



UNIVERSITY OF
CANBERRA



INSTITUTE FOR
APPLIED ECOLOGY



2017 RESEARCH HIGHLIGHTS

AND ANNUAL REPORT

“SCIENCE FOR KNOWLEDGE OF OUR NATURAL WORLD”



ACKNOWLEDGEMENT OF COUNTRY

The University of Canberra acknowledges the Ngunnawal people – the traditional custodians of the land on which the University is situated – and pays respect to the Elders of the Ngunnawal Nation both past and present.

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Cover image: Wallaby amongst flowers, North of Cooma, NSW, by Charles Davis.

Charles is an award winning photographer, and University of Canberra alumnus graduating with a Bachelor of Ecology in 2016. He returns to assist on field trips, enjoying the opportunity to learn more about ecology and take photos in remote parts of Australia. His work focuses on Australian wildlife around his home in the Snowy Mountains, NSW, and Charles has found his studies in ecology a valuable asset in his career as a professional nature photographer. www.charlesdavisphotography.com

Inside cover image: Anemone buttercup *Ranunculus anemoneus*, Kosciuszko National Park, NSW. Photo by PhD student Matt Young.

DIRECTOR'S REVIEW

In looking back over 2017 for the Institute for Applied Ecology (IAE), I was struck by some really impressive numbers.



The IAE with 26 full-time research and teaching staff has produced 1,224 peer-reviewed papers over the last ten years, with an average impact factor of 4. Those papers have appeared in the very best journals, and have been cited at high rates (see Figure below). The IAE has attracted >\$7M in research grants from the Australian Research Council, and >\$35M from other sources over the last decade. In 2017 the IAE attracted one quarter of the University of Canberra's external research income.

This year has seen the continuation of long running partnerships, particularly with the ACT Government, ICON Water and our colleagues in Diversity Arrays Technology (DART). Other relationships have been reinvigorated; a long-time partner in the Invasive Animals CRC and Weeds CRC, University of Canberra is now a hosting partner of the newly established Centre for Invasive Species Solutions. The renewed focus by government on impact of research has challenged us to work even more intensely on building our partnerships and networks of impact, to ensure that our research is both excellent and relevant to society.

The most profound change in 2017 has been the announcement by the University that the IAE will form part of the newly established Faculty of Science and Technology. Institute staff have contributed to undergraduate teaching for many years, and have been important leaders in the recent 'refresh' of undergraduate science courses. The merger into the new faculty will provide new opportunities for collaboration, and to some extent this has

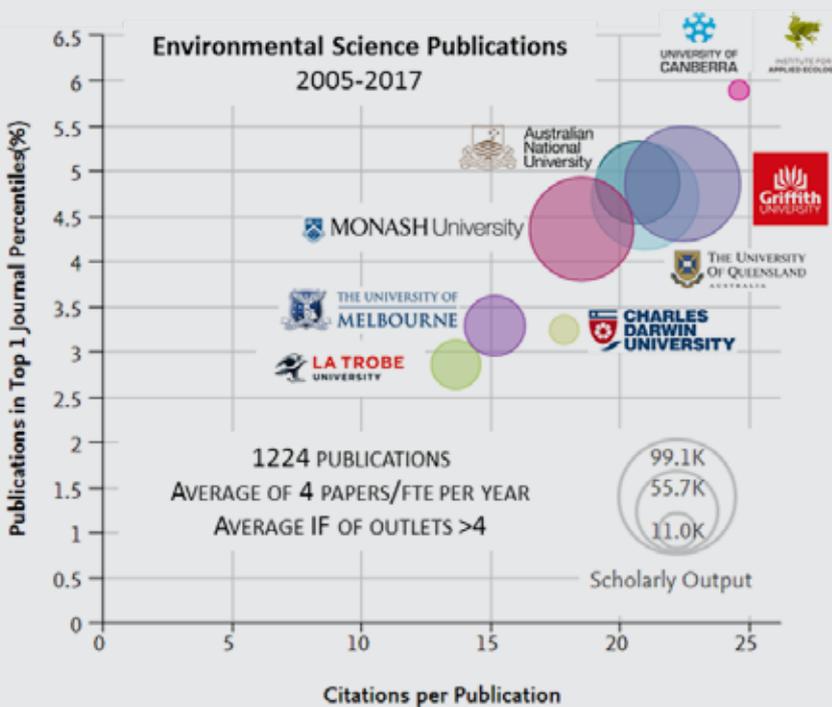
already borne fruit. Working with colleagues in Engineering, the IAE was successful with major funding applications with the ACT Government, addressing water quality in urban lakes (\$1M; Dyer, Thompson, Foster, Lemckert) and the Commonwealth 'Smart Cities' program (\$964K; Manasinghe, Norman, Thompson).

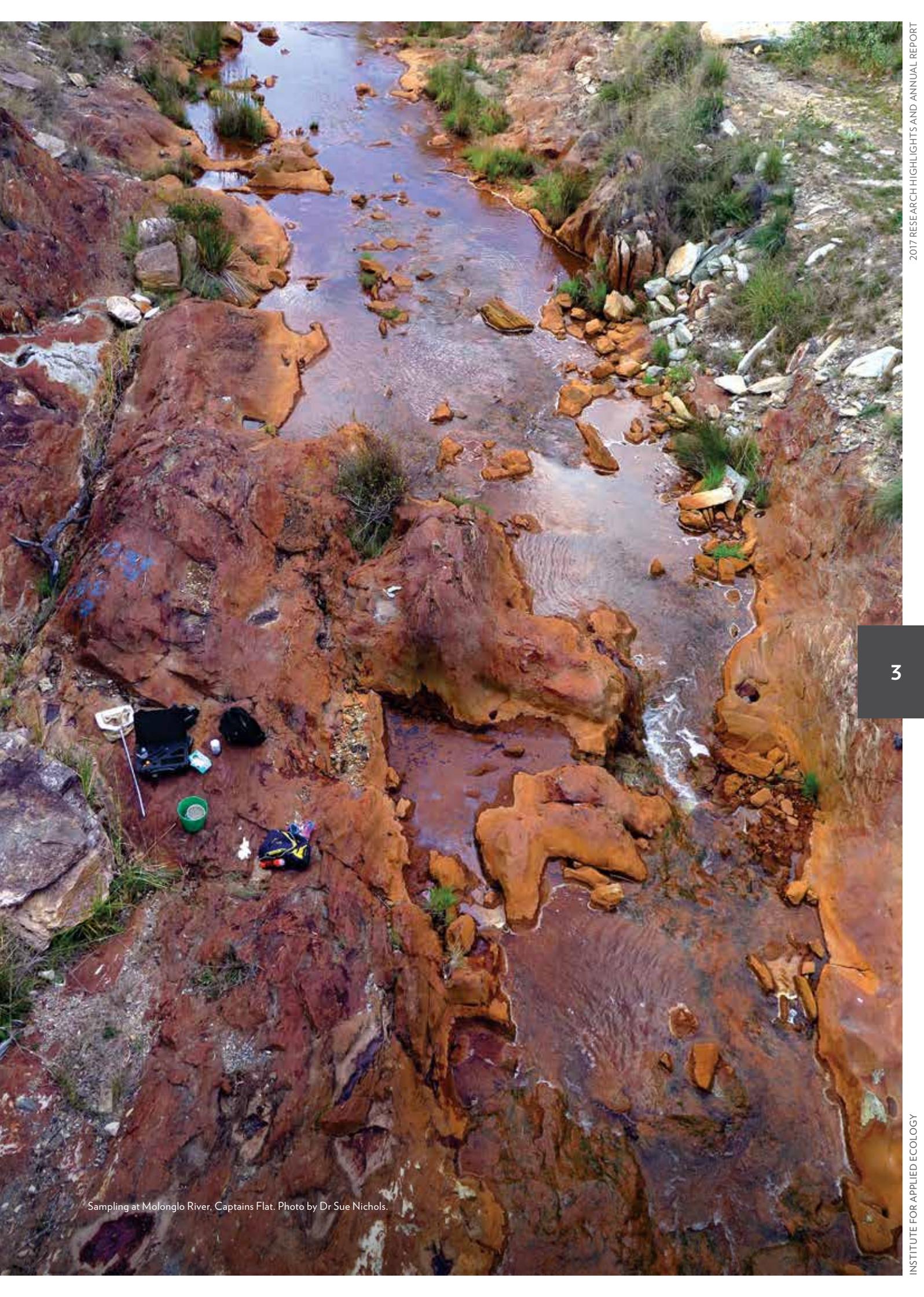
This is the first year of new IAE Strategic Plan 'From research to application in a changing world'. The Plan outlines the IAE's strategy for becoming a world-class research centre in environmental science. There is a focus on internationalisation, and I highlight our achievements in graduate training, where the IAE currently hosts 60 graduate students from 20 countries, and emerging links with Thailand, India and Canada. The strength in the IAE's research capabilities, coupled with strong engagement with industry, the public sector and the community, positions the IAE to become a global leader in applying the very best science to solve environmental problems.

On a sadder note, we bid farewell to the Deputy Vice Chancellor in Research and Innovation, Professor Frances Shannon. Frances was instrumental in helping the IAE achieve a step-change in productivity and success, and she will be sorely missed.

The following pages represent a snapshot of 2017's achievements. There is much to be proud of, and I congratulate all staff, students, adjuncts, support staff and partners on a wonderful year.

Professor Ross Thompson, Director





Sampling at Molonglo River, Captains Flat. Photo by Dr Sue Nichols.

ABOUT THE INSTITUTE

The Institute for Applied Ecology (IAE) has a reputation for world class research with an applied focus.

We engage with on-ground managers and policy makers to enhance decision-making for natural resource management.

Our expertise in freshwater ecology, conservation biology, genetics, environmental chemistry and landscape modelling combine to address environmental problems.

We engage with external stakeholders to provide innovative and practical solutions.

The IAE:

- Carries out quality research both independently and in partnership
- Provides technical advice to private and public-sector partners on environmental issues
- Brokers the creation of interdisciplinary teams to address environmental research needs
- Develops the next generation of environmental scientists through Honours, PhD and early career training and mentoring programs

FUNDAMENTAL RESEARCH & INNOVATION

Conservation Biology

Ecology

Ecotoxicology

Environmental Chemistry

Genetics & Genomics

Landscape Modelling

Natural Resource Management

Water Science

TRANSDISCIPLINARY SCIENCE

ENGAGEMENT

TRAINING

SOLUTIONS



Photo by PhD student Duminda Dussanayake.

RESEARCH STRENGTHS

Our researchers span a broad range of expertise, and we regularly collaborate across disciplines to solve environmental problems.

ENVIRONMENTAL DNA

Environmental DNA (eDNA) is increasingly being used in surveys to establish the presence or absence of target species at sampling sites. Institute researchers have used this detection method for a range of invasive aquatic species, including redfin perch and carp. We have also developed a method for detecting the threatened Macquarie perch spawning, shown that eDNA can detect the presence of terrestrial vertebrate species at water sources. Environmental DNA is gaining popularity as a detection tool in difficult-to-survey locations, such as aquatic habitats, and for difficult-to-detect taxa, such as rare or cryptic species.



Spawning of the threatened Macquarie perch has been detected by IAE researchers by comparing the abundance of different types of eDNA produced during the spawning period. This application can help evaluate management actions aimed at increasing the reproductive output of endangered populations. Photo by Ben Broadhurst.

CONSERVATION ECOLOGY

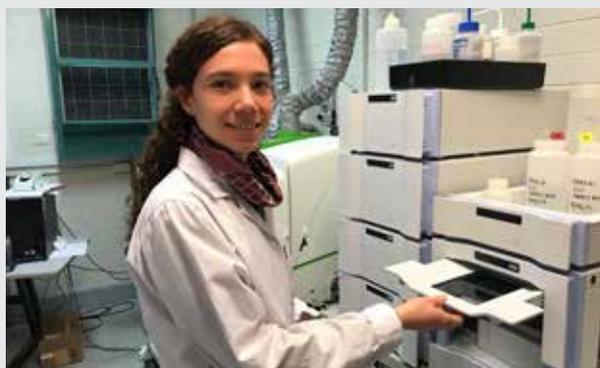
Our conservation ecology team carries out research that underpins environmental management, providing knowledge and tools to manage threats to Australia's native biodiversity. Our research focuses on how plant and animal communities function, and their response to changes such as land transformation, the spread of alien species, climate change, fire and nutrient cycles. This knowledge is applied to effectively manage or mitigate these impacts.



Measuring habitat characteristics in native grassland communities to find out what might make some rocks more appealing to the endangered grassland earless dragon (*Tympanocryptis pinguicolla*), Monaro region, NSW. Photo by Anna MacDonald

ENVIRONMENTAL CHEMISTRY AND ECOTOXICOLOGY

Our environmental chemistry and ecotoxicology researchers have renowned expertise in freshwater and marine chemistry, nutrients, metal and metalloid cycling through aquatic ecosystems, and ecotoxicology. Of special interest to the group are the transport and fate of elements in the environment, including water, sediment, dust and biota, focussing on element speciation. Our researchers are experienced in the sampling and analysis of a wide range of sample types, and have a well-equipped environmental chemistry and toxicology facility.



Researchers at the IAE are working to understand the fundamental science underpinning the metabolism pathways of organic arsenic species. This work is an important first step in understanding the risk associated to arsenic exposure. Photo by Teresa González de Chávez Capilla

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WILDLIFE GENETICS

The wildlife genetics team have a broad range of expertise from traditional population genetics through to eDNA and genomic tools. Applying DNA technologies for biodiversity and conservation outcomes is a prime focus of the team. The group combines genomic trace DNA and DNA genotyping to probe the historical phylogeography of Australasian fauna and to solve problems of forensic and ecological importance. End users of this science include conservation management agencies, environmental regulatory authorities, and other research institutions.



The presence of foxes (*Vulpes vulpes*) in Tasmania has been hotly debated. Researchers from the IAE used DNA analysis of predator scats (faeces) to detect its presence across northern and eastern Tasmania. The distribution of foxes was determined using systemic survey of potentially suitable habitat. This information was used to develop and implement a broad-scale fox baiting and monitoring program.

WATER SCIENCE

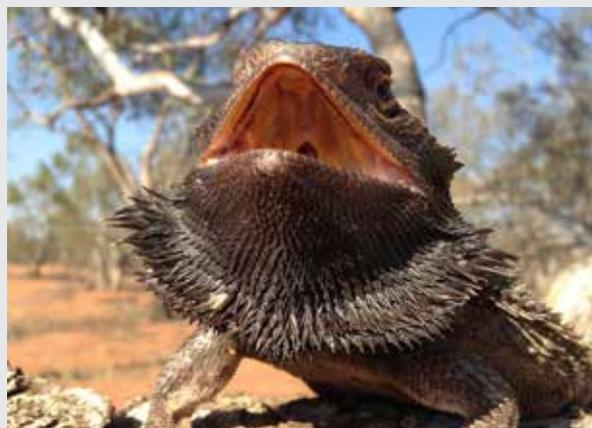
Our water science team aims to increase the understanding of freshwater systems to inform management and policy decisions. Our researchers study the fundamental ecology of Australia's freshwater systems, from stream metabolic processes, to endangered native freshwater fish. This knowledge is applied to environmental problems such as management of environmental flows, effects of water pollution, impacts of land-use and climate change. Our team works across disciplines, research organisations and agencies to generate integrated solutions to water science challenges.



In 2010 the IAE began an ongoing assessment program to determine the impact of inundation and operation of the Cotter Reservoir increase in capacity from 4 to 78 GL on two threatened fish species – the Two-spined blackfish (*Gadopsis bispinosus*) and Macquarie perch (*Macquaria australasica*). Photo by Ugyen Lhendup.

GENETICS AND GENOMICS

Our genetics and genomics research brings the power of DNA technologies to bear on central questions in ecology and evolution. We engage in detailed examination of epigenetic factors in plants and animals to unveil the mysteries surrounding the interaction of genes and the environment. By combining genetic and genomic analysis with whole organism and field studies we can discover the role genetic processes have in determining basic life histories and characteristics such as sex determination or disease resistance.



IAE researchers are unravelling the mystery surrounding sex determination in bearded dragons (*Pogona vitticeps*) and other reptiles. They discovered male dragons can become female – a process called “sex reversal” – when subject to extreme temperatures. Photo by Stephen Sarre.

EXTERNAL ADVISORY PANEL

In 2017 the IAE assembled an External Advisory Panel of exceptional calibre.

Chaired by Adjunct Professor Peter O'Brien (independent consultant), the members of the panel include Dr John Hewson AM, Professor Kate Auty (ACT Commissioner for Sustainability and the Environment), Dr Andrew Young (CSIRO), Adjunct Professor Allen Rodrigo (ANU), Adjunct Professor Neil Byron, Adjunct Professor Peter Bridgewater, and Dr Victor Pantano (Office of the Deputy Vice Chancellor, Research and Innovation). The panel meets several times a year to provide advice to the Director and Executive Committee on matters including strategic planning and implementation, building connections to other research organisations, and fostering relationships across academic, government and non-government organisations in the environmental space.



Black Roly Poly. Photo by Alica Tschierschke.

KEY EVENTS

The IAE hosts many events throughout the year, ranging from informal weekly seminars, conferences, and workshops, to large public events with high profile speakers.

NORRIS LECTURE

The IAE was honoured to host Professor David Dudgeon from the University of Hong Kong as he presented on the prospects for conserving freshwater biodiversity in densely-populated East Asia. Professor Dudgeon discussed the widespread challenges to human water security and associated faunal impoverishment.

“Water-engineering schemes intended to boost economic development degrade riverine habitats, further imperil biodiversity, and compromise the livelihoods of people who depend on freshwater ecosystem services,” says Dudgeon.

“If the benefits accruing from intact and biodiverse freshwater ecosystems do not constitute sufficient basis to ensure their preservation, what will? The prospects for conserving freshwater biodiversity in a rapidly-changing world are grim unless we take action now.”

The Richard Norris Lecture commemorates the life and scientific contributions of the late Professor Richard Norris, a foundation member of the IAE and an internationally significant researcher in freshwater ecology.



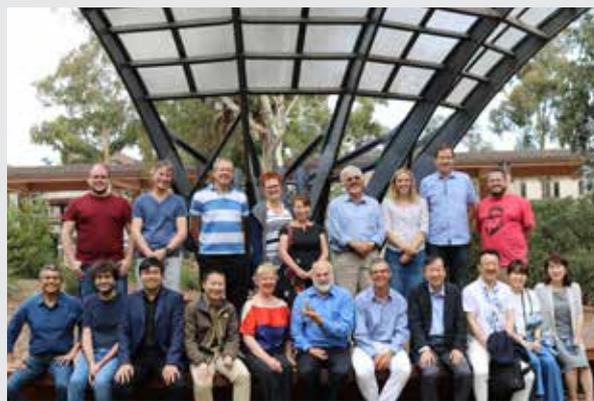
Professor David Dudgeon presented the 2017 Norris lecture.

CYTOGENETICS IN THE GENOMICS ERA

The IAE hosted 18 eminent researchers from the field of cytogenetics, genomics, environmental science and behavioural ecology. Leading researchers from around the world came together to identify where and how a combined cytogenetic and genomics approach will lead to major breakthroughs.

The workshop was organised by Professor Tariq Ezaz and Professor Janine Deakin, and also marked the start of the organisation for the “6th Asia Pacific Chromosome Colloquium and Genetics Society of Australasia” conferences to be held at the University of Canberra in July 2018. The University was also nominated to organise and host the 2020 International

Chromosome conference. This is an exciting opportunity, and one that will showcase our cytogenetics and genomics research on an international scale.



Attendees of the Cytogenetics in the Genomics Era workshop held at the University of Canberra. Photo by Rod Ubrihien

HDR STUDENT CONFERENCE

The enormous talent of the IAE student cohort was showcased in our first ever annual student conference. Students had the opportunity to present their work as a speech or poster, and gained valuable insight into the academic conference experience. Deputy Vice Chancellor (Research and Innovation) Professor Frances Shannon gave the opening address, and UC graduate Dr Anthony Chariton gave the keynote speech. The conference was strongly supported by our adjunct community, who provided feedback to presenters and awarded prizes. Special thanks to Jill Bartlett, Rod Ubrihien, Anthony Davidson and Teresa Chavez-Capilla who were the conference co-chairs and organising committee.



Celebrating women in science at the inaugural HDR student conference.

KREBS LECTURE

The Krebs Lecture was delivered by one of the United States of America's leading thinkers in ocean health and advisor to former US President Barack Obama. Distinguished Professor Jane Lubchenco delivered a dual message of urgency and hope about the world's oceans, telling the audience that science is needed now as never before.

The renowned academic posited that although there are very serious problems such as ecosystem collapse, coral bleaching and overfishing, the situation is far from hopeless.

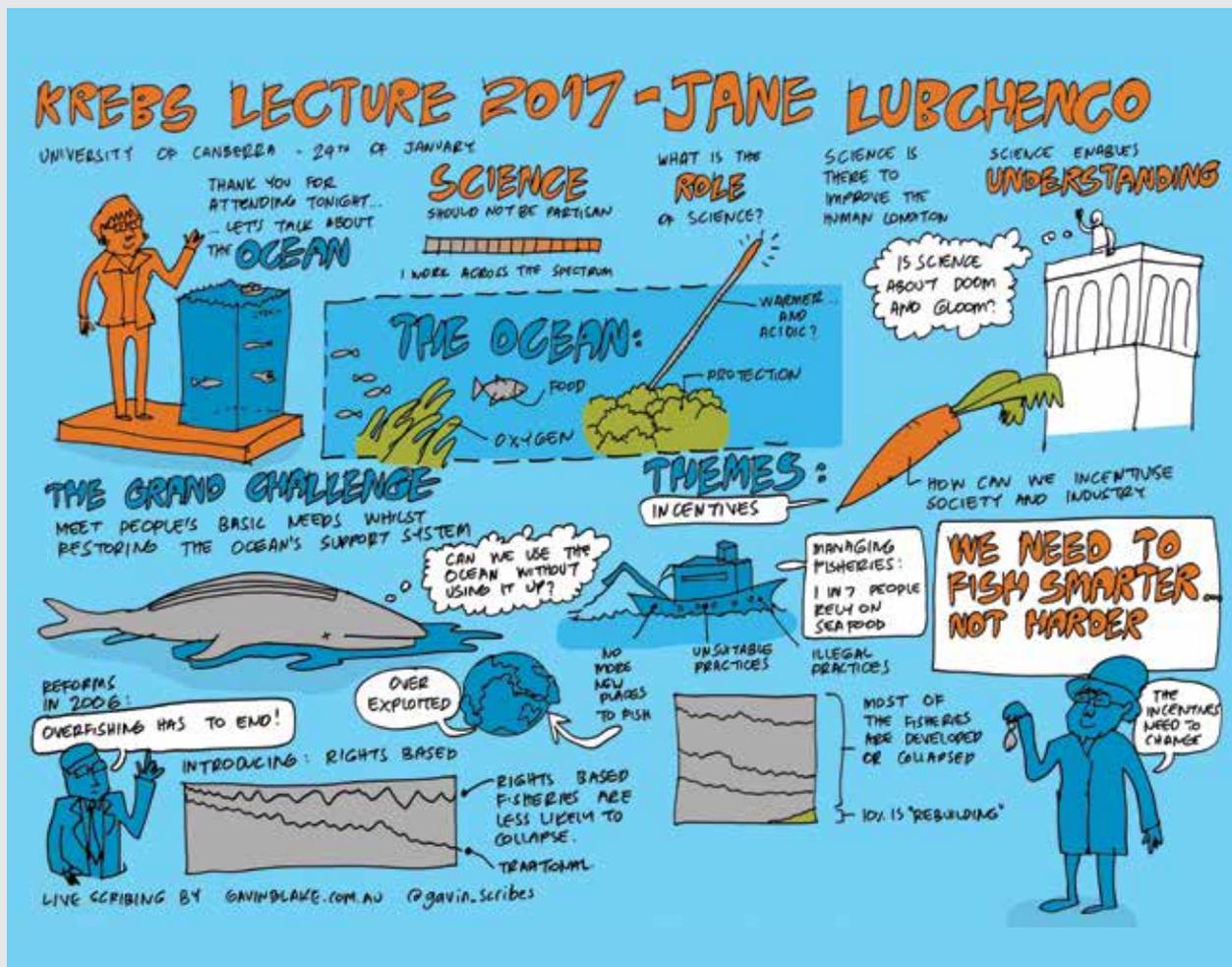
"Solutions to seemingly intractable problems are providing glimmers of hope. The challenge is to understand why certain solutions are working, then to replicate and scale them up to have global impact," Professor Lubchenco said.

"A common thread across these solutions is a change in incentives for the key actors. If economic and social incentives can be aligned with conservation, there can be powerful outcomes," she said. "The world can't afford to let these problems run away from us, with so many people depending on our seas for their life and livelihood."

The University's annual Krebs Lecture is dedicated to Professor Charles Krebs for his extraordinary contribution to our understanding and appreciation of our natural world. Past speakers include former federal Liberal Party leader Dr John Hewson AM, former Environment and Education Minister Peter Garrett AM, and internationally renowned environmentalist and author Professor Tim Flannery.



Professor Charles Krebs and Professor Jane Lubchenco



A creative infographic summarising key points of Professor Jane Lubchenco's lecture, created in real-time by Gavin Blake of GavinBlakeScribes.

MEETING OF THE NATIONAL LANDCARE NETWORK BOARD

The National Landcare Network (NLN) is the peak representative body of Landcare groups across Australia. The NLN Board convened at the IAE for their annual face-to-face meeting to discuss a range of issues affecting the national Landcare community. These face-to-face meetings rotate around Australia, with the Chair of Landcare ACT and IAE Adjunct Professor Peter Bridgewater hosting the 2017 event. The NLN delivers practical results from some of the research activities IAE undertakes, and we were pleased to have the opportunity to engage with them at such a high level.

A highlight of the session included a visit to Parliament House to meet with Minister Josh Frydenberg, and an evening function attended by the ACT Minister for the Environment, Mick Gentleman and Minister for Sustainability, Shane Rattenbury. The Ministers were able to learn from high-level state and territory representatives how to help develop an ACT perspective on Landcare. The meeting was a great success, with the Board charting a course of action for the next five years.



National Landcare Network board meeting with Josh Frydenberg, Minister for the Environment and Energy.

NATIONAL YOUTH SCIENCE FORUM

The National Youth Science Forum is a 12-day forum designed to deliver transformative STEM experiences to high school students, and encourage passion for these subjects. The IAE has been actively involved in the forum since 2014, and in 2017 Professor Ross Thompson ran two full day workshops, allowing the students to experience environmental science in the field at Lake Ginninderra, in our freshwater lab on campus, and learn about data analysis.

“It’s always a lot of fun working with these students,” says Professor Thompson. “Once again I was impressed by the calibre of the students attending the forum. I hope they were inspired by environmental science and decide to pursue further study in the area, hopefully with the University of Canberra.”



Professor Ross Thompson explains aquatic bioassessment techniques to students at Lake Ginninderra as part of the National Youth Science Forum.

KASETSART UNIVERSITY COLLABORATION

Institute Director Professor Ross Thompson and Professor Tariq Ezaz visited a number of faculties at Kasetsart University in Bangkok, to celebrate the signing of a major Memorandum of Understanding with the University of Canberra. Kasetsart is one of the largest universities of Thailand with 58,000 students currently enrolled, and five large campuses nationwide. Science, biology and fisheries are among Kasetsart’s strengths, and an active program of staff and student exchanges is expected to emerge from this agreement.

The IAE has already seen a number of students visit the institute including two PhD placements, and a lab visit by a small group of students. Endeavour Fellowship recipient Dr Srikulnath will spend six months at the IAE researching sex determination in reptiles. The IAE and Faculty of Science and Technology are actively working on undergraduate student exchange program to establish ongoing undergraduate student exchange between the two universities.

SEMINAR SERIES

The IAE hosts a weekly seminar series with speakers drawn from external organisations, as well as IAE researchers and students. Attending our Seminar Series is a great way to learn about what our colleagues are working on, and help contribute to their research. A list of Seminar Series speakers and topics are listed below.

Associate Professor Jeremy Austin, University of Adelaide

Where the wild things are: A brief history of thylacine and devil extinctions over the last 20,000 years

Professor Luciano Beheregaray, Flinders University

Ecological genomics of adaptation to environmental change

Adjunct Professor Peter Bridgewater, IAE

The thin blue/green line: governance for saltmarshes and mangroves in the Anthropocene

Jonas Bylemans, IAE PhD student

Monitoring freshwater fish communities using environmental DNA (eDNA) metabarcoding

Adjunct Professor Neil Byron, IAE

The challenges of being the Commonwealth Environmental Water Holder

Cat Campbell, IAE PhD student

Poo, paws & PCR: molecular ecology for wildlife conservation

Dr Renee Catullo, Western Sydney University

Using genomic, physiological, and landscape data to better inform predictions of biodiversity loss under climate change

Professor Saul Cunningham, The Australian National University

Ecosystem services and modern agriculture: friends or enemies?

Nick Dexter, Booderee National Park, Department of the Environment

Marsupial decline following fox control: What can reindeer tell us?

Dorjee Dorjee, IAE PhD student

Assessing the risk of alien plant invasions to the developing world: Bhutan a case study

Tim Fisher, Assistant Secretary, Water Policy at Department of Environment

Australia's Water Reforms

David Forsyth, NSW Department of Primary Industry

The emerging issue of wild deer in eastern Australia: Is the genie out of the bottle?

Associate Professor Bryan Fry, University of Queensland

Endless forms most beautiful: the dynamic diversification of snake venom

Teresa Gonzalez de Chavez Capilla, IAE PhD student

The arse-scenic life of arsenic in the human body

Kasey Hills, IAE PhD student

Toxicity of saline effluents from coal bed derived waters to stream invertebrates

Rheyda Hinlo, IAE PhD student

Improving eDNA detection probabilities for monitoring aquatic invasive species

Emeritus Professor Jim Hone, IAE

A tale of the bird, the cat and the pig: Smaller, bigger, biggest patterns and processes in the size of birds and other wildlife

Bill Johnson, Murray-Darling Basin Authority

Bridges and barriers to adaptive management and adaptive governance: The implementation of the Murray-Darling Basin Plan

Margarita Medina, IAE PhD student

Biogeography, spatial patterns and conservation of marsupials in the world

Elodie Modave, IAE PhD student

Identification, distribution and diet of Tasmanian predators inferred by scats

Michelle Montgomery, IAE PhD student

Controlling electric ants

Dr Paul Oliver, The Australian National University

New windows into the history and diversity of the Australian biota

Dr Stuart Pearson, Department of Defence

What is it about research in natural resource management that makes it so good?

Professor Deep Saini, Vice Chancellor, University of Canberra

Emissions of methyl-halide and -thiol compounds from plants: Biological significance and metabolic regulation

Rodney Ubrihien, IAE PhD student

Snails and copper: an intergenerational story of toxicity, adaptation and death

Angelica Lopez, IAE PhD student

Ecological niche modelling using presence only data. An evaluation of methods and applications

Michael Peat, IAE PhD student

Linking science with water policy: an assessment of contemporary approaches

WHERE WE WORKED IN 2017





AUSTRIA

JORDAN

YEMEN

UGANDA

KENYA

INDIA

MALDIVES

THAILAND

MALAYSIA

INDONESIA

PAPUA NEW GUINEA

AUSTRALIA

**BREMER
COMMONWEALTH
MARINE RESERVE**

NEW ZEALAND

ANTARCTICA

JAPAN

GUAM

RESEARCH EXCELLENCE, ENGAGEMENT AND IMPACT

The Commonwealth Government's National Innovation and Science Agenda is focused on promoting quality research, as well as encouraging universities, industry and others to work together so that Australia can benefit from the outstanding research that our universities produce.

Research excellence is assessed in conjunction with engagement and impact benefits, showing how universities are translating their research into economic, social, environmental and other impacts.



EXCELLENCE

SAVING FROGS FROM EXTINCTION

Amphibians are under threat worldwide from a range of pressures including an emergent disease, chytrid fungus. Many have gone extinct, and others have undergone dramatic declines. A few global refugia provide a glimmer of hope, such as those on the island of Papua New Guinea (PNG) to our north.

Distinguished Professor Arthur Georges, along with researchers from universities around Australia and the United States, used the prestigious journal *Science* to call for immediate pre-emptive action to save global frog populations.

The deadly fungus infects frogs when their skin comes into contact with its spores. These spores can be transported to new environments by humans particularly through footwear. The disease is yet to affect frogs in PNG, and improved bio-protection awareness and legislative changes such as importation bans could ensure the disease doesn't gain a foothold there.

"Stopping the inexorable march of the chytrid fungus should it ever reach the island of PNG will be a challenge," says Georges. "Our options for prevention are much more achievable than the cure. This work needs to be done now because if the fungus gets to PNG it may be too late to start."

PNG contains around six per cent of the world's frog species that have not been exposed to chytrid fungus. Other research and conservation actions identified include genome storage of vulnerable species, assisted reproduction, and captive breeding to help populations recover.

The researchers are calling for collaborative efforts among scientists, legislators, policymakers, managers, extractive industries and local landowners to prevent chytrid establishing itself on PNG.

Lead author of the article, James Cook University's Dr Deborah Bower, said rapid and concerted action is needed to protect the remaining chytrid-free populations.

"It is much easier and cheaper to conserve species before they are nearly gone," says Bower "Acting now will save many of the world's frog species. It's better to spend a penny now in prevention than a pound later on a cure."

Find out more: Bower, D. S., Lips, K. R., Schwarzkopf, L., Georges, A., & Clulow, S. (2017). Amphibians on the brink. *Science*, 357(6350), 454-455. DOI: 10.1126/science.aao0500



The chytrid fungus has devastated northern Corroboree frog (*Pseudophryne pengilleyi*) populations in Australia. Honours graduate Jack Rojahn used eDNA to detect the presence of Corroboree frog DNA in Namadgi National Park, and aims to infer the survival of captive bred individuals over time.

SOUTH GEORGIA: A SENTINEL FOR CLIMATE CHANGE

A study of long gone glaciers on remote South Georgia Island is providing new information on the impact of climate change on Antarctic ice caps. Today South Georgia is home to over 100 glaciers, juxtaposed with green grass and abundant wildlife. But this wasn't always the case. Twenty thousand years ago ice extended tens of kilometres out into the ocean from the island, with life only existing at the ice margin and beyond. Associate Professor Duanne White worked with a team of international researchers to discover that ice on South Georgia is sensitive to short-lived cooling and warming, growing and shrinking dramatically as the climate changed after the last ice age.

While the island is small compared to Antarctica and its ice caps, this is an important result. South Georgia is located in a part of the sub-Antarctic that is particularly sensitive to changes in climate, and can be considered a "sentinel" to climate change.

"Glaciers in the sub-Antarctic are retreating dramatically today, in response to an ever-warming atmosphere and ocean," says White. "It is perhaps unsurprising that South Georgia's glaciers were sensitive to climate change in the past, but our work has really shown that they were dynamic and underwent big changes in response to past warming."

"Improving the history of glacier behaviour on South Georgia even further is now essential so that we have a long-term context for the alarming recession we are witnessing right now," he said.

A team of researchers from the UK, Germany and Australia visited the island twice and used sophisticated sonar technology mounted to the hulls of ice-breaking vessels to reveal patterns of glacier growth and retreat. They discovered clear patterns of past glacier extent, with moraine ridges bulldozed into the seabed. This proved that contrary to previous estimates, the ice shelf extended many kilometres across the continental shelf. They also used weighted gravity corers to retrieve samples of ancient sediment from the ice-carved troughs that radiate from the island.

The research was led by the University of Exeter, UK, and funded by Natural Environment Research Council.

Find out more: Graham, A. G. C., Kuhn, G., Meisel, O., Hillenbrand, C. D., Ehrmann, W., Wacker, L., ... Bohrmann, G. (2017). Major advance of South Georgia glaciers during the Antarctic Cold Reversal following extensive sub-Antarctic glaciation. *Nature Communications*, 8, 1-15. DOI: 10.1038/ncomms14798



Associate Professor Duanne White taking rock samples on South Georgia Island to better understand previous ice coverage on the island.



AFTER THE BIG WET: THE FUTURE RESILIENCE OF SOUTHEASTERN AUSTRALIA'S BIOTA

Australia has a reputation for droughts and flooding rains. Understanding how plants and animals respond to extreme climate cycles is critical for future wildlife management as droughts are predicted to become more severe under various climate change scenarios.

Centenary Professor Ralph Mac Nally and Professor Ross Thompson were awarded Australian Research Council funding to investigate how a range of biotic elements responded to the 1997–2010 Millennium drought ('The Big Dry'), followed by above-average rainfall and large-scale floods of late 2010–2012 ('The Big Wet'). They did this by re-enacting drought survey programs during, and after, the floods.

"Long-term ecological data sets are increasingly valuable as they allow ecologists to track the effects of large-scale, decadal pressures, such as land-use and climate change," explains Mac Nally. "The ability of plants, animals and ecological processes to maintain their health in the face of extreme pressures, and their capacity to rebound following the relaxation of that pressure, tell us much about the ecological future of southern Australia."

From an ecological perspective, project outcomes suggest that the effects of the Big Dry propagate on despite the Big Wet and the moderate conditions since 2012. River red gum forests of the Murray River floodplains still show a decrease in health, for example, and this has repercussions for other species that rely on them.

"We know that floodplain forest birds track forest health, so on-going declines mean that the long-term prospects for birds in these forests is not promising," explains Mac Nally. "Our work showed that floodplain birds generally did not rebound to anywhere near the same degree to which they declined in the Big Dry, leading to general falls in species richness, numbers of birds and breeding activity."

The project also showed a particularly severe decline in the box-ironbark forests health of central Victoria, and the birds that that rely on them, as well as amphibians of the central Victorian plains.

Outcomes of this work can feed into management programs to maintain or improve biodiversity and ecological processes, which

is why partner organisations, such as EPA Victoria, Parks Victoria, the Victorian Department of Sustainability & Environment and two Catchment Management Authorities invested in the work.

Find out more: Mac Nally, R., Nerenberg, S., Thompson, J., Lada, H. & Clarke, R. H. (2014) Do frogs bounce, and if so, by how much? Responses to the 'Big Wet' following the 'Big Dry' in south-eastern Australia, *Global Ecology and Biogeography*, 23, p. 223-234. DOI: /10.1111/geb.12104

THE DEVIL'S IN THE DETAIL: USING GENETICS TO TRACK THE DEVIL FACIAL TUMOUR DISEASE

Just when researchers and conservationists thought Tasmanian Devils were getting an upper hand on the infectious Devil Facial Tumour Disease, another cancer reared its ugly head.

This second cancer was discovered in 2014, and at first glance the tumours look the same. Both produce facial tumours causing disfigurement so huge that the animal can't eat and ultimately dies, and both are spread from animal to animal as they bite in frequent confrontations. However researchers have discovered that the genetic make-up of the two cancers are different.

Professor Janine Deakin is working with a team of researchers from around Australia to investigate and track the disease. Specifically, Deakin is charged with characterising the chromosome rearrangements and uses this information to determine how these tumours originated and how they are evolving as they spread through the population.

"Both cancers have a problematic and fragile chromosome 1. In the original cancer some of the X chromosome attached itself to chromosome 1, while in the second cancer chromosome 6 is fused to chromosome 1," explains Deakin. "Devil chromosomes have odd telomeres which may have played a part in how it started. Telomeres are the caps at the end of chromosomes that stops them from fusing to each other. One copy of each chromosome in devils has short telomeres. These short telomeres expose the chromosome to increased likelihood of this chromosome rearrangement, and transmissible tumours."

When the first cancer was discovered researchers predicted that devils would be wiped out. Yet here they are some twenty years later. One explanation for their resilience is their immune system is fighting back, with antibodies detected in their blood. Researchers have now developed a vaccine to help boost the devil immune system, and this vaccine is currently undergoing field trials and looks promising. So maybe death isn't the inevitable outcome from the first cancer.

"I was hopeful for the future of the devil with the introduction of a vaccine. But the discovery of a second cancer is really worrying. What's to stop a third or even fourth cancer developing and causing extinction?" asks Deakin. "This is why understanding the genetics behind the disease and tracking its evolution is so important. Only if we understand how the current cancer is spreading, can we combat future variations of the disease, and help save the devil for generations to come."

Find out more: Taylor, R. L., Zhang, Y., Schöning, J. P., & Deakin, J. E. (2017). Identification of candidate genes for devil facial tumour disease tumorigenesis. *Scientific Reports*, 7(1), 8761. DOI: 10.1038/s41598-017-08908-9



A Tasmanian Devil suffering from Devil Facial Tumour Disease. Photo by Rodrigo Hamede.

TREES NEED BIRDS: FOREST FRUITFULNESS DEPENDS ON SEEDY LIVING

An unwinding ecological disaster on the Pacific island of Guam has provided an IAE led team with a rare opportunity to quantify the importance of forest fruit lovers to maintaining the diversity and health of arboreal habitats.

The introduction of the brown tree snake (*Boiga irregularis*) to Guam in the 1950s led to the extinction of all the island's native vertebrate seed dispersers apart from one small population of Micronesian starlings (*Aplonis opaca*) and a few bats. This species loss has provided a chance to gauge how Guam's forests have been affected by the almost complete absence of animal seed dispersers, compared to the forests the neighbouring Micronesian islands of Saipan and Rota, where animal seed dispersers remain relatively abundant.

About 70% of tree species across the three islands have fleshy fruits adapted for dispersal by birds. The research team led by Dr Elizabeth Wandrag of the University of Canberra created "canopy gaps" on each island, counting tree seedlings that grew in each gap after one year. Seedlings were classified as either having come from seedfall from nearby trees or from further afield via active dispersal.

Seedling diversity was consistently higher in the gaps on Rota and Saipan compared to Guam, according to the research published in the *Proceedings of the National Academy of Science*. The loss of vertebrate seed dispersers on Guam, the paper estimates, resulted in about half the number of tree species taking root.

On Guam the gaps were also generally populated by one species or another, while on Saipan and Rota species were more evenly distributed.

"Gaps in tropical forests are nurseries for the future," Wandrag says. "These seedling species simply aren't getting to the gaps and will therefore struggle to survive."

"Losing native seed dispersers from the landscape could irrevocably change the way these forests look. Introduced species such as the brown tree snake could end up threatening not just local animals but ultimately entire ecosystems."

Collaborators in this research include IAE Centenary Professor Richard Duncan, Dr Amy Dunham, Assistant Professor in BioSciences with the Department of Biosciences at Rice University in Houston, Texas and Dr Haldré Rogers, Assistant Professor with the Department of Ecology, Evolution, and Organismal Biology at Iowa State University.

Find out more: Wandrag, E. M., Dunham, A. E., Duncan, R. P., & Rogers, H. S. (2017). Seed dispersal increases local species richness and reduces spatial turnover of tropical tree seedlings. *Proceedings of the National Academy of Sciences of the United States of America*, 114(40), 10689-10694. DOI: 10.1073/pnas.1709584114

* This news article was written by Liz Drummond and first published in *Cosmos science magazine*.



The brown tree snake (*Boiga irregularis*) was introduced to the island of Guam in the 1950s and has decimated native bird populations.

ARC FUNDING SUCCESS

The IAE are leading two Discovery Projects awarded by the ARC in 2017.

Professor in Wildlife Genetics Stephen Sarre, Dr Bernd Gruber and Centenary Professor Richard Duncan, in collaboration with colleagues from the University of Sydney and Harvard University received more than \$530,000 for their project titled: *Does dynamic ecological change cause rapid evolution?*

Their research aims to determine how highly variable climate can drive rapid evolutionary change. Specifically, they will study the genomics and demographics of mammals and reptiles in the Simpson Desert in order to understand key evolutionary processes in a boom-bust environment.

“In arid locations, species are confronted by highly variable rainfall events, and they’ve adapted to this,” says Sarre.

“Understanding how they cope with these changes can inform how other species might adapt to the rapid climate change we are likely to see in the near future.”

Associate Professor in Water Science Ben Kefford, Professor Ross Thompson and Professor LeRoy Poff have been awarded more than \$380,000 for their project titled: *Does climatic thermal variability matter?*

Associate Professor Kefford and the team will collaborate with Griffith University colleagues to investigate aquatic invertebrates to assess their response to changing climatic conditions.

“We aim to better understand how species have adapted to past thermal variability and how climate change may affect them,” says Kefford.

ENGAGEMENT AND IMPACT



Alica Tschierschke and Ugyen Lhendup calibrating a data logger used to record dissolved oxygen concentrations at Lane's Bridge in the Lower Lachlan river system. Photo by Fiona Dyer.

LOWER LACHLAN FLOODING PROVIDES UNIQUE MONITORING OPPORTUNITY

Dams and weirs control flow along the Lachlan River for use by agricultural industries and communities. While this provides water for users, river regulation has had significant effects on the ecology and the function of rivers, floodplains and wetlands. The Commonwealth Environmental Water Office in collaboration with NSW government agencies manage environmental water in the Lachlan River system to benefit the regions ecosystems. Associate Professor Fiona Dyer leads a team of researchers from the IAE, UNSW, CSU and NSW State Agencies in monitoring and evaluating the outcomes of environmental watering for fish, vegetation, stream metabolism, waterbirds and frogs.

"We have been monitoring the Lower Lachlan area for three years now, and 2017 was particularly exciting as we experienced the fourth biggest flood on record," says Dyer. "We saw flora and fauna respond in different ways, and the delivery of Commonwealth environmental water had to be adapted accordingly."

Waterbirds took advantage of habitat for nesting and foraging, and a very successful breeding season was established. Commonwealth environmental water was used to support nesting waterbirds by providing water at the tail end of the flood to keep water levels stable and prevent nest abandonment because of falling water levels.

The widespread flooding also had a significant effect on fish communities. There was a substantial reduction in the numbers of native fish species such as Murray cod and Golden perch compared with the previous years of monitoring. Low dissolved oxygen levels (blackwater) post flooding are thought to be the culprit, and environmental water was used as the flood receded to provide refuge for aquatic species and provide higher quality water to help abate this.

Long-term monitoring of the Lachlan River not only provides an opportunity to establish valuable datasets for industry and government, but also supports student research. Two students from the IAE are taking advantage of this long-term monitoring project for their PhD studies.

Will Higgisson is working to understand the impacts of water resource development for floodplain vegetation communities. He is developing an understanding of the inundation requirements of key floodplain vegetation species for their reproduction and survival. Will is also investigating the genetic characteristics of two important plant species in the lower Lachlan river system, lignum and river cooba.

Foyez Shams is investigating two native fish species monitored in the area: Golden perch and Murray cod. Foyez is using genetic analysis to determine what proportion of the fish are wild or stocked, and to discover sex markers. His work will benefit the conservation and management of both species.

"This is a valuable opportunity for our students to apply their research to real world water management," says Dyer. "Their work will directly benefit conservation efforts, and the skill sets they develop by working with river managers will aid them in future career endeavours."

Find out more: <http://bit.ly/LowerLachlanMonitoring>

PLANNING FOR "CARPEGEDDON" – USING eDNA TO COUNT CARP

Millions of carp are wreaking havoc across Australian waterways. Managers need efficient and reliable methods to determine carp distribution and numbers to better assist eradication efforts. Associate Professor Dianne Gleeson and her team are using newly developed environmental DNA (eDNA) technologies to do just this.

The National Carp Control Plan are planning to release a carp herpesvirus with the expectation it will significantly reduce carp numbers. There is a catch, though. Carp can make up to 90% of fish biomass in some areas, and killing vast numbers of carp could result in "blackwater events". A blackwater event is where masses of dead fish deplete dissolved oxygen in a waterway, which in turn kills other aquatic fauna. Given how quickly the virus could spread, there is a risk that blackwater events could be many kilometres long. As such, environmental managers need information on carp distribution and quantities to inform the most effective strategies for virus release and clean-up operations.

Researchers at the IAE have shown that eDNA technology has the ability to detect carp DNA in waterways and provide a probability of their presence or absence in a given location. "The increased sensitivity of eDNA has a potentially distinct advantage over traditional survey methods, for example netting or electrofishing. It is also quick and cost effective" says Gleeson.

The IAE eDNA team is now working on further developing this technology in order to assess the relative abundance of carp within a given system. This assumes that carp release DNA into the water at a rate commensurate with their biomass, thus the concentration of eDNA can potentially be used as an estimate of biomass.

Researchers have started to calibrate the ability of eDNA technology to determine biomass by taking advantage of a

unique situation whereby local ponds within the ACT and NSW were drained for development purposes. Various survey methods were used prior to drainage to estimate carp abundance including eDNA. These results were compared to the absolute biomass obtained from all fish found post drainage. This preliminary study showed a strong correlation between total biomass and eDNA concentration, which indicates this method has potential for further application.

“We are now collaborating with a range of state agencies to further calibrate our eDNA method alongside targeted mark-recapture activities,” says Gleeson. “This is an exciting opportunity for our research to be at the forefront of the carp eradication program.”

Find out more: Hinlo R, Furlan E, Suitor L, Gleeson D.M. (2017). Environmental DNA monitoring and management of invasive fish: comparison of eDNA and fyke netting. *Management of Biological Invasions*, 8, (1) 89–100. DOI: 10.3391/mbi.2017.8.1.09



Research Assistant Rhian Clear holding a large carp caught at Lake Ginninderra, ACT. Photo by Elise Furlan

QUANTIFYING BIVALVE HEALTH: A “CANARY” IN MARINE ENVIRONMENTS

Oysters not only taste good, but are a reliable indicator of environmental stress. Researchers at the IAE have developed a new technique that quickly and cheaply quantifies bivalve condition. This methodology can be used to assess marine environmental health, and test product quality in the aquaculture industry.

Bivalve energy stores and usage (as total carbohydrates, proteins and lipids) are an indicator of organism health, also known as Cellular Energy Allocation (CEA). Energy available for use by bivalves varies with changing environmental conditions, and a positive energy balance needs to be maintained for growth, reproduction and fitness. This new assessment technique uses near infra-red spectrometry (NIRS) and quantitative modelling to accurately calculate CEA.

“Our methodology has many advantages over traditional wet chemistry techniques,” says PhD candidate Jill Bartlett. “It is quicker, cheaper, more reliable, and reduces the need to extensively sample individual species. We have included a

number of different species in our model, and our analysis show that aggregating data from like species produces robust results.”

Bivalves are filter feeders, sessile and long lived – this makes them a useful monitoring species. In addition they respond rapidly to environmental stressors, such as temperature, pH, salinity, and contamination. The NIRS methodology can be used to assess environmental impacts, with biomarkers providing an early warning system to environmental stress.

Bivalves also have significant economic value, with oysters, mussels and other aquaculture industries globally worth \$19 billion US. Changing physiochemical conditions in estuarine and coastal environments influence bivalve fitness and affect the commercial success of the aquaculture industry via reduced growth rates, reduction in fecundity and harvest die-offs. Operators currently use oyster size and growth rates as an indicator of product quality, but this doesn’t necessarily give an indication of meat quality. Local farmers are already showing interest in the technique where they can establish measurable parameters associated with best meat production, and optimise their operations accordingly, e.g. stocking density, cage type and location. Being able to quickly and cheaply assess these will be an advantage to farmers who want a competitive edge.

“The ability to rapidly and accurately assess the energetic condition of bivalves in the wild and commercially grown means managers can respond quickly to environmental conditions. This will be a valuable tool for environmental and aquaculture managers, and we are excited to be at the forefront of this technology,” says Bartlett.

Find out more: Bartlett, J. K., Maher, W. A., & Purss, M. B. J. (2018). Near infra-red spectroscopy quantitative modelling of bivalve protein, lipid and glycogen composition using single-species versus multi-species calibration and validation sets. *Spectrochimica Acta - Part A: Molecular and Biomolecular Spectroscopy*, 193, 537-557. DOI: 10.1016/j.saa.2017.12.046



Oyster farmer Stefan Paschalidis is helping the IAE with their research by providing oysters for use in their study.

TRADITIONAL KNOWLEDGE INFLUENCING WATER MANAGEMENT

Brad Moggridge is an Indigenous water scientist from the Kamilaroi nation and a PhD candidate at the IAE. His research explores ways in which traditional approaches in water management can be used to influence western practices and policy.

“The two fields of thought can enrich each other. Unfortunately the Indigenous voice has been missing from water management conversations for a long time because we haven’t had the science to back it up,” Brad explains. “But we can validate ancient lore, and I want to see this traditional knowledge influence the way we do business.”

Brad’s research will reflect on how best to engage First People’s voices in water management, building on his extensive knowledge from working within the NSW State Government. His thesis will take three approaches; reflection on existing and past models of engagement in Australia, working on country with First People to understand how best to apply cultural water allocations, and comparing experiences in First People’s water management between New Zealand and Australia.

RESEARCH TRAINING

Our students are valued members of the Institute who contribute greatly to our research environment.

Students have many opportunities to develop their research skills through activities such as writing workshops, weekly in-house skills development workshops, and regular research program meetings. These activities enable students to hone their research skills by exploring and testing ideas, as well as analysing and interpreting their data under the mentorship of leading researchers.

Science communication is a vital part of research training. Our students compete in the 'Three Minute Thesis' and 'Pitch for Funds' competitions, where they develop the communication skills vital for widely disseminating their research finding and ideas. They also participate in the Institute's seminar series and organise an annual research student conference.

We are committed to training professional and highly employable graduates. The diversity of employment backgrounds and networks of the Institute's staff and adjuncts provide students with opportunities for work-integrated learning and enable them to prepare for a variety of employment roles upon completion of their candidature.



Undergraduate field trip to the Snowy Mountains, NSW. Photo by Duanne White.

IN THE FIELD

SAVING TROPICAL ECOSYSTEMS FROM INVASIVE FIRE ANTS

Michelle Montgomery

PhD candidate

Electric Ants (*Wasmannia auropunctata*) are one of five ants on the International Union for Conservation of Nature Invasive Species Specialist Group's "world's worst invasive species" list and are widespread throughout the Pacific. Michelle aims to develop best management practices for Electric Ants in tropical ecosystems. Based in Hawaii, Michelle has travelled across the Hawaiian Islands and the Pacific to help residents, farmers, and government agencies manage the invasive ant.

Michelle's research takes her to some hard to reach places. Field work usually involves applying insecticidal baits or conducting ant surveys in rough terrain. During an eradication effort on the island of Kauai, Hawaii (USA) she had to navigate through thorny hedges and abseil down sheer cliffs for treatments and surveys.



GUARDIANS OF THE GALAXIAS: INVESTIGATING THE ECOLOGY OF STOCKY GALAXIAS

Hugh Allan

Masters candidate

Stocky Galaxias (*Galaxias tantangara*) were first described in 2014 in a small alpine stream in Kosciuszko National Park. Not much is known about the species, so Masters student Hugh Allan is working to discover more about their ecological requirements to aid in their conservation campaign.

Each month Hugh travels to the high country in Kosciuszko National Park to sample the only known population of Stocky Galaxias. Using backpack electrofishing, Hugh temporarily stuns the fish making them easier to catch. "We measure and weigh the fish, and inspect them for signs of disease, parasites and health condition," explains Hugh. A small sample of fish are brought back to labs at the IAE to determine reproductive development and age.

Fish are also tagged, and Hugh uses a portable tag detector to monitor fish locations. "We waded up the stream using a purpose built long-range antenna to determine precise fish locations. We compare this information to those collected previously to see how far fish have moved since we last detected them, and what sort of habitat they are using," says Hugh.

It's not all hard work though, once surveys are complete the focus shifts to fishing, spotlighting, exploring historic huts, and camping in some pretty special places.



Masters student Hugh Allan using a portable tag detector to determine the exact location of Stocky Galaxis.

USING GENOMICS FOR CHEETAH CONSERVATION

David Thuo

PhD Candidate

Cheetahs are an iconic animal of the African plains. Conflict with humans is one of many pressures leading to a drastic decline in numbers. Local land owners see cheetahs as a threat to domestic livestock, and will kill them to protect their animals. But maybe cheetahs are not the culprit?

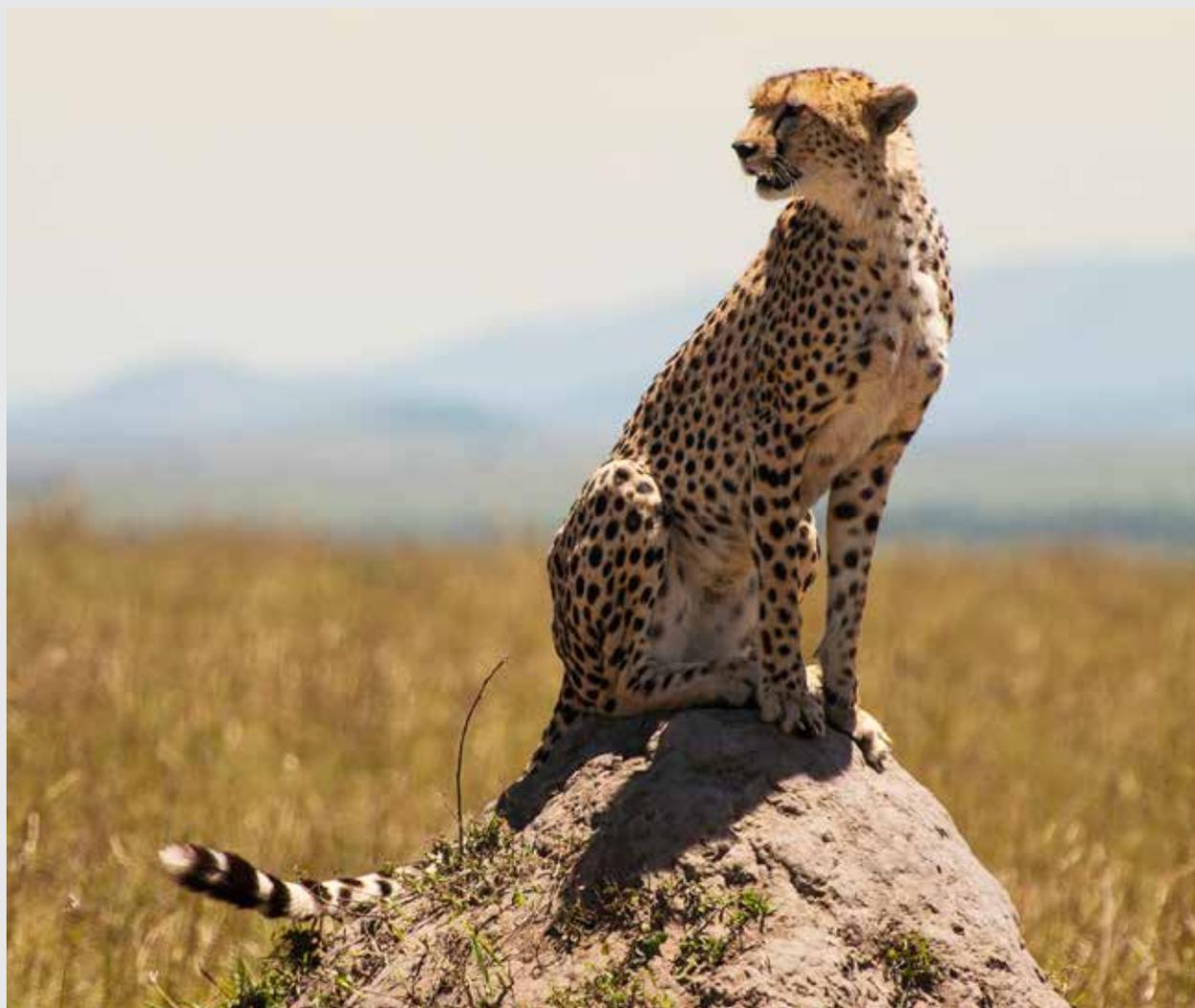
Research student David Thuo is collecting scats from Kenyan cheetahs and will use genetic analysis to determine their diet, as well as taking tissue samples to develop a high resolution genetic tool that can be used to differentiate cheetahs and assess their health and population structures. David hopes this information will be used to influence cheetah management policy and education programs.

Having spent years in the bush monitoring rhinos, cheetahs and lions, David thought his PhD field work would be a walk in the park. "While my field work was hugely successful, it was equally challenging," says David. "It wasn't just the technical aspect that was challenging. I also collaborated with various local

government and conservation groups, and spent two weeks training research assistants on cheetah identification, data and sample collection and sample preservation."

David's days in the field usually involved cheetah spotting or travelling long distances between sites. "A typical day would start at 4:30 am when temperatures are low and the chances of sighting a cheetah is high. We would wait until the cheetah dropped poo which we would collect, or the wildlife veterinary arrived to take a biopsy. This could take up to 10 hours. We would also take a cheetah ID photo, and record other data such as location, body condition, sex etc." The cheetahs didn't always cooperate, however. Some days David wouldn't find any of the big cats, or was unable to take a sample for various reasons. "But I always had fun watching the other wild animals, and breath-taking predator hunts."

When David wasn't observing cheetahs he would drive long distances between sample sites, or transport samples collected by different organisations to the Institute of Primate Research in Nairobi for preservation.



TRAINING AUSTRALIA'S FUTURE MARINE SCIENTISTS

Breaking into the professional or research world of marine science can be tough. Industry and government expects graduates to have real world experience – but this can be close to impossible to achieve as an undergraduate.

Enter the Collaborative Australian Postgraduate Sea Training Alliance Network (CAPSTAN) – a new national approach to developing the next generation of marine scientists and providing multidisciplinary at-sea training. The University of Canberra is proud to be a partner of this innovative program, with Associate Professor Leah Moore a committee member and voyage Co-Chief Scientist.

The inaugural CAPSTAN voyage on research vessel travelled from Western Australia to Tasmania via Bremer Submarine Canyon, south of Western Australia, in November 2017. As Co-Chief Scientist, Moore played a key role in defining the scientific program and coordinating logistics with the ship's crew. Moore and colleagues oversaw 20 students as they conducted scientific experiments including how to tow plankton nets and analyse the catch; collect sediments using coring and dredge devices; measure water profiles using a sonde; collect seawater for hydrochemical testing; and map the seafloor using geophysical techniques. Students also learnt about the

practicalities of life at sea, such as vessel operations, ship protocols and safety procedures.

“The CAPSTAN program creates a rare opportunity for early career researchers to acquire ship time,” say Moore. “This investment in teaching and learning is hugely important. Individuals can gauge their aptitude for oceanic research from a career and personal well-being perspective.”

The voyage was hugely successful. Not only did students learn about ship life, but they gathered information about Bremer Canyon that will contribute greatly to our knowledge of sediment flow and nutrient cycling in the area.

“Students mapped a previously unmapped region of the seafloor, providing a detailed assessment of the bathymetry in the area that complements work already undertaken by Geoscience Australia in nearby regions. I'm impressed by the quality of the work the students undertook, and its contribution to real world research,” says Moore.

The second CAPSTAN voyage is scheduled for April 2019, and the IAE will encourage students to apply for this outstanding learning opportunity.

Image: Voyage Co-Chief Scientist Associate Professor Leah Moore (left) with scientific crew taking specifications of a gravity core sampled during the inaugural CAPSTAN voyage. Photo by Marine National Facility.





LEARNING TO ASSESS RIVER HEALTH

The Australian River Assessment System (AUSRIVAS) is a nationally consistent rapid bioassessment method taught online and through workshops run by IAE, University of Canberra. AUSRIVAS uses standardised methods to collect aquatic macroinvertebrate data along with physical and chemical variables, and predictive models to assess ecological condition. Trained assessors identify organisms living in a river, and by understanding the sensitivity of these organisms to environmental pressures and using predictive models to compare these results to reference conditions, determine the health of the river.

This course is particularly useful to students, environmental managers and agency staff needing to assess the ecological condition of streams and rivers. Information gained from an AUSRIVAS assessment can inform environmental management actions, measure the success of river rehabilitation actions, and ongoing monitoring.

The theoretical knowledge required to use AUSRIVAS for river health assessment can be learnt online in four interactive modules. A 5-day practical face-to-face workshop is offered as a fifth module, teaching the practical skills required.

Sampling for macroinvertebrates at the Cotter River, ACT.
Photo by Sue Nichols

ALUMNA

JODY SWIREPIK

Jody Swirepik completed her undergraduate studies at the University of Canberra, as well as a Master's degree in freshwater ecology and management. Jody now has over 25 years of experience in the water sector, including a number of executive positions where she has been responsible for driving water reform on a state and federal level.

What role do you currently hold? And what does it entail?

My current role is the Commonwealth Environmental Water Holder which is probably a curious sounding title to most people. As the "CEWH" my office – which sits within the Department of Environment and Energy – is responsible for managing the Commonwealth environmental water holdings in the Murray-Darling Basin worth over \$3 billion: - we work with Basin states and other partners to deliver water to wetlands, rivers and floodplains to protect and restore their environmental health. Our office is also responsible for coordinating Australia's obligations under the Ramsar Convention.

Your career includes a number of government organisations. Why did you choose a career in government over academia or private industry?

That's a good question. I am not sure I left University with a firm view of where I wanted to work and what different types of jobs entailed. I'd done some project work for the ACT government and the people were nice – they seemed to be pretty enthusiastic about their work and the project I did for them was interesting. When I graduated there were some temporary opportunities going with the ACT government, so I jumped in and have never really looked back.

There are such diverse opportunities in government that you can move around and never get bored or stop learning. I really like the complexity of the issues you get to work on, that your job has a practical end point and that you are delivering outcomes for the public at large.

What project are you particularly proud of your involvement in? Why?

There are so many things I been involved in over the decade that I'd hate to single one out. I really like policy reform and program implementation. You get to work with teams with different backgrounds from different disciplines to solve problems, which is great.

How did your undergraduate and graduate degrees at the University of Canberra prepare you for the workforce?

That's easy – how to think critically and approach your work in a structured way. I also learnt content knowledge which proved to be directly useful in my jobs as it set me up well with the basics (e.g. hydrology, chemistry, ecology basics). However I'm pretty sure that was not as important as just teaching you how to think as you keep learning the content knowledge your whole life.

What do you think is the biggest environmental challenge facing Australia at the moment?

It has to be climate change and its implications. What that means for places like the Great Barrier Reef and the Murray Darling Basin (changing hydrology) are really important for all of us, not to mention the possible impacts on our coastlines, ecological systems and the Pacific islands etc.



STUDENT PROFILES

TUTI SIREGAR

PhD candidate



What is your background?

I completed a Bachelor degree in Chemistry with honours from Gadjah Mada University, Yogyakarta, Indonesia, then continued my studies with a Masters degree from James Cook University. I have taken leave from my job at the Ministry of Marine Affairs and Fisheries in Indonesia to complete my PhD here at the IAE.

What is your thesis topic, and what drew you to it?

My thesis is about arsenic metabolism in marine organisms. I chose this topic because I am concerned about marine pollution and the safety of seafood consumption, especially in Indonesia. Arsenic is ubiquitous in marine organisms, and while most arsenic species in seafood are identified as non-hazardous, their presence in marine organisms is still worrying.

What do you like about the IAE?

There is strong support between staff and students at the IAE, which has really helped my study. There are lots of activities we can participate in to help us prepare during our research journey, such as the writing club, weekly seminars, and the HDR conference.

What would you like to do after you finish your PhD?

I will return to my role as a researcher in the Ministry of Marine and Fisheries in Indonesia. I hope to maintain my good relationships with my IAE colleagues and friends.

male in appearance! This led me to find out about the sex reversal phenomena and how the environment can influence sex among the offspring in many animals.

Why study at the IAE?

The researchers in IAE are recognised globally for their work in this field, particularly in Agamid lizards, which is why I chose the IAE for my higher degree research.

What would you like to do after you finish your PhD?

I would like to continue my research career in academia.

FAYHA AL-SHIBLI

PhD Candidate



What is your background?

I have a Bachelor degree in Agricultural Resources and Environment (Irrigation), and a Masters degree in Environmental Studies, both from the University of Jordan. For my thesis I investigated the main constraints of conducting Rio environmental conventions in Jordan. I also worked as a researcher at the Ministry of Water and Irrigation /Jordan and Ministry of Agriculture/Jordan

What is your thesis topic?

I am modelling the future water budget in Jordan, and evaluating the major stressors affecting water availability. Climate change, population growth and groundwater over-abstraction are the main pressures I am analysing.

What drew you to this study?

Jordan is one of the poorest countries with regard to water resources. I am from Jordan, and am passionate about helping this situation. I hope the information generated through my thesis can be used to support decisions for Jordan's water security.

Why study at the IAE?

My supervisors, Professor Bill Maher and Professor Ross Thompson, are very supportive of my research, and the work environment here is very positive. The IAE has also offered me the opportunity to learn about hydro-climatological studies, which I am really enjoying.

What would you like to do after you finish your PhD?

I am still affiliated with the School of Agriculture at the University of Jordan, so when I finish I will return there and continue teaching.

SHAYER ALAM

PhD Candidate



What is your background?

I hold a Bachelor degree in Zoology and a Masters in Wildlife Biology from the University of Dhaka, Bangladesh. I also completed a Masters in Biodiversity and Conservation from Stockholm University, Sweden.

I worked as an Assistant Programme Officer at the International Union for Conservation of Nature in Bangladesh, and as a Research Monitoring Officer at the Center for Natural Resource Studies. I am an Assistant Professor in Wildlife and Biodiversity Conservation at Jagannath University in Bangladesh, and I am currently on leave while I complete my PhD at the IAE.

What is your thesis topic?

My PhD topic is "Evolution and Ecology of Sex Determination Mechanisms in Agamid Lizards." I am trying to identify how sex is determined in different Agamid lizard species and what the evolutionary significances behind such phenomena are.

What drew you to this study?

I have a special interest in the genetical aspect of species ecology and conservation. During fieldwork in Bangladesh, I noticed an Agamid lizard laying eggs in its nest and it looked

SARAH BATES

PhD Candidate

What is your background?

I studied a bachelor of science at Melbourne University, where I majored in botany and environmental studies. For my honours thesis I investigated arsenic transfer through the lower levels of the food chain as part of an overarching research project investigating phytoremediation of mining waste.

After my degree I worked in the environmental sector. Some of my roles included planning and installing wetlands in urban environments, large-scale revegetation projects, and grassland management.

What is your thesis topic?

I am researching the interaction between plants and soil microbes in weed invasion. In particular, if weeds are gaining an advantage from interactions with soil microbe communities.

What drew you to this study?

I was drawn to this topic because of my work in environmental management. Native grasslands in Australia are in decline, estimated to be just 1% of their original extent. Apart from habitat loss, weeds are a big part of this story. Many invasive species have the potential to transform

native grasslands into a degraded weed patch. After years of nutting out management processes and seeing the range of success from the same methods across different plant species, I wondered: what can't I see? What aren't I considering? That's when my interest in soil microbiota began... and here I am!

Why study at the IAE?

I chose the IAE because of the weed invasion research that Professor Richard Duncan and his group are doing. Being able to work with invasion ecologists is a great opportunity. I also like that the IAE has connections with other research and industries groups. This means researchers can see the on-ground problems, and research is integrated where it matters.

What would you like to do after you finish your PhD?

After I finish my PhD I would love to continue on with research. I always have more questions than I have time to answer them.



OUR RESEARCHERS

Research undertaken by our staff constitutes the key activity of the Institute.

We carry out quality research in a range of areas and pride ourselves on the interdisciplinary and applied nature of our work, and our ability to help solve environmental problems. Our researchers supervise over 60 HDR students, and are closely involved in the delivery of the University's Environmental Science courses and other research training initiatives.

To find out more about our researchers please visit <http://bit.ly/IAEProfiles>.

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DEPUTY DIRECTOR / PROFESSOR JANINE DEAKIN

BSc(Hons), PhD, Macquarie University

Professor Janine Deakin is a geneticist focused on bringing the more traditional field of cytogenetics (the study of chromosomes) closer to the rapidly advancing field of genomics. Combined with a passion for Australian wildlife, her research aims to provide a deeper understanding of fundamental biological mechanisms important for species conservation, such as the role of chromosome rearrangements in the rock-wallaby speciation, the origin and evolution of transmissible tumours affecting Tasmanian devils, and how sex is determined in the central bearded dragon.

Professor Deakin is a member of the steering committee and leader of the Whole Genome Sequencing group of the Oz Mammals Genomics Initiative funded by Bioplatforms Australia. This initiative aims to develop genomic resources for a better understanding and conservation of Australian mammals. She is also a member of the Australian Research Council College of Experts, is an editor for the Australian Journal of Zoology; an Associate Editor for BMC Genomics; and AIMS Genetics and an editorial advisory board member for Chromosome Research.

WHO WE ARE

DIRECTOR / PROFESSOR ROSS THOMPSON

BSc (Hons), PhD, University of Otago, New Zealand.



Professor Ross Thompson is a community and ecosystem ecologist with an interest in 'saving the world'. His research seeks to understand the rules that underpin the assembly of complex, diverse and persistent natural communities. While he maintains a passion for fundamental science, his research increasingly concentrates on the ways in which human activities (climate change, pollution, habitat loss, invasions and extinctions) impact on natural systems, and how we can use ecological principles to protect and restore those systems.

Professor Thompson primarily works on freshwater ecosystems, with a particular interest in the effects of human activities at large scales on patterns of freshwater biodiversity. His research includes studies of the effects of land use change; the potential for environmental flows to restore natural food webs, and the ways in which changing climates may impact on freshwaters.

Professor Thompson leads the Water Science program at IAE, and also engages widely across disciplines, states and countries to build research teams to address major environmental issues.

DISTINGUISHED PROFESSOR ARTHUR GEORGES

BSc Mathematics, BSc (Hons) Physiology, PhD Zoology, University of Queensland.



Distinguished Professor Arthur Georges has a broad interest in fostering research that underpins decisions on the management of our natural environment. Within this broad context, he has specific research interests in the ecology, evolution and conservation biology of Australia's reptiles and amphibians.

A fundamental interest in these fascinating animals takes him into the field and laboratory to learn more of their biology and to apply what he has learned in solving contemporary problems of their conservation.

Professor Arthur Georges is Chair of the Australian Capital Territory Scientific Committee, and is an Associate Editor of the *Journal of Experimental Zoology*. He was Dean of the Faculty of Applied Science, and has served as president of the Australasian Wildlife Management Society and the Australian Society of Herpetologists.

CENTENARY PROFESSOR RICHARD DUNCAN

BSc (Hons), PhD, University of Canterbury, New Zealand.



Professor Richard Duncan has broad research interests in ecology and conservation with a focus on biological invasions and extinctions. His recent work examines the ways in which invasive species arrive, establish, spread and impact natural ecosystems. He works with a variety of taxa, including plants, birds and mammals, and uses a variety of approaches to understand the changes associated with biological invasions and to answer both applied and fundamental ecological questions.

Professor Duncan is an Associate Editor for the journal *Diversity and Distributions*, a member of the International Science Advisory Panel for New Zealand's Biological Heritage National Science Challenge, and was awarded the Te Tohu Taiao Award for Ecological Excellence by the New Zealand Ecological Society in 2011.

CENTENARY PROFESSOR RALPH MAC NALLY

DSc, BSc (Hons), Grad Dip Computer Science, PhD, The University of Melbourne



Professor Ralph Mac Nally trained as a community ecologist, and has developed extensive interests in the emerging disciplines of whole-catchment ecology, conservation ecology, landscape ecology and ecological futures. He uses large-scale modelling to treat landscapes as integrated systems of multiple terrestrial and aquatic ecosystems and is focusing now on developing ways to understand how human impacts will affect biodiversity and ecosystems in the coming decades. He has extensive collaborations with researchers in Brazil and western North America apart from his work in south-eastern Australia.

Professor Mac Nally serves on the editorial boards of *Diversity and Distributions* and the *Journal of Applied Ecology*. He was a scientific expert for the second Australian bird atlas program and Victoria's strategic document: *Land and Biodiversity at a Time of Climate Change*. Professor Mac Nally has been an Australian Research Council Discovery Outstanding Researcher.

ADJUNCT PROFILE: THINKER IN RESIDENCE JENNY GRAVES, AO

The Institute is thrilled to have Professor Jenny Graves AO as a Thinker in Residence for the last six years. Professor Graves has numerous accolades to her name, and was recently honoured with the Prime Minister's Prize for Science, and is the first solo woman to do so. The prize is in recognition of an outstanding career in science during which Professor Graves has transformed our understanding of vertebrate chromosome evolution. Professor Graves pioneered our understanding of how sex chromosomes evolved and how they work, and led to the realisation that the human male Y chromosome may be on a path of degeneration and possible extinction.

"Awards and prizes are not the drivers of good science – but it certainly is nice to have the work of my group over 40 years so handsomely recognised. I see the Prime Minister's Prize as a win for basic science that must underpin innovation, and a win for women in science," says Graves.

Professor Jenny Graves has contributed greatly to the Institute's research on genomics and sex determination in Australian animals, with findings published in leading journals such as *Science*, *Nature* and *Science Advances*. The IAE has also experienced firsthand the positive effect that Professor Graves has, in particular as an outstanding role model for women in science.

"Our "Sex in Dragons" project is one of the most exciting research projects I've been involved in," says Graves. "It was born from a fusion of IAE expertise in reptile biology and my group's expertise in molecular biology and cytogenetics. Its success just shows that answers to really fundamental questions can come from really weird animals."

Professor Graves' work focuses on understanding mammalian genome organization and evolution, and exploits the genetic diversity of Australia's unique mammals as a source of genetic variation to study highly conserved genetic structures and processes. Professor Graves is also a Distinguished Professor at La Trobe University, and Emeritus Professor at ANU.



PROFESSOR TARIQ EZAZ

BSc (Hons) Zoology, MSc (Fisheries), University of Dhaka, Bangladesh. PhD in Aquaculture Genetics, Institute of Aquaculture, University of Stirling, Scotland, UK



Professor Ezaz's research focuses on the evolutionary and comparative genomics of sex determining mechanisms and sex chromosome evolution in non-traditional vertebrate model species, a discipline primarily devoted to basic research aiming to expand the current knowledge base. His areas of research interest include development and application of molecular markers, molecular cytogenetics, epigenetic regulation of sex differentiation, plasticity and adaptation. Professor Ezaz uses diverse taxa, ranging from fish to birds, as well as invertebrates including crustaceans and mollusc to answer his research questions. Professor Ezaz co-authored papers published in high impact journals including *Nature*, *Science*, *Current Biology* and *Molecular Biology and Evolution*.

Professor Ezaz's contributions to his field of expertise have led to a deeper understanding of the mechanisms and evolution of sex determination and sex chromosome evolution, particularly in reptiles. In recognition of his significant contributions he was awarded prestigious ARC Future Fellowship. He holds a very strong track record in the context of his discipline expectations and led the establishment of an international network of cytogeneticists (chromosomics network) which has members from more than 18 different countries. Professor Ezaz supervises research projects for postgraduate, honours and undergraduate students. He also convenes and teaches units on Genetics and Genomics and teaches on plants and animals to 2nd and 1st year undergraduates respectively.

PROFESSOR BILL MAHER

BAppSc (Hon), MAppSc, The University of Melbourne. PhD, University of Southampton, United Kingdom.



Professor Bill Maher has a sustained track record of research in the understanding biogeochemical cycling of trace metals, metalloids and nutrients in aquatic ecosystems, development of water quality and sampling guidelines, and development of analytical procedures for measuring trace contaminants in water, sediment and biota. He has a particular interest in understanding the exposure of organisms to contaminants, and how and where they accumulate contaminants (dose) and effects at the subcellular and whole organism level.

Professor Maher has published over 270 papers and has been awarded the RACI Analytical Divisions medal in 2002 and the RACI Environmental Chemistry Divisions medal in 2004. He also co-authored a Handbook of Sediment Quality Assessment that won the Eureka Prize for water research in 2006.

PROFESSOR STEPHEN SARRE

BAppSci, MSc, University of Canberra. PhD, Australian National University



Professor Stephen Sarre's research interests are broad, but centre on the genetics and genomics of wildlife with an emphasis on endangered and invasive species. He has a particular interest in studying the genetics of populations through the application of DNA markers usually in conjunction with intensive field ecological studies. This combined approach enables a much deeper understanding of the dynamics of natural populations than could be obtained by either approach alone.

Professor Sarre's other main research interest is sex determination of reptiles. He is particularly interested in understanding how the interplay between genetics and temperature ultimately determines sex and how this interplay has evolved among different reptile groups.

Professor Sarre is a Member of the Scientific Advisory Committee for the Invasive Species Council and the Research Committee of the Hermon Slade Foundation.

PROFESSOR LEROY POFF

Bachelors of Arts in Biology, Hendrix College, Conway Arkansas, USA. MEnvSci, Indiana University. PhD in Biology, Colorado State University, USA.



LeRoy Poff is a stream and river ecologist who holds a Distinguished Professorial Chair in Riverine Ecology and Environmental Flows at the IAE, and Professorship in the Department of Biology at Colorado State University USA. His research aims to understand how natural and human-caused variation in river flow and water quality shapes the structure and function in freshwater aquatic and riparian ecosystems. His research is theory-based and applications oriented.

Professor Poff is a recognised global leader in the scientific arena of 'environmental flows' and in ecologically sustainable river management. He collaborates with biologists, hydrologists, geomorphologists, engineers and social scientists, and he currently has research projects on hydro-ecology and climate change in the USA, Ecuador, and Australia. He is the former President of the International Society for Freshwater Science, an elected Fellow of the American Association for the Advancement of Science, an Aldo Leopold Leadership Fellow, and an elected Fellow of the Ecological Society of America. He is also a Highly Cited Researcher.

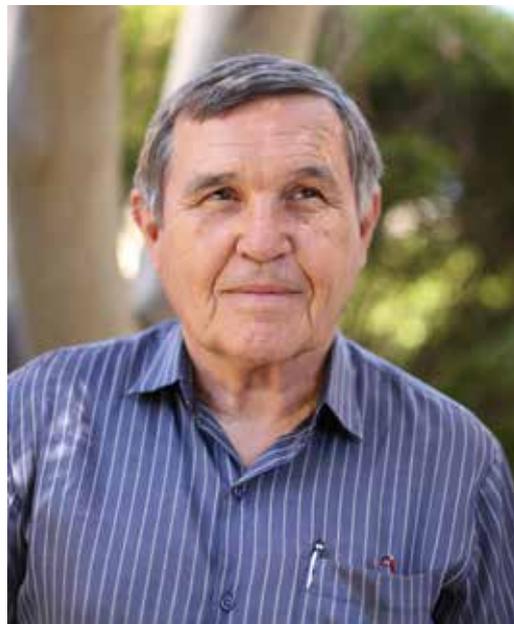
PROFESSOR BEN GAWNE

Biology B.Sc. (Hons) University of Melbourne, Dept. of Zoology. Ph.D. Monash University,



Professor Ben Gawne has broad research interests in the protection and restoration of freshwater ecosystems. His recent work has focussed on wetland and river responses to flow modification and how this major stress may interact with other stressors (e.g. invasive species) to affect ecosystem condition. Over the last two decades, he has worked closely with water managers in the Murray-Darling Basin to both generate new knowledge, but also to apply knowledge to the management decisions, condition assessments and evaluating the outcomes of management actions. Professor Gawne is currently working with researchers to develop a collaborative venture to support implementation, review and adaptation of the Basin Plan.

Prior to joining the IAE, Professor Gawne was the Director of the Murray Darling Freshwater Centre, a joint venture research facility that seeks to generate the knowledge required to sustainably manage the water resources of the Murray-Darling Basin. Prior to this, he established the MDFRC's laboratory at Mildura.



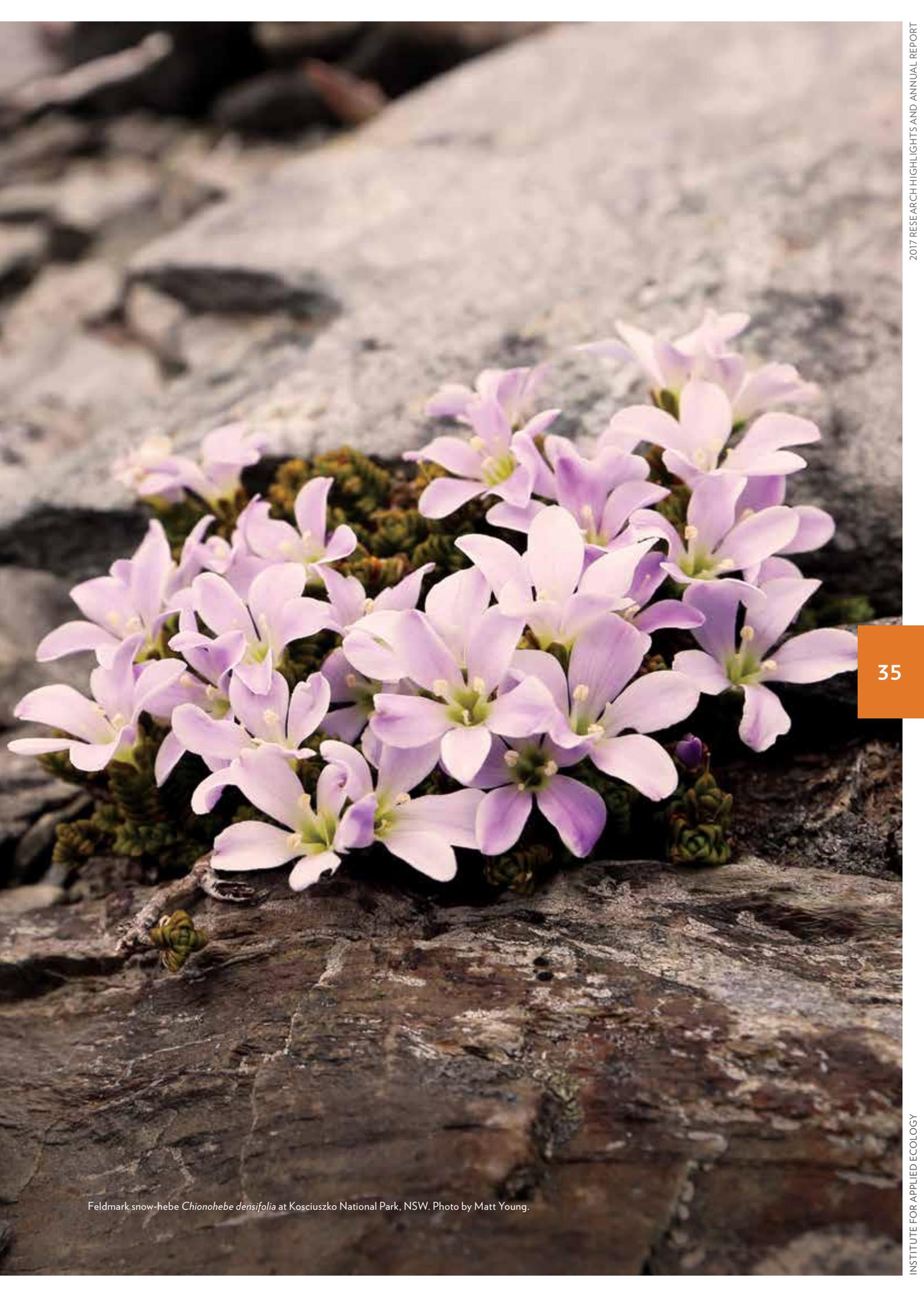
ADJUNCT PROFILE: PROFESSOR NEIL BYRON

BSc (Hons) Forestry, MA Economics, PhD Resource Economics, AICD

Neil Byron has been an environmental economist and policy advisor for the past 40 years, in Australia and inter-nationally, working on forests, rangelands, fisheries, bio-diversity conservation, water resources and climate change.

In his recent work on water, he has advocated a collegiate path forward in water and catchment management which includes engaging all stakeholders seriously, tapping into local knowledge and decentralising the approach. He recognises that every valley is different and the environmental watering demands of every priority wetland are extremely complex.

Byron was the Commissioner responsible for environment, agriculture and natural resource management issues at the Productivity Commission from April 1998 to March 2010, and before that was the Assistant Director General of the Centre for International Forest Research based in Indonesia for 5 years. He is currently a Non-Executive Director of Alluvium Consulting and Natural Capital Economics, the Chair of Trust for Nature Foundation, and a Trustee of the Forest Environment Trust.



Feldmark snow-hebe *Chionohebe densifolia* at Kosciuszko National Park, NSW. Photo by Matt Young.

ASSOCIATE PROFESSORS



Dr Paul Downey



Dr Simon Foster



Dr Dianne Gleeson



Dr Bernd Gruber



Dr Jacki Schirmer



Dr Duanne White



Dr Ben Kefford



Dr Fiona Dyer

ASSISTANT PROFESSORS



Dr Jasmyrn Lynch



Mr Mark Lintermans



Dr Sue Nichols

SENIOR RESEARCH FELLOWS

POSTDOCTORAL FELLOWS



Dr Elise Furlan



Dr Hania Lada



Dr David Pepper



Dr Tim Reid



Dr Rob Rolls



Dr Peter Unmack



Dr Lizzie Wandrag

2017 AWARDS

IAE AWARDS

Dr Sue Briggs
Adjunct Award

Ben Broadhurst
Richard Norris Award

Cat Campbell
Stakeholder Engagement (Student)

Professor Richard Duncan
HDR supervision (voted by students)

Teresa Gonzalez de Chavez-Capilla
Student Service Award

Dr Wendy Ruscoe
Professional Staff Award

Professor Ross Thompson
Outstanding Research Excellence

Rod Ubrihien
Research Excellence (Student)

Dr Lizzie Wandrag
Excellence in research (Early Career)

UNIVERSITY OF CANBERRA AWARDS

Will Higgsion and Dr Valerie Caron
University Citation for Outstanding Contributions to Student Learning at the Teaching Excellence Awards

Adjunct Professor Peter O'Brien
Vice Chancellor's Diversity Award

Associate Professor Ben Kefford
Commendation for Early Career Research Excellence in Health, Science and Technology

Associate Professor Jacki Schirmer
Deputy Vice-Chancellor's Award for Distinction in Engagement and Impact

EXTERNAL AWARDS

Yolarnie Amepou
United Nations 2017 Youth Champion for the Sustainable Development Goals in Papua New Guinea

Cat Campbell
Mayo Prize for best student presentation at the Genetics Society of AustralAsia Conference

Fradly Gouany
Australia Awards – Endeavour Fellowship 2018

Adjunct Professor Jenny Graves
Prime Minister's Award for Science

Adjunct Professor Charles Krebs
Honorary Member, American Society of Mammalogists

Brad Moggridge
Aboriginal and Torres Strait Islander Community Alumni Award, Australian Catholic University

Dr Will Osborne
Hero in the fight against extinction, awarded by the Threatened Species Commissioner

Berenice Talamantes Becerra
Selected as Top 100 Latinos under 35 to attend the first Latin American Summit of Young Leaders in Biotechnology

RESEARCH FACILITIES

The Institute invests heavily in new and upgraded research facilities and scientific infrastructure for the benefit of our researchers and students. Some of our facilities are outlined below.



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E2R AQUATIC MESOCOSM ARRAY

The E2R (Education, Engagement and Research) facility was largely completed in 2017, and provides ten 2500L recirculating streams for experimental research. The largest facility of its type in Australia, E2R will provide facilities for undergraduate projects, graduate research, and a range of research projects in environmental chemistry, ecotoxicology, fish biology and freshwater ecology.

FRESHWATER ECOLOGY LABORATORY

The Freshwater Ecology Laboratory has the capacity for the analysis of macro invertebrate and fish samples, algae and stable isotope samples, as well as a range of habitat characterisation parameters.

The Laboratory contains a range of Leica microscopes, micro balances mutiprobe meters and data loggers as well as instruments for measuring water quality, algal biomass and chlorophyll concentration.

ECO-CHEMISTRY LABORATORY

The Ecochemistry Laboratory is a highly specialised laboratory undertaking analysis of chemical species in biological tissues, waters and sediments from aquatic ecosystems.

The Laboratory undertakes full chemical speciation analysis in water, sediments, soil, animal and plant tissues. We have particular expertise in arsenic, mercury and selenium speciation.

WILDLIFE GENETICS LABORATORY

The Wildlife Genetics Laboratory allows researchers to undertake high quality DNA research through the use of separate pre- and post- PCR space equipped for DNA sequencing, genotyping, cloning, and state-of-the-art cytogenetic work.

EPIGENOMICS LABORATORY

The Epigenomics Laboratory complements the high quality research undertaken in the Wildlife Genetics Laboratory. It is equipped to perform epigenetic and epigenomic studies, from the level of entire genomes or chromosomes down to individual genes, on model and non-model species for biomedical and ecological research projects.

The facility consists of dedicated laboratories for cell culture, molecular cytogenetics and fluorescence microscopy, as well as a large main laboratory with 16 individual work spaces and communal equipment benches.

COSMOGENICS FACILITY

The Cosmogenics Facility is a purpose built facility equipped with a robotic Vulcan 84 automated sample preparation system that enables acid digestion of solid and liquid samples.

The Cosmogenics Facility enables research into cosmogenic nuclide dating of geological samples, general analysis of environmental soil and sediment, complementing the Ecochemistry Laboratory.

GLASSHOUSE

The Glasshouse is a state-of-the-art auto grow facility with an 'on the go' mobile platform and comprehensive climate controls that enable researchers to cultivate their experiments in a measurable environment. The Glasshouse facility also contains an in-built alarm system that sends alerts if there are any deviations to set climate measures.

GEOGRAPHIC INFORMATION SYSTEM AND ECOLOGICAL MODELLING LABORATORY

The Geographic Information System and Ecological Modelling Laboratory is a highly specialised IT Laboratory equipped with high-end computers comprising of ARCGIS and other modelling software. This assists our researchers through parallel computations to manipulate, simulate and model their research with ability to facilitate the production of maps.

TRACE DNA LABORATORY

The Trace DNA Laboratory is isolated from all other DNA work related buildings to enable researchers to undertake DNA work used for genetic analysis of samples where DNA quantity is low and the potential for contamination significant.

RESEARCH VEHICLES/VESSELS

The Institute maintains a fleet of fully equipped four-wheel drive vehicles, boats, remote controlled electrofishing vessel to support our researchers throughout their time in the field during research collection periods. The Institute has recently rejuvenated its vehicle fleet, acquiring two brand new fit for purpose vehicles. These vehicles and trailers have the ability to go fully off road and reach remote areas.

RESEARCH INCOME

In 2017 the IAE received \$3,012,000 of research income from industry groups, philanthropic societies, federal, state and international governments.

37%

OTHER GOVERNMENT SOURCES
\$1,129,000

28%

AUSTRALIAN COMPETITIVE
GRANTS REGISTRY
\$835,000



25%

AUSTRALIAN OR INTERNATIONAL
INDUSTRY OR NON-AUSTRALIAN
GOVERNMENT AGENCIES

\$740,000



10%

CO-OPERATIVE RESEARCH CENTRES

\$308,000



PUBLICATIONS

Researchers at the IAE publish in a range of journals, books, and conferences. This section provides a summary of our publications.

Authors from the IAE are shown in UPPER CASE.

Publication type	Number
B1 (Book chapters)	10
C1 (Refereed journal)	111

B (BOOK CHAPTERS)

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