20- plus journal articles. It refined the arguments but the story stayed the same. We further pin-pointed the primary source of the sediment pollution to the in-channel features such as the benches and inset floodplains. But, as identified 18 years ago, works aimed at reducing the supply of sediment should focus primarily on rehabilitation of the channel network with the highest priority being for the placement of riparian vegetation on the inset features.

ARI's new project funded by the Ian Potter Foundation offers yet another opportunity to improve the state of South East Queensland's channel network and to protect Moreton Bay against the ecological consequences of fine sediment pollution.

I for one will continue to push that riparian vegetation is to be protected and enhanced as part of any development in the region. The evidence for this is overwhelming. You could well ask why has this has not happened yet? This is a question I have often asked myself. I think it is because the type of change required in peoples' thinking is large and achieving that change is a social question, not just a scientific one.

Professor Michele Burford

Complex problems require global multidisciplinary developed solutions.

Working as an ecologist, I am motivated by a desire to reduce the impact humans are having on the planet for the sake of the incredible and complex array of animals, plants and habitats and for people that will come after us. Unfortunately, environmental issues affecting our planet are growing rapidly in scale and complexity, whether it be climate change, land and water degradation or loss of biodiversity. We don't just need to study the problem, we need to find solutions.

Meeting this challenge will require scientists to take new and more complex approaches. In order to help solve complex problems. An interdisciplinary approach is needed, which means ecologists working with engineers, modellers, social scientists, hydrologists and so on. Holistic and integrated approaches are also increasingly the approach we need to take so that we don't just study a river, or section of a river, or a particular animal, but think on larger scales from catchments to the sea, and across continents and ecosystems.

There is also a need to tap into new monitoring and modelling techniques and to more effectively take advantage of the wealth of environmental data that already exists across the globe. So, the science of the future will need a more sophisticated approach and higher levels of investment to support infrastructure such as high performance computers, state-of-the-art facilities that simulate environmental conditions and change, and next generation equipment for rapid and remote monitoring and experimentation. Last, but not least, scientists have to work even harder to strengthen collaborations with the public, government and industry.

An example of where we have built a research program directly from the needs of communities, industry and government is a National Environmental Science Program (nespnorthern.edu.au/) project in the Gulf of Carpentaria region. We have a suite of researchers within Griffith University and partner organisations studying how future extraction of water from rivers in this region for irrigated agriculture is likely to impact on estuaries and coastal areas.

In this pristine area of Australia, there is a wide range of plants and animals that rely on these freshwater flows in the wet season to fuel productivity. For example, endangered migratory shorebirds rely heavily on this region. However, it is not just the ecosystems, it is fishing companies and local communities that also rely on the flow-fuelled productivity of estuaries. Working in remote locations is logistically challenging and expensive. However, it is unavoidable as these areas are poorly studied and we need fundamental information to inform decision-making and make predictions about how water extraction and other factors such as climate change will affect the environment, indigenous values of the land and water, families who rely on tourism and fisheries and the future of country communities. In fact, the impetus for the research came from industry, local communities and government, rather than the researchers themselves. This level of collaboration ensures the research outputs are as useful for future planning as possible.

Another example of where our research is striving to make a difference is the work we are doing with rice-shrimp farming communities in Vietnam. These subsistence farmers in the Mekong region face mounting pressures due to sea level rise, multiple dams being built in the upstream Mekong River, a growing human population and overstretched resources.

Our Australian Centre for International Agricultural Research project (https://www.aciar.gov.au/node/12956), which involves a collaboration with a wide range of Australian and Vietnamese organisations, is examining how we can make rice-prawn farming more productive and reliable in the future by undertaking high quality, practical research and translating it into useful outcomes for farmers.

These are just two examples of research we are doing in the Australian Rivers Institute where we are striving to make a difference, to ensure a sustainable future for humankind and the environment.

Key insights and lessons learned:

- Today's research needs to start with knowledge gaps identified from those funding the research, not necessarily from researchers themselves.
- As the environmental challenges grow, so too must the sophistication of the science in all its facets.
- New approaches and a broader suite of skills will be needed to tackle our environmental problems.

LIFE AS A SCIENTIST

Marieke Frassl

Living as a scientist lets you see and explore the world. A friend once called me a migratory bird. I think this is a good analogy for many scientists. We have the privilege, but also the duty to exchange, discuss and test our knowledge at an international level. Workshops, conferences and research stays allow us to explore the globe.

I enjoy the international aspect of science. It provides me with the opportunity to see places and learn new things. More importantly, it helps to build bridges between different countries and cultures.

Taking the opportunity to live in another country can be challenging, but also highly rewarding. I feel that my life in Australia has broadened my mindset, and is helping me to develop and reflect on my values and goals, which ultimately shapes my research.

What I value most about my life as a scientist is the ability to be creative with academic freedom. How many hours have I spent in front of my computer screen engrossed in large amounts of data? The answer is many. How often have I found an amazing pattern that leads to new knowledge? Well, not so often. But, that is science.

The questions are always changing and there is no 'one way of doing things'. The moments when we have a creative idea or find something new keeps us curious, passionate and engaged. How boring would it be, if we knew the answer to everything?

Modelling is ever changing, just like the climate

I currently work with mathematical models on various projects, which helps me understand water quality changes in a lake or water supply reservoir. Recently, our research team worked on a lake that was closed for swimming due to a persistent bloom of potentially toxic cyanobacteria. The occurrence of cyanobacteria blooms is a common problem worldwide.

Valuable data from long-term monitoring informs us that the common factor of deteriorating water quality is often due to high nutrient pollution, but increasingly it also hints towards climate change. Developing and applying models assists us in testing the effectiveness of different management options to improve water quality in lakes. They also help us to understand and predict changes that are more likely to occur in a changing climate.

To be fully effective, however, we have to base the models on as much information about the lake as possible. High quality data from experiments, fieldwork and regular monitoring programs are crucial, as is knowledge about the system from local stakeholders and managers. As a modeller, I work as an interpreter between different stakeholders and partners, I have a tool to summarise, but also question our current knowledge of a system.

'I enjoy the international aspect of science.'

PHD SPOTLIGHT

Man Xiao

My PhD

I commenced my PhD in 2014 at the Australian Rivers Institute, funded by a prestigious Griffith University International Postgraduate Research Scholarship (GUIPRS) and a Griffith University Postgraduate Research Scholarship (GUPRS). During my PhD I felt very lucky to have worked with such a wonderful supervisory team including Professor Michele Burford and Dr Anusuya Willis from ARI, and two other wonderful supervisors from UQ. With their support, I developed expertise in cell physiology, modelling and molecular biology.

While at ARI I attended several significant conferences. In 2016 I attended the SIL Conference held in Torino, Italy, which addressed major issues relating to water research, and in 2017 I attended the GLEON19 All Hands Meeting, held in New York, USA. This conference aimed to increase networks of lake researchers and experts, and how they can respond to changing global environments, and we attended expert workshops in modelling and statistical analysis. ARI's generous PhD travel grant for PHD students helped me cover the costs of travelling to these industry events.

During my PhD I also received training in writing research articles, how to manage your time wisely and how to manage professional relationships in your PhD life. I was also awarded a SciComm Cadetship which provided a cash prize and numerous training workshops, including video editing, interviewing techniques for senior researchers and how best to use Twitter to build my scientific profile.

As part of my SciComm cadetship I also held an extremely successful Twitter conference which produced 22 presentations, from all over the world covering: modelling, experimental and field studies, cyanotoxin measurement and production, impacts of eutrophication, stratification on cell physiology, water treatment and management. There were over 1050 tweets from over 170 participants and this reached over 20,000 people.

I have also been involved in several field work trips with colleagues, and some that involved industry partners like SEQ, where we collected cynobacteria samples in the North Pine Dam.

On 2 August 2018, I was awarded my doctoral degree, I am very proud of this achievement and I believe the support I received from ARI greatly facilitated my rapid advancement. I think the Institute is very supportive of international students.

Working for ARI

More recently, I've had the opportunity to work as a Postdoctoral Research Fellow in ARI with Professor Michele Burford and ARI Deputy Director, Professor David Hamilton. In this role I am working on a new project to look at the impacts of nutrient availability on the growth of a cyanobacterium *Raphidiopsis raciborskii*, which is one of the most common and toxic cyanobacterial (blue-green algae) species in South East Queensland reservoirs.

This project aims to:

- Understand how different strains of *Raphidiopsis raciborskii* respond to different nutrient levels in the laboratory.
- Predict the amount of toxin produced by this species using a modelling approach.

The aim of the project is to improve predictions of cyanobacterial blooms, ultimately helping water resource managers avoid the potential for adverse human health effects from blooms.

'I felt very lucky to have worked with such a wonderful supervisory team including Professor Michele Burford and Dr Anusuya Willis from ARI.'

NEW STAFF

Research

- Dr Ryan Pearson
- Dr Michael Sievers
- Dr Jodie Haig
- Dr Vivitskaia Tulloch-McShane
- Dr Vanessa e Souza Reis
- Dr Jing Lu
- Dr Habtamu Kassahun
- Dr Man Xiao
- Dr Kimberly Finlayson
- Dr Bonnie Lewis
- Dr Joe McMahon
- Dr Edoardo Bertone
- Professor Chris Fleming

Technical

- Ms Chantal Saint Ange
- Ms Nickolina Nenadic

Professional

- Mr Eric Jinks
- Dr Tom Raynar

Visitors

- Professor Bao Li - Linyi University, Shandong Province, P. R. China.
- Mr Leiyi Zhang - Sun Yat-sen University, Panyu District, Guangzhou, China
- Dr Natacha Hogan - Department of Animal and Poultry Science, Canada
- Dr Alice Baynes - Brunel University London, UK.
- Mr Daniel Ramos Gonzalez - Nottingham University, UK.
- Associate Professor Wenyu Zhao - Changsha Uni of Science & Technol, PR China
- Mr Qu Chenchen - Call Chen in regards to this visitor.
- Mr Qi Li, College of Resources and Environment Huazhong Agricultural University,Wuhan, China
- Associate Professor Yintao Jia - Institute of Hydrobiology, Chinese Academy of Sciences, Hubei, Wuhan, China
- Dr Yuzhu Zhang - Northwest University, China.
- Professor Julita Dunalska - University of Warmia and Mazury in Olsztyn, Poland
- Ms Antonia Weltmeyer - Rhein-Westpfählische Technische Hochschule, Aachen, Germany.

New PhD Students

- Arthur Barraza, Assessing toxicology of sea turtles.
- Julieta Gamboa Cutz, Microbial Community and Methane Activity in Solis of Coastal Wetlands Throughout a Salinity Gradient
- Lorelle Holcroft, Integrating morphology and mitochondrial DNA for species delimitation in Figuladra
- Sebastian Lopez-Marcano, Measuring cross-habitat movements among habitat hotspots of fish with artificial intelligence
- Jonathan Wanderley Lawley, Investigating endogenous and exogenous drivers of polychromatism in jellyfish.
- Donghwan Kim, Study on prediction of the Great Barrier Reef protection measures using a model
- Olivia King, Risk assessment of the interactive effects of multiple stressors for the Great Barrier Reef.
- Alyssa Giffin, Assessing toxicology of sea turtles.
- Mr Gebiaw Ayele, A grid-based hydrologic model for erosion assessment in the Bowen Basin in North Queensland.

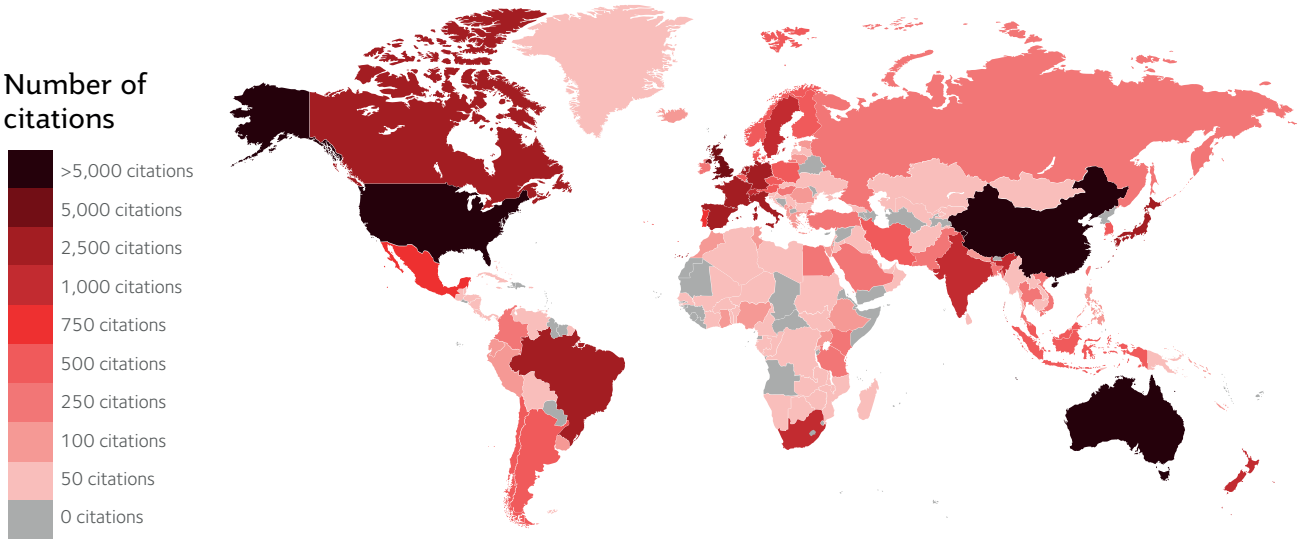
PhD Conferrals

- Tareq Saeed M, Almalki, Associate Professor Albert Jerome Gabric
- Vanessa E Souza Reis, Dr Simon Linke and Professor Stuart Bunn
- Kimberly Finlayson, Dr Jason Van de Merwe and Associate Professor Frederic Leusch
- Hangyong (Ray) Lu, Professor Bofu Yu, Pat Natin Professor Rod Connolly
- Harmony Patricio, Emeritus Professor Jon Olley and Dr Simon Linke
- Ryan Pearson, Professor Rod Connolly and Dr Jason Van de Merwe, Ameneh Shobeirinejad, Dr Ben Stewart-Koster, Margarita Vorsina, Dr Christopher Fleming

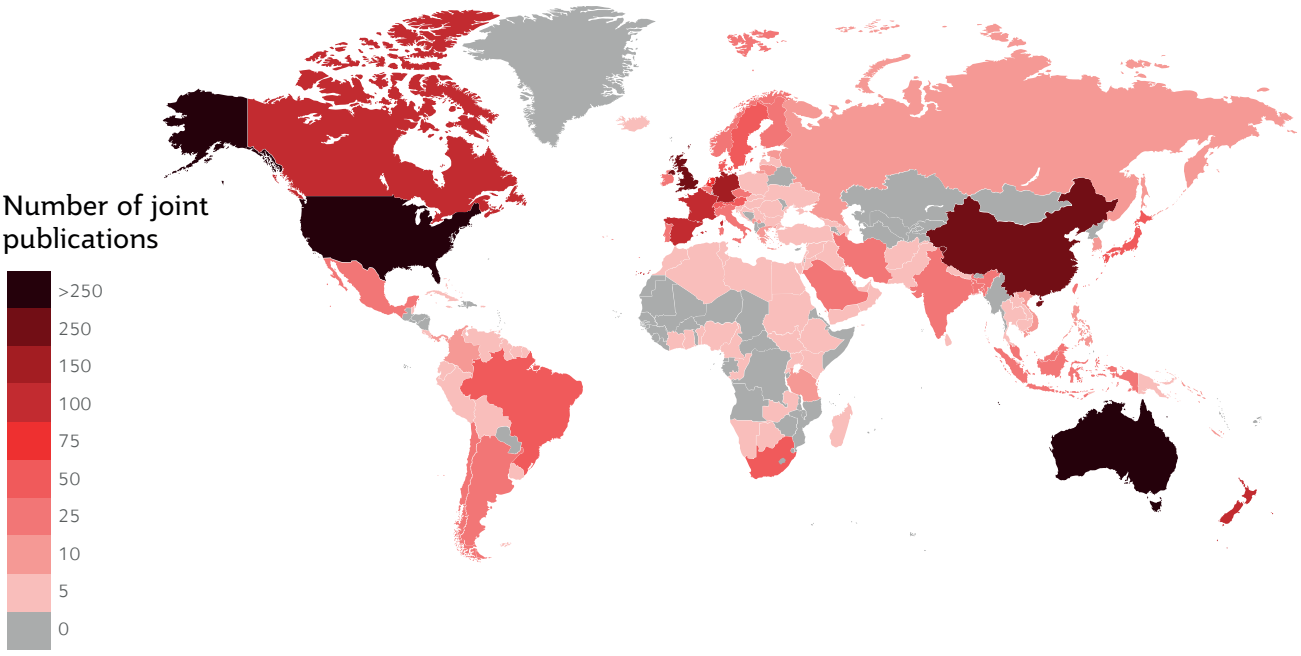
Photo Courtesy of Tom Raynar

ARI researchers have a strong network of international collaborators and our science is having a significant impact around the world

Journal citations



Journal papers co-authored



(All map data figures captured from year of Institute establishment 2006 until 2019).

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