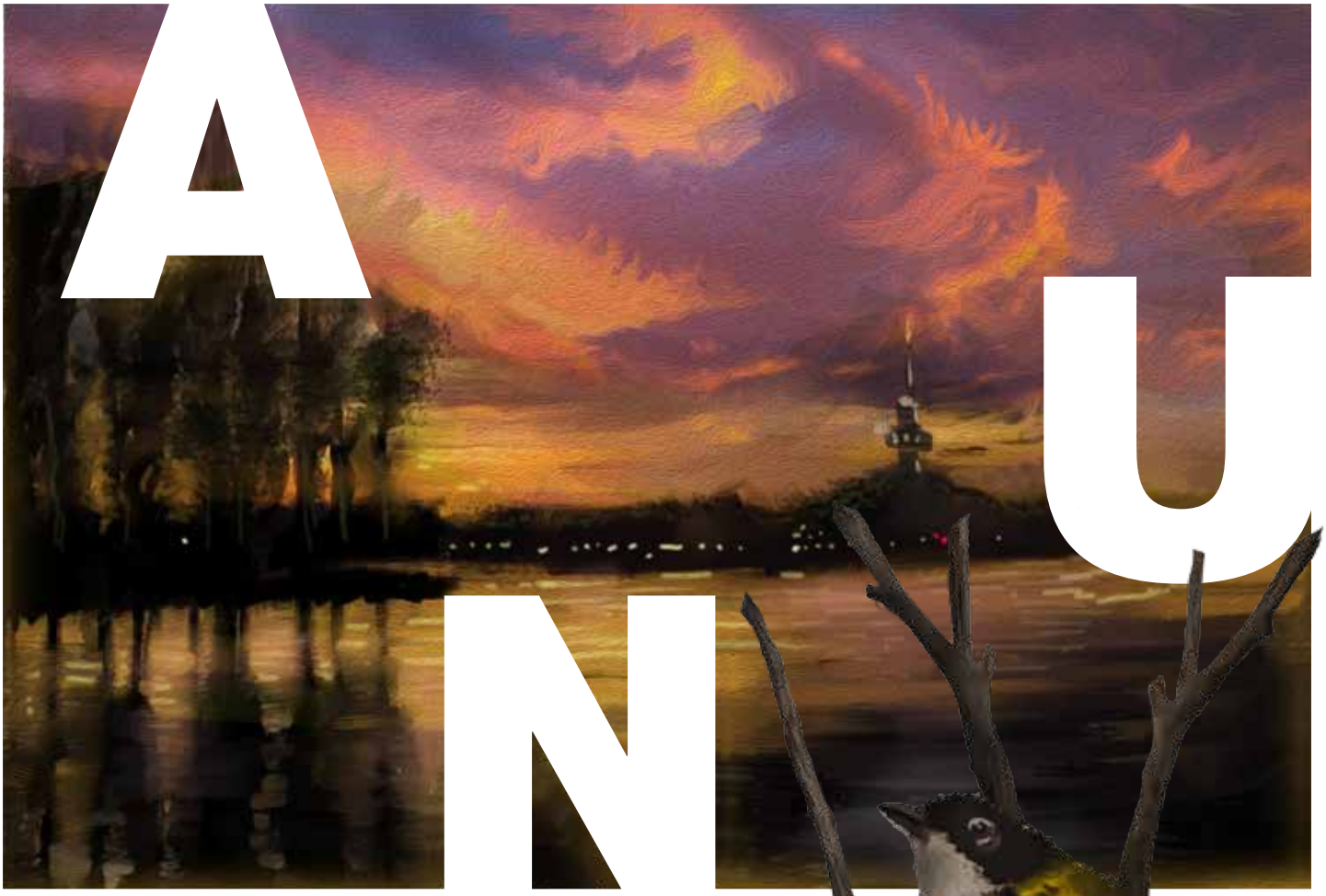
Australian National University



FENNER SCHOOL OF ENVIRONMENT & SOCIETY

Research Highlights

ANU College of
Medicine, Biology
& Environment

CONTENTS

Cover: Artwork by Ed Radclyffe. Photo by Steve Leahy

Director’s introduction

The Fenner School of Environment and Society at The Australian National University (ANU) is at the forefront of developing the knowledge and skills needed to meet the biggest challenges and seize the greatest opportunities of the 21st Century.

In this Research Highlights, we present some of our most exciting research in sustainable development and environmental science and management. These stories reflect not only the diversity of our research, but also that of our researchers – from internationally-recognised senior professors, to the emerging stars among our early-career researchers and doctoral scholars.

This is just a small sample of the breadth and depth of our research. To learn more about our work, visit http://fennerschool.anu.edu.au/research.

The fields of research and education we are active in are more crucial than ever, as demonstrated by the science and policy agendas set out in recent global agreements and processes. These include the high-level United Nations Sustainable Development Goals, the 2015 Paris climate conference outcomes, the far-sighted global science collaboration Future Earth, the Sendai Framework for Disaster Risk Reduction 2015-2030, and the new international System of Environmental-Economic Accounting.

In such initiatives, humanity is seeking new and better ways to achieve its ecological, social and economic aspirations. We cannot achieve those aspirations without knowledge and skills of the highest quality. In the Australian Research Council’s independent Excellence in Research for Australia (ERA) 2015 assessment, ANU was rated ‘5’ – outstanding – in the three fields of research dominated by the Fenner School: Environmental Science and Management; Ecological Applications; and Forestry Sciences. Globally, the University has been ranked in the top 20 in Environmental Science and Geography, and in the top 10 in Agriculture and Forestry, and is the only Australian university to be ranked overall in the world’s top 20.

The Fenner School’s level of research excellence is matched by its breadth of capacity across the natural and social sciences and the humanities. The School boasts elected Fellows of all four Australian Learned Academies. We also teach what we research, in undergraduate and graduate coursework and research-only degree programs featuring award-winning courses and lecturers. Small class sizes, innovative teaching methods, numerous field activities and active engagement with leading researchers create a stimulating learning environment that we believe is second to none.

Learn about our programs at http://fennerschool.anu.edu.au/education

The Fenner School of Environment and Society is a vibrant and cosmopolitan community of nearly 100 academic and professional staff, over 700 undergraduate and graduate coursework students, more than 100 PhD scholars, and dozens of adjunct and honorary members. That community is proud of its research, its educational innovation and excellence, and its contributions to Australian and global efforts to embrace the challenges of the coming decades. We extend a warm welcome to you: please do reach out and connect with us.

Professor Stephen Dovers FASSA

Image: Fenner School of Environment & Society. Photo by Col Bennetts.

LAURA RAYNER

Saving woodland birds: Using new knowledge to tackle an old problem

Temperate woodlands are globally under threat due to high levels of land-use conversion and limited levels of formal protection. This is certainly the case in Australia, where almost 90 per cent of temperate woodland vegetation has been cleared. This loss has had an enormous impact on species inhabiting these systems, including birds, which are considered to be in widespread decline.

According to Dr Laura Rayner, a postdoctoral fellow at the Fenner School, putting a halt to the loss of birds from temperate landscapes is vital to protecting the intrinsic value and ecological function of our Aussie bush. ‘Not only can we humans derive joy from the charismatic call of a Superb Parrot and the brilliant red of a Scarlet Robin, the bush needs birds to perform important ecological roles as pollinators, seed dispersers and regulators of insect abundance’, she explains.

Without question, the factors contributing to long-term declines in woodland bird populations need to be identified and understood. Yet high quality long-term field data is often not available in areas where factors threatening woodland bird persistence most need examining.

‘Despite 50 years of focused research, the conservation of woodland birds is informed by only a dozen or so long-term studies of population change. These few studies represent our knowledge for a massive 750,000 km^2 of temperate Australia – that’s an area larger than France’, says Rayner. ‘We still lack a strong understanding of where woodland birds are continuing to decline, why, and which species are at greatest risk of extinction.’

In the Australian Capital Territory (ACT), Rayner and colleagues have engaged with the Environment and Planning Directorate of the ACT Government, as well as passionate citizen-scientists from the Canberra Ornithologists Group, to develop new insights into the conservation of birds in Australian temperate woodlands. Using 14 years of empirical field monitoring data to explore the role of weather, reservation and urbanisation in driving the population trajectories of woodland birds, their research has revealed important avian responses to these globally relevant factors.

For example, although serious concerns have been expressed in the literature about the effects of drought on bird survival, Rayner and colleagues found no clear link between drought and long-term bird decline in the ACT – an important finding when forecasting future impacts of climate change. ‘We actually found a significant *positive* relationship between drought conditions and the abundance of some declining species’, says Rayner. ‘These findings challenge the notion that extreme weather events in isolation are a contemporary driver of long-term population decline.’

Examining the effectiveness of reserves for ensuring species persistence – the primary, yet critically understudied, aim of establishing protected areas – confirmed that the position of reserves was crucial to maintaining woodland bird diversity over long periods. ‘There is clear evidence that better choices are being made in terms of where to locate reserves to best protect birds of conservation concern in and around Canberra’, says Rayner. Interestingly, compared to protected sites, off-reserve areas were found to make a stronger contribution to woodland bird conservation in the ACT by maintaining a greater number of bird species through time.

Rayner and colleagues also identified urbanisation as a dominant factor shaping woodland bird communities in the ACT. Species occupying fringe habitats vary in their tolerance of urban encroachment, and this tolerance can change through time depending on the proximity, extent, and speed of development. For most species, the response to rapid, large-scale development was found to be negative. ‘This is a previously undescribed threat to woodland bird populations, and has really important implications for not only where we develop land, but how quickly we develop it’, explains Rayner.

Important trend patterns such as those identified by this research could not be detected with short-term data, she emphasises. ‘We have shown how long-term population monitoring can reveal associations that are highly relevant to conservation. We owe much to the dedicated volunteers who collect this type of data, which is otherwise rare in Australia.’

The findings of this research offer new evidence in the fight to save woodland birds from pervasive declines and local extinctions. A future for woodland-dependent birds relies on thoughtful policy responses in a world where historic land pressures, such as agricultural and urban development, not only prevail but are intensifying.

‘We are not concerned with keeping these bird species around for another five or ten years’, says Rayner, ‘we want to keep them around for good, and that requires long-term vision.’

Further reading:

Evidence for decline: http://www.sciencedirect.com/science/article/pii/S0006320714000317

Reserves and woodland birds: http://onlinelibrary.wiley.com/doi/10.1111/j.1600-0587.2013.00388.x/full

Avifauna and urban encroachment: http://onlinelibrary.wiley.com/doi/10.1111/ddi.12293/full

Rayner, L., Ikin, K., Evans, M.J., Gibbons, P., Lindenmayer, D.B. and Manning, A.D., 2015. ‘Avifauna and urban encroachment in time and space’, *Diversity and Distributions*, 21(4), pp. 428-440.

Ikin, K., Le Roux, D.S., Rayner, L., Villaseñor, N.R., Eyles, K., Gibbons, P., Manning, A.D. and Lindenmayer, D.B., 2015. ‘Key lessons for achieving biodiversity-sensitive cities and towns’, *Ecological Management & Restoration*, 16(3), pp. 206-214.

Image: Golden Whistler. Photo by Marwan El Hassan.

MISHKA TALENT

Residential energy and water consumption

Why do some households consume 10 times more energy and water than others? Fenner School PhD candidate Mishka Talent is attempting to answer such questions by investigating what determines residential energy and water consumption in the nation's capital.

Talent is basing his research on consumption data collected over a 10-year period from 60,000 dwellings across Canberra, showing that the top 10 per cent of water users in Canberra consume 24 per cent of the water, while the bottom 10 per cent consume only 2.7 per cent of the water. 'As the population increases and we look to use our resources more efficiently, it's vital that we understand how water and energy are being used by households', he says. 'For example, during the recent drought in Canberra, water restrictions were introduced that limited certain activities like garden watering, filling swimming pools and cleaning driveways. Such policies could be viewed as penalising people who live in detached dwellings with gardens and pools, and leaving those who live in high density apartments unaffected. Were gardens and pools responsible for the city's high water consumption? We need to understand what drives water consumption in detail to answer such questions. This is where my work can be applied.'

According to Talent, there has been a tendency in the past to assume that energy and water consumption is lowest in high density dwellings – an assumption he says is not based on rigorous data analysis. Supported by the ACT Government and local electricity, gas and water supplier, ActewAGL, Talent and colleagues are addressing this shortcoming by introducing updated statistical modelling techniques to analyse real-world consumption data, in what he claims is 'one of the largest and most detailed analyses of energy and water consumption in Australia and the world'.

'By integrating multiple sources of data, we can really start to improve our understanding of consumption', he explains. 'To give an example, if only population density is considered to affect consumption, then one could superficially conclude that consumption is lowest in higher density dwellings. However, people living in high density apartments usually have lower incomes, more often live alone, and are more likely to be renting, compared with people living in detached houses. Our models consider all these kinds of factors simultaneously. Once we take into account these other variables, we find that energy and water consumption is higher per capita in high density apartments than in townhouses and other single storey dwellings. It completely changes our understanding of consumption.'

Talent's ongoing mission is to improve our understanding of the drivers of domestic water and energy consumption. 'The degree to which behavioural or technological upgrades can reduce consumption is poorly understood', he says. 'We can see in the data that personal behaviour plays a significant role in the amount of energy and water people consume. At the same time, government-imposed efficiency programs are also affecting consumption. But without analysing the data, the effectiveness of such programs is unknown. Understanding all the factors that determine consumption, and untangling the complex relationships between these, will help inform government policy and allow an informed and robust debate on the topic.'

Further reading:

Talent, M., 2015. 'Robust Criteria for Sustainable Development: How to Lie with Transport Statistics', *The State of Australian Cities (SOAC) National Conferences Proceedings 2015*, State of Australian Cities Research Network: http://apo.org.au/tags/soac-7, and http://soacconference.com.au/wp-content/uploads/2016/02/Talent.pdf

Image: Canberra night from Mount Ainslie. Photo by Marwan El Hassan.

DEJAN STOJANOVIC

Swift Parrot v Sugar Glider

The Swift Parrot (*Lathamus discolor*) is an endangered bird species native to south eastern Australia. Although this species has a relatively high profile because of its interactions with forestry, agriculture and development as an endangered species, basic information about its life history has not been available. Dr Dejan Stojanovic, a postdoctoral fellow at the Fenner School, is working to address these gaps in knowledge, with the aim of improving the management of Swift Parrots and their habitat.

'Swift Parrot breeding has not been studied in detail before for a simple reason: the species is really quite difficult to research in its Tasmanian breeding range', explains Stojanovic. 'The parrots' nests are typically 20 to 50 metres above the ground in mature trees, meaning that to access and monitor them, tall trees must be climbed. The parrots are also quite picky about which tree cavities they use for nesting, selecting only hollows with small entrance diameters and deep chambers.'

For his research, Stojanovic surveyed trees across a broad area of eastern Tasmanian forests, finding that tree cavities suitable for wildlife in general are not common, and that potential Swift Parrot nests are even less common. 'One possible explanation why Swift Parrots prefer such a scarce subset of an already rare resource is the high rate of attempted predation on their nests', he suggests. 'Using camera traps, I monitored Swift Parrot nests from the time that eggs were laid, up to the point when the chicks fledged. I found no less than eight different species attempting to prey on the nests.' While most predation attempts failed because the nests have such a small entrance and a deep chamber, one species of predator, the Sugar Glider (*Petaurus breviceps*), was small enough to get in.

Stojanovic found that Sugar Gliders – a species that evidence suggests may have been introduced to Tasmania – have a huge impact on Swift Parrot breeding success, causing 60-100 per cent breeding failure, and often resulting in the death of the adult female parrot.

'It's difficult to do applied ecological research on species like the Swift Parrot because of lack of funding', Stojanovic says. 'More than that, the nature of the field work means it takes specialist skills and perseverance to collect the necessary data. The rewards, however, can be great, with important new information being generated to help conserve one of Australia's most endangered birds.'

Further reading:

'Parrots versus possums', Catalyst story: www.abc.net.au/catalyst/stories/4335033.htm

Stojanovic D., Webb M., Heinsohn R., 2014. 'Discovery of a novel predator reveals extreme but highly variable mortality for an endangered migratory bird', *Diversity and Distributions,* 20(10):1200-1207.

Image: Swift Parrot. Photo by Dejan Stojanovic.

CRIS BRACK

Arboretum

Forests are much more than just the trees we can see. Like icebergs, a significant proportion of each tree exists out of sight. Tree roots interact with the ground, with soil, fungi and other organisms, and with each other. Similarly, tree leaves, too many to count, interact with each other and the atmosphere in a two-way process. The trees themselves are dynamic organisms: growing, changing, and dying all the time. They respond to their local environment as well as influencing each other and changing their own local and large-scale environment. And, of course, other plants and animals (and even humans) interact with components of these trees and their environment.

Fenner School forest researcher, Associate Professor Cris Brack, says an improved understanding of these kinds of interactions is vital to managing our forests and trees in the face of an increasingly variable climate. 'We know root systems extract water from the ground, but we understand very little about the depths that forests can access this water, how it changes over time and with the seasons, or how the roots and associated fungi can intercept throughflow', he says. 'We know leaves can shade us, but not how much difference they make to the temperature in the canopy, near the ground, or even underground. We understand little about the impact of trees on mitigating temperature and moisture extremes, both within the forest and in the wider area.'

'All these dynamically interacting components can make a forest resilient, able to resist negative impacts and take advantage of additional resources. However, the scale or speed of some impacts may be too great, and may overwhelm the dynamic equilibrium of the forest, leading to significant degradation or even catastrophic change.'

Brack gives the example of eucalypt species, which have evolved a wide range of approaches to coping with and manipulating their environment. 'We need to understand whether one or more of the mechanisms evolved by eucalypt species is likely to be more successful than the alternatives', he explains. 'If we can better understand how individual trees interact with each other and their environment, we will be able to help forests become established in harsh environments, protect them from climate extremes, manage them to help protect ourselves from climate extremes, and more fully explore the value of these wonder-filled environments.'

According to Brack, the creation of the National Arboretum Canberra, with its 'one hundred forests situated only 10 minutes from ANU', provides a unique opportunity to measure and understand the impacts and interactions of trees. In a collaboration between the Friends of the National Arboretum, ACT Government, CSIRO and ANU, measurements on a scale previously inconceivable are being collected from forests ranging from mature cedars to juvenile acacias. Lasers (LiDAR – a remote sensing technology that measures distance) and giga-pixel digital photographs are capturing details of the leaves, branches and trunk of each tree in a forest, while arrays of temperature and moisture sensors are capturing details of energy and water flows through the surrounding air and soil. As the forests grow, this array of sensors will capture detailed and multi-scaled data showing the responses of the trees to their environment, as well as their effects on that environment. 'Such a comprehensive sensor network is unique. Nowhere in the world are forests as big as 10 hectares being studied in such detail in a network that will allow integration over scales from a few metres to hundreds of metres.'

Ironically, the devastating Canberra bushfires of 2001 and 2003 that led to the creation of the National Arboretum also destroyed a precursor to the intensively-measured forest experiment that is now such a research focus at the Arboretum. Brack says the Biology of Forest Growth (BFG) experiment, as it was called, was more manually intensive than the current project, but was nevertheless able to capture data that allowed Australia to predict the growth of its extensive plantation estates. At the time, the BFG-based models formed an important part of Australia's 'National Carbon Accounting System', which won the 2008 Eureka Prize for Environmental Science. Brack and several other scientists involved in that prize-winning experiment now continue the research, but with greatly improved technology at the National Arboretum. Scientists from countries around the world, including Finland, Canada and the US, have expressed interest in working with the data captured by this unique site.

'Technology like lasers, sensors, digital cameras, and the computers that network all these data collection devices, has developed incredibly quickly over the past half a decade', says Brack. 'It is becoming possible to understand forests, and the interactions between individual trees and other organisms in forests, at a new level of detail – a level that will potentially allow us to improve forest resilience in our increasingly variable and potentially hostile continent.'

'Trees and forests provide many of the products and services of our planet, but changing demands and environments may be stressing these trees in new ways. By revealing how trees and forests work as an integrated and multi-scalar environment, this research will show us how best we can work to face the challenges of these new stresses, for the benefit of both the forests and our society.'

Further reading:

National Arboretum Canberra http://www.nationalarboretum.act.gov.au/

Image: National Arboretum Canberra. Photo by Marwan El Hassan.

CRAIG STRONG

Back paddock blowing – more than dust in your eyes

Dust storms, dust hazes, or the back paddock blowing are just a normal part of life for many Australians. The wind picks up and the dust starts to fly, getting into people's eyes, in their houses, over their washing, reducing visibility, and making it hard to work. But dust is more than a nuisance – it is the 'business end' of wind erosion, the fine mineral organic and nutrient-enriched component of our soils.

According to Dr Craig Strong, a researcher based at the Fenner School, Australian dust can contain up to 35 per cent organic material, which is 'incredible, considering that, on average, our ancient soils have an organic component of less than 2 per cent'. 'It's all about the physics of blowing soil,' Strong says. 'When the wind picks up, larger soil particles begin to roll, bounce, or hop across the ground. The impact of these grains on the soil initiates the movement of other grains, and releases finer particles of soil and organic material, which are carried high into the airstream. The wind acts like a sieve, sorting the finest particles out of the soil, taking organic matter with it. The smaller the particle, the higher and further it will travel. Dust from South Australia is frequently tracked to beyond the eastern Australian coastline, the Gulf of Carpentaria and even to Antarctica.'

Loss of these fine nutrient-rich organic (and inorganic) components by wind erosion makes dust a serious land degradation issue, stripping Australian soils of their limited nutrients. Wind erosion is a major threat to the soil assets of Australia. Strong believes that the removal of valuable topsoil has far-reaching impacts that adversely affect our rural and urban communities. 'Once in the air, dust can affect the functioning of many different ecosystems and production systems', he explains. 'At the source, there is a loss of carbon stores and a reduced ability to produce food and fibre. Further downwind, there is a decrease in air and water quality, potentially impacting human health. But critically, dust in the air can also impact our climate. It does this through intercepting solar radiation and changing the proportion of light reflected by snow, as well as by influencing the marine food web and altering the carbon dioxide drawdown in our oceans.'

As an aeolian geomorphologist (a scientist who studies the wind's ability to shape the surface of the Earth), Strong is active in national monitoring of wind erosion. 'Monitoring is an essential part of effectively managing the dust threat', he explains. 'We need monitoring to tell us where the problem is, what causes the erosion, and how effective the actions we take to mitigate the erosion are. Dust is an excellent indicator, because it can be measured remotely by stand-alone sensors, and the "immediacy" of the data produced can inform land managers, as well as the community at large, when and where dust events are happening.' Working with colleagues at Griffith University, and the NSW Government, Stong has implemented a community dust monitoring network called DustWatch, http://www.dustwatch.edu.au/ which provides a system of instrumentation and community training, and produces hourly records online.

'One of the best ways to reduce wind erosion is to make sure there are plenty of plants providing ground cover. Research has shown that dust source areas tend to be very dry and loose, often indicating poor land management practice', says Strong, adding that there are also natural dust sources such as dry lake-beds and river systems, or areas of past rangeland fires (fire-scars). 'In general, a minimum of 50 per cent ground cover is necessary, and monitoring of ground cover is therefore a key to understanding wind erosion.'

But vegetation is only part of the ground cover story, and this is where Strong's research moves from continental scale issues to microscopic processes. 'In rangelands, a lot of soil surface ground cover is made up of micro-organisms like algae, lichens and fungi, and the substances they secrete, which together form what is called a biological soil crust', he explains. 'These soil crusts are known to reduce the rate of wind erosion by protecting fine soil particles against the impact of bouncing grains. What isn't known yet is how these organisms grow and respond to climate. Simple questions like "does the amount or timing of rainfall change the strength and integrity of a biological soil crust?" remain unanswered. Given the prevalence of these organisms throughout arid and semi-arid Australia, it would be very useful to understand them better, and find out if they can somehow help land managers reduce the negative impacts of wind erosion and soil loss.'

Strong says the presence of biological soil crusts is not only a useful indicator of good land management practices, demonstrating the presence of ground cover, but is also important to the sequestration (storage) of carbon in Australia's extensive rangelands. 'Biological soil crusts contribute to both the production and storage of soil carbon in environments where there is very little else', he explains. In a collaborative research venture with researchers in the UK and USA, he hopes to find out more about the secret lives of soil crusts and build a better understanding of their role in wind erosion. 'I believe the findings of this research will provide a crucial link for land managers, helping them find sustainable soil management solutions that conserve soil crusts, capture carbon, and reduce the greater impacts of wind erosion.'

Further reading:
http://www.dustwatch.edu.au/

Image: Dust storm Northam, Western Australia. Photo by Michael Dunstan.

XUEMEI BAI

Achieving a sustainable urban planet

The world is urbanising rapidly, with more than 65 per cent of its population projected to live in cities by 2030. The rate and magnitude of this change makes it one of the largest social transformations in history. This is a mixed blessing. On the one hand, cities are often the engines of economic development in a nation, and where technical and cultural innovations take place. On the other, they are responsible for the majority of world resource consumption and greenhouse gas emissions. What we do in and with our cities largely determines the sustainability of the planet.

Professor Xuemei Bai is at the forefront of research on urbanisation and sustainable urban systems. Her research explores how different drivers interact to shape the urbanisation trend, their impacts, how urban systems evolve, and what to do about them if we are to achieve a sustainable future.

She has a particular interest in China and other Asian countries, because of the rate and magnitude of urbanisation happening there. ‘These countries are like fast-moving, vast living laboratories where you can develop hypotheses, and actually test and apply them to influence the process’, Bai says. Collaborating with colleagues in China and globally, she is looking at the drivers and impact of urbanisation on society and the environment, urban system performance and sustainability, the role of various players in the low carbon city initiatives and sustainability transition, and urban policy and governance.

Building healthy, resilient and sustainable cities is a priority research area of ‘Future Earth’, a 10-year global research program on sustainability. As a member of the Future Earth Science Committee, Bai is working with colleagues in China, Europe, USA, Africa, and Asia to establish the ‘Urban Knowledge Action Network’, a global research and engagement platform looking at some of the most dynamic urban regions in the world.

Professor Bai is also co-leading the Future Earth urban research theme in Australia, together with colleagues at CSIRO and Monash University, to establish a strong, collaborative network involving researchers, practitioners and decision-makers within Australia and Asia. One initial focus is to understand complex interactions, trade-offs and synergies among different processes of urban systems, to better inform policy.

‘Many more cities will be built in the next half century’, says Bai. ‘Big decisions are being made every day by policy-makers, local governments and urban planners, which will likely remain in force for many decades. It is my hope that our research will contribute to better informed decisions, and influence the trajectory of cities towards a more sustainable future.’

Further reading:

Bai X., van der Leeuw S., O’Brien K., et al. 2015. ‘Plausible and desirable future in the Anthropocene: A new research agenda’, *Global Environmental Change:* http://dx.doi.org/10.1016/j.gloenvcha.2015.09.017

Bai X., Shi P., Liu Y. 2014. ‘Realizing China’s urban dream’, *Nature*, 509:158-160.

Image: Guangzhou City, China. Photo by Jonas Sauciunas.

PHILIP BARTON

Using carrion to unlock the secrets of nutrient cycling and biodiversity in woodlands

The decay of dead animals (carrion) is fundamental to the recycling of nutrients in ecosystems. New research by Dr Philip Barton in the Fenner School is helping to shed light on the important role that insects play in the decomposition process, and therefore in nutrient recycling.

Box-gum grassy woodland around the city of Canberra is one of the most endangered ecological communities in Australia, and is home to many rare plant and animal species. Barton, a leading researcher in the ecology of carrion in natural systems, is studying how nutrients are being recycled through these woodland ecosystems, and which invertebrates are involved, using local road-killed kangaroos as a model.

During a 12-month experiment, Barton measured several variables at the site of dead kangaroos – including soil chemistry, ground-level plant species, nitrogen levels in the plant leaves, and the diversity of invertebrates such as beetles, mites and ants, finding that carrion is a 'hotspot' for invertebrate diversity and abundance, as well as for nutrient cycling. 'The results showed there were more than 100 different species of beetle, 30 species of ant and 25 mite species on and around these kangaroo carcasses', he says, adding that many of the species found are only rarely encountered in other places. 'I also found evidence of very high nitrogen levels in the soil and leaves of nearby plants.'

Barton is now leading a three-year project looking in greater detail at how insects, especially flies and beetles, affect carrion decomposition rates, and how this depends on where carrion is located in a landscape. He anticipates his results will show how decomposition can be maintained in variable and changing environments, by revealing how the loss or gain of fly and beetle species might alter this process. 'The ecology of dead animals isn't everyone's cup of tea, but it's something I find fascinating', says Barton. 'No-one else is doing this research in Australia, and this gives me the opportunity to make new and important discoveries. My hope is that, by thinking differently about dead animals, it might prove possible to manage carcasses in ways that can benefit biodiversity and the health of ecosystems, such as the endangered grassy woodlands around Canberra.'

A large part of Barton's research is focused on better understanding why biodiversity matters. 'We know biodiversity is important and that it provides many services of value to humans', he explains. 'Without decomposer insects, for example, plant litter, dung and dead animals would be piling up around us and take much longer to break down. The role these insects perform in breaking down carrion and returning nutrients to the ecosystem is priceless. My research project will take a really close look at the role insects play in the decay of dead animals, and how the loss of insect diversity might impact on this critical ecosystem service.'

Further reading:

Macdonald B., Farrell M., Tuomi S., Barton P., Cunningham S., Manning A. 2014. 'Carrion decomposition causes large and lasting effects on soil amino acid and peptide flux', *Soil Biology & Biochemistry*, 69:132–140

Barton PS, Weaver HJ, Manning AD 2014. 'Contrasting dynamics of phoretic mites and beetles at vertebrate carrion', *Experimental and Applied Acarology,* 63:1-13.

Barton PS, Cunningham SA, Macdonald B, McIntyre S, Lindenmayer DB, Manning AD 2013. 'Species traits predict biodiversity dynamics at ephemeral resource patches created by carrion', *PLoS ONE*, 8(1):e53961.

Barton PS, Cunningham SA, Lindenmayer DB, Manning AD 2013. 'The role of carrion in maintaining biodiversity and ecological processes in terrestrial ecosystems', *Oecologia*, 171:761-772.

Image: Kangaroo carrion. Photo by Philip Barton.

JAMIE PITTOCK AND
DAVID DUMARESQ

Dams, fish and food in the Mekong

The Mekong River in South East Asia spans six countries and supports many millions of people. In the lower Mekong River basin, a new hydropower dam development threatens to significantly diminish the wild fish catch that provides critical protein and other nutrients for 60 million residents. Until now, the main stem of the Mekong River in Cambodia, Laos, Thailand and Vietnam has remained undammed, enabling the migration and breeding of a vast number of fish. However, in Laos, the first of 11 dams on the lower Mekong River is currently under construction. This is the first of 88 hydropower dams planned for the lower basin, to be built by 2030. Blocking fish passage with these dams is projected to kill off up to 40 per cent of the river's fish, while the new reservoirs may support only 10 per cent of the former fish population.

While the loss of fish is a well-known consequence of dam construction and is usually taken into consideration in development environmental impact assessments, the impact of activities required to replace those lost resources is not. In their research in the Mekong, Fenner School scientists Associate Professor Jamie Pittock and Emeritus Fellow David Dumaresq are collaborating with European colleagues to model the main options available to the four national governments affected, to replace the protein supplies they stand to lose once the dams are constructed.

'The first option we looked at is the most obvious option, which is greater reliance on the livestock produced by the region', explains Dumaresq. 'Using food and agriculture statistics provided by the governments, we developed a model in which production of these meat sources was scaled up in proportion to current consumption, to fill the projected gap in protein supply. This showed that, to create the extra pasture needed to support the necessary number of grazing animals, forests and woodlands covering an area of up to 24,000 km^2 would need to be cleared. Since then we have repeated the analysis with new data, finding that an even larger area of land would be required.'

The research team is now investigating two alternative options. The first of these is to replace the lost wild freshwater fish by diverting half of Vietnam's aquaculture exports, or a third of Thailand's marine fish catch, to local consumption. The second is to grow protein-rich crops such as soya and peanuts to supplement protein in the diet, although this would also require more land as well as an unlikely change in local diets.

Dumaresq says protein supply is critical in the Mekong basin, where around three million people live in poverty and childhood malnutrition is common, especially in rural areas. 'A lot of fish is caught by subsistence farmers and fishers', he explains. 'If river fish numbers are greatly reduced, these people are unlikely to be able to access sufficient land to produce alternative protein-rich foods. Nor are they likely to be able to afford to buy these foods from other farmers.'

'Our research is challenging the national governments that will be affected by the dams to articulate how they will develop hydropower at the same time as securing local food supplies. While these governments have the right to decide to build dams, we believe they also have a moral obligation to ensure there is sufficient food for their people.'

The research program is currently expanding to examine other aspects of the issue, including the impacts of existing water infrastructure development on food supply in Vietnam, the implications for food trade in the region, and the greenhouse gas emissions likely to result if alternative development pathways are followed.

Further reading:

Orr S., Pittock J., Chapagain A., Dumaresq D., 2012. 'Dams on the Mekong River: Lost fish protein and the implications for land and water resources', *Global Environmental Change* 22, 925–932, www.sciencedirect.com/science/article/pii/S0959378012000647

Image: Fishing on the Mekong.

DIANE ERCEG

A history of Antarctic tourism

PhD candidate Diane Erceg says that when she tells people she is writing a thesis on the history of tourism in Antarctica, they often reply with a mixture of relief and surprise. Relief that they don't require a dictionary or flowchart to understand her research topic and surprise that there is enough tourism activity to fill the pages of an entire doctoral thesis.

'Organised tours to Antarctica have been going on since 1966,' she says. 'Over the following decades, tourist numbers grew, gradually at first and then rapidly, and activities diversified to include skiing, mountaineering and marathon running. Today, tour operators take around 40,000 people to visit the frozen continent each year.'

Is tourism appropriate in such an extreme environment? Is it interfering with the work of scientists? What is its impact on fragile Antarctic ecosystems? Such questions have inspired public debate, academic scholarship and government regulation for almost fifty years. However, few studies or debates have approached the topic from the tourist's perspective. What draws people to the world's most uninhabited and uninhabitable continent? Who is responsible for pioneering, promoting and packaging Antarctica as a tourist destination? And how have broader cultural and technological shifts shaped the course of Antarctic tourism? These are the questions Erceg is addressing in her research, and she believes the answers will add a useful and insightful perspective to the conversation about Antarctic tourism.

Erceg has spent much of the first two years of her PhD gathering primary sources on which to base her work. This has involved recording the oral histories of Antarctic tour operators around the world, some of which were recorded from her desk in Canberra, and others which have taken her as far as New York City, the Netherlands and, of course, Antarctica. She has also sifted through government and private archives in Australia and the United States, finding reports, letters, photographs and advertising material that brings Antarctic history to life.

One of the best sources of information is her own personal experiences in Antarctica. For the past nine years, she has worked as a guide on expedition cruises in Antarctica and been immersed in the world she has now set out to study. 'The opportunity to step back and reflect on that world – how it emerged and what it tells us about ourselves – is a great privilege,' she says. 'I find that having such an intimate understanding of the subject I'm studying really enriches my work.'

Erceg says she agrees with the social historian, R.T. Tawney, who once wrote that historians need 'a stout pair of boots.' She would only add that Antarctic historians should make sure that theirs are insulated.

Further reading:

Erceg D., July 2, 2015, Stories from the field 'Digging Deep into the US National Archives': http://ceh.environmentalhistory-au-nz.org/stories-from-the-field/digging-deep/

Image: Antarctic tourism. Photo by Suzanne Mendes.

WENDY MERRITT AND BARRY CROKE

From good intentions to good outcomes – watershed development and sustainable livelihoods in India

Across much of the developing world, governments are struggling with the task of improving the lives of rural agricultural communities and enhancing food security, while protecting the natural resource base on which both depend.

In India, governments and other organisations have invested large amounts of time and money in watershed (drainage area) development programs intended to protect land and water resources as well as provide communities with opportunities to improve their livelihoods. These programs have a range of positive and negative impacts on local and nearby communities that vary over time, across the landscape, and between different groups.

Funded by the Australian Centre for International Agricultural Research (ACIAR), and as part of a team comprising three Australian universities and four research organisations in India, Fenner School researchers Dr Barry Croke and Dr Wendy Merritt have investigated the range of impacts that past watershed development programs have had on the landscape and local communities in Andhra Pradesh, India. 'There is an urgent need for tools that can help organisations design, implement and evaluate these types of programs more effectively', says Croke. 'In our research, we found that the programs we studied did not properly consider the geology and hydrology of the area, and so did not achieve all their intended outcomes.'

'For example, check dams are meant to capture surface water and let it soak through the soil into groundwater. When there is a rock layer not far below the land surface, not much water can be stored in groundwater and so check dams are not appropriate. Where check dams and other infrastructure are able to increase groundwater availability, farmers often use the "extra" water to irrigate crops that have more value, but use more water than for the crops they grew in the past. Instead of being protected from the effects of droughts, farming households could actually be more vulnerable after watershed development, despite having greater access to water.'

To help researchers and agencies understand the strengths and failures of past projects and better design future projects, the research team has developed a number of tools. Among these is a computer model developed by Dr Merritt, which relates hydrology, and land and water use, to socio-economic impacts. 'This model is useful because it allows you to explore how climate, land use and management, or other policy scenarios, might affect people's access to water and their capacity to maintain their livelihoods during drought', explains Merritt. The project culminated in the joint launch of the book *Integrated assessment of scale impacts of watershed interventions* (V. Ratna Reddy and G.J Syme [eds]) with a national workshop drawing together participants from more than 20 government and non-government organisations, aimed at building capacity and recognition of the need to take an integrated approach to watershed development.

Without perfect knowledge of the landscape or the ways in which people make decisions about how they use and manage land and water resources, identifying the effects a watershed development program can be difficult. Factors such as climate variability, or other policies at the time of implementation, may enhance or mask a program's impacts. The recent move away from village-scale to larger-scale programs in India has the potential to reduce negative impacts on downstream communities, although it may also further increase the challenge for agencies to design and implement programs that achieve environmental and social benefits across landscapes and communities. Models that can integrate biophysical knowledge (such as geology and hydrology) with socio-economic analyses may support an improved understanding of the landscape and social systems, and allow alternate design options to be explored.

'There is a great deal of interest across India in improving the outcomes of watershed development', says Croke. 'It is our hope that the methods, procedures and recommendations developed by our research team may be used to help guide the design, implementation and evaluation of watershed development projects in the future. An encouraging start is that the Department of Rural Development, a keen contributor to our research project, and the agency responsible for watershed development in Andhra Pradesh, has expressed enthusiasm to implement the project's recommendations, and this raises the real prospect that its future watershed development programs will better incorporate hydrogeological and socio-economic knowledge into their designs. Hopefully other organisations can also make use of our research to design improved watershed development programs, and implement appropriate interventions that safeguard the livelihoods of rural households.'

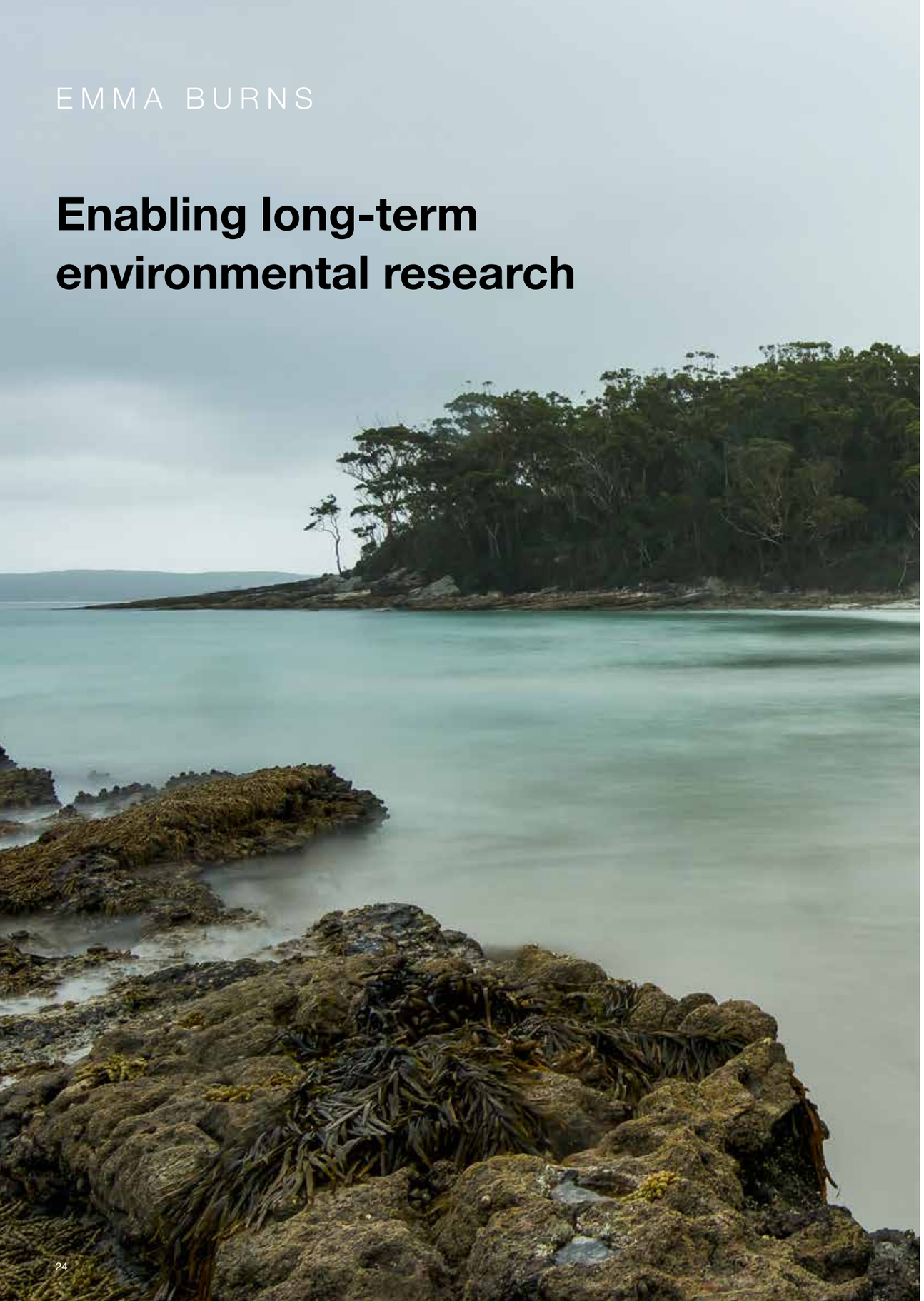
Further reading:

http://aciar.gov.au/project/lwr/2006/072
http://link.springer.com/article/10.1007 per cent2Fs10668-015-9650-1
http://www.sciencedirect.com/science/book/9780128000670

Image: Dam infrastructure in India.

EMMA BURNS

Enabling long-term environmental research



The state of our planet is changing. There are many factors – operating from local to global scales – that influence its health, including climate, soil, water, nutrients, vegetation distribution and diversity, and faunal distribution and diversity, among others. These factors affect the Earth's atmospheric, terrestrial, marine, rural and urban systems, as well as human social systems and wellbeing. It has become clear from extensive research that the rate of change being observed is greater than that of any previous period in the Earth's history. Research has also highlighted the significant risks associated with the multiple demands of a large and resource-intensive human population, a changing climate, and a dwindling natural resource base. The unanswered question is: if this is all *known*, then why does Australian society collectively act as if it isn't?

To help address information and education needs so that society can be more informed of, and responsive to, environmental challenges, the Long Term Ecological Research Network (LTERN) Facility was established in 2012. Headed by the Fenner School's Dr Emma Burns (Executive Director) and Professor David Lindenmayer (Science Director), LTERN is part of the Terrestrial Ecosystem Research Network, and is a capability within the Australian Government's National Collaborative Research Infrastructure Strategy. According to Burns, LTERN is all about supporting long-term ecological research plot networks, which produce and publish world-class science, and developing products that communicate their cumulative knowledge.

'It's difficult building something new, and everyone within LTERN has worked very hard over the last four years', she says. 'Tackling the world of data publication has been especially daunting. But real advances have been made, as evidenced by the hundreds of data packages we have been able to publish, and the LTERN Data Portal, which has had 30,000 visits so far.' Critical to this success is the diversity in skills of those involved with the network, which range from data management science and curation, to ecological monitoring and science communication.

'A key motivating principle of LTERN is to make the knowledge within the network accessible beyond scientific circles, so it becomes part of social knowledge', explains Burns. She cites the example of a book produced in 2014, covering what LTERN researchers and others have learnt from studying ecosystems in Australia. The book, *Biodiversity and Environmental Change* (Lindenmayer et al., 2014), is based on long-term research that has directly measured the changes occurring in our ecosystems, and provides an analysis of causes and trends. To complement this, a policy handbook, *Learning from Long-term Research to Better Manage Biodiversity in Australia* (Burns & Lindenmayer, 2014) was developed to make the findings and key messages more accessible to the general public and government. Then in late 2015, a web-page was developed through the LTERN Data Portal, that allows people to learn about the ecosystems studied within LTERN – tropical rainforests, alpine, heathlands, temperate eucalypt woodlands, Northern Australian tropical savannas, deserts and tall eucalypt forests – and to download a selection of data used in the book. LTERN concurrently produced a number of other publications, ranging from how-to booklets (*Making ecological monitoring successful*), to manuals (*The Long Term Ecological Research Network, Australia: Objectives, design and methods*), to articles in scientific journals.

Burns says it has also been gratifying that LTERN was recently able to help inform the International Union for Conservation of Nature's (IUCN) *Red List of Ecosystems*, by providing detailed risk assessments for a diverse selection of Australia ecosystems. 'By contributing this kind of data, LTERN has helped place Australia at the forefront of this important global innovation', she explains.

'A recent special issue of the journal *Austral Ecology* showcases LTERN's work in this area. In applying the IUCN criteria to Australian ecosystems – from our coast to the central deserts, the tropics to the sea – researchers tried to identify the defining features of these ecosystems and the processes that threaten them, evaluate trends in key variables relevant to their persistence, and assess their risk of collapse in the 21st Century.'

'As an example, an analysis of decades of scientific monitoring from the Victorian Tall Eucalypt Forest Plot Network (a network headed by the Fenner School's Professor David Lindenmayer) revealed that the Mountain Ash forest ecosystem of Victoria's highlands is at very high risk of collapse within half a century, largely due to clear-fell logging and bushfires. In fact, all 39 scenarios that were modelled indicated a greater than 90 per cent chance of ecosystem collapse by 2067. This resulted in the ecosystem being classified as critically endangered.' The research, led by Burns, generated heated debate in 'The Conversation', 'The Ecologist' and other media. It was also influential in the recent up-listing of Victoria's Leadbeater's Possum to critically endangered.

These are just a few of many examples of the work and outcomes being achieved by LTERN. Burns says LTERN infrastructure and products have already been used by all levels of government, as well as non-government organisations, domestic and international research institutions, schools, and members of the general public. In the longer-term, a key goal is to see LTERN data featured in key environmental reporting such as the Australian Government's *State of the Environment Report*.

'There is a growing need for a more effective transfer of scientific knowledge about the environment to broader society. To help enable this, LTERN will continue to advocate for the stable policies and recurrent funding needed to support Australian long-term research.'

Further reading:

LTERN website: www.tern.org.au/ltern

Austral Ecology IUCN special issue: http://onlinelibrary.wiley.com/doi/10.1111/aec.12200/abstract

The Conversation: https://theconversation.com/a-job-for-victorias-next-leaders-save-the-central-highlands-34608

Image: Jervis Bay, one of the LTERN Plot Networks. Photo by Marwan El Hassan.

JENIFER TICEHURST

Murray Darling Basin water cuts – farmers have part of the answer

With rising world population and a dramatic change in water availability due to climate change, farmers are being put under pressure to increase their food and fibre production using less water. For the irrigation farmers in the Murray Darling Basin of Australia, there is currently the added pressure of major water reform aimed at redistributing some of the water used for agriculture back into the environment. One of the responses from the agricultural industry has been to use more water-efficient methods to irrigate crops and pastures, and therefore not 'waste' as much water.

Fenner School researcher Dr Jenifer Ticehurst, together with Professor Allan Curtis from Charles Sturt University, recently conducted a study to investigate how much water could be saved by irrigators in the Namoi catchment of the Murray Darling Basin, by adopting more water-efficient methods of farming. 'The adoption of new agricultural practices is a complicated matter', says Ticehurst. 'It can be influenced by personal beliefs and values, trust in the government, and perceived risks, as well as more obvious factors such as financial circumstances and belief in the practice itself. Our research is novel because it used a social survey to find out which irrigators intended to adopt various water-efficient irrigation practices, and used the information gathered to estimate the likely water savings specific to this region.'

Irrigated agriculture is a huge industry in Australia, worth about $13.5 billion and employing about 40,000 people. According to Ticehurst, it was 'extremely controversial' when the Murray Darling Basin Authority (MDBA) first released its draft water allocation plan in 2011. 'A lot of people thought the proposed cuts were unfair, and were worried they would send them broke and completely wipe out many rural communities', she explains. In response to this pressure, and with additional scientific information, the plan was revised and the level of cuts to water allocations reduced in many areas. 'It's a complex environmental and socio-economic problem for Australia, bound by governmental policy. The MDBA needs to work out how to achieve its goal of a healthy and sustainable environment without sacrificing the economic and social well-being of the people who live in the region.'

'Farmers aren't idiots', Ticehurst says. 'When faced with increasing restrictions on water availability, those who are able to will make changes to remain profitable.' Some farmers are already taking steps to reduce water use while maintaining yield production, such as modifying their existing flood irrigation practices, changing from flood irrigation to overhead spray irrigation, and deepening dams. Others have expressed interest in making these sorts of changes.

'Our research found that the revised MDBA plan could achieve its targets in the Namoi catchment if these farmers are supported to act on their interest in changing irrigation practices. It's also possible that additional water could be saved, allowing irrigators to actually increase their production and profit, and further increasing the amount of water remaining in streams and groundwater stores. The NSW Department of Primary Industries is supporting this approach by providing irrigators with subsidies to help them assess and improve their current water use efficiencies.'

Ticehurst says this research shows that supporting farmers to make changes to their irrigation practices could be a win for the environment and socio-economic systems, as well as the government. Another potential solution is the use of 'managed aquifer recharge', which aims to add or 'bank' water into groundwater stores when there is plenty of rainfall and then draw on these stores during periods of drought, thereby reducing water lost to evaporation when it is above ground in dams and streams. This technique, also known as a form of 'conjunctive use', is being explored in further research by Ticehurst and Curtis in partnership with the MDBA. The research team, led by the Fenner School's Professor Tony Jakeman, is also exploring the costs and benefits of adopting various water saving measures. The potential for these methods in water management in Australia will be reported back to the MDBA to inform its future planning.

Ticehurst says that despite the uproar against the initial proposal for water cuts throughout the Murray Darling Basin, it appears that many farmers 'had a large part of the answer within their control', as well as the desire to change to meet the needs of the environment and the government. 'Our research shows the difference that farmers can make by changing current irrigation practices to more water-efficient alternatives. This should give them confidence that they can continue to adapt to the changing environment, including the political environment, and cope with the current cuts in water allocation, without sacrificing their long-term profitability.'

Further reading:

Ticehurst J.L. & Curtis A.L., 2015, 'Can existing practices expected to lead to improved on-farm water-use efficiency enable irrigators to effectively respond to reduced water entitlements in the Murray-Darling Basin?', *Journal of Hydrology*, 528: 613-620. http://www.sciencedirect.com/science/article/pii/S0022169415004680

For more information on the social research conducted in the Namoi catchment:

Sharp E. & Curtis A., 2012, Groundwater management in the Namoi: a social perspective. Institute for Land, Water and Society, Charles Sturt University: http://www.csu.edu.au/__data/assets/pdf_file/0005/702662/67_Namoi.pdf

Image: Long Island near Murray Bridge. Photo from Murrayriverphotos.com.au

ALBERT VAN DIJK, MARTA YEBRA AND GEOFF CARY

Managing bushfires from space

Bushfires can have devastating impacts, and understanding and predicting fire behaviour is a priority for fire services, land managers and residents alike. This is an enormous scientific challenge – bushfires are complex processes, with their behaviour and severity driven by local patterns in living and dry vegetation, topography and weather conditions.

A good understanding of fire risk across the landscape is critical in preparing and responding to bushfire events. ‘The vast array of spatial data sources we now have access to is not being used as well as it could be in fire management. We would like to change that’, says Professor Albert van Dijk, who leads the Water and Landscape Dynamics Group at the Fenner School. Van Dijk and his research team develop cutting-edge technologies that combine satellite measurements with models of landscape processes, including fire risk, drought, flooding and other natural hazards.

Dr Marta Yebra is a specialist in bushfire and remote sensing, and leads the team’s project in the Bushfire and Natural Hazards Cooperative Research Centre developing new technologies to map the risk and impacts of bushfire. ‘Fuel moisture content, fuel load and fuel structure are all critical factors when assessing bushfire risk, or when predicting how fire will spread. Remote sensing technology has tremendous applications in managing bushfire, but it is critical to have the right understanding and techniques to apply it well’, Yebra explains.

Van Dijk and Yebra collaborate with Associate Professor Geoff Cary, a Fenner School scientist who specialises in and teaches bushfire science and management. The group works closely with the ACT Parks and Conservation Service and fire agencies in several other states to better understand their procedures and information needs, examining the spatial data and mapping methods that are currently available, and developing the next generation of mapping technologies to help these services and agencies better prepare and respond to bushfires.

For example, the team is working with the CSIRO in applying field and airborne laser scanners to provide extremely detailed information about forest fuel structure. The information is used to predict fire risk or measure the impact of fires, including fuel reduction activities such as prescribed burning. Over larger areas, satellite observations from space are being used to map forest fuel structure and moisture content, to better understand fire risk and predict fire spread. The satellite data are also combined with models to predict changes in water resources, carbon storage, ecological habitat, and remaining fuel load after a fire has been through an area.

‘Technologies to observe and predict our environment are developing at an incredible rate’, says van Dijk. ‘Our challenge is to keep up our scientific knowledge and analysis methods, so we can solve some of the really big problems in mitigating bushfire risk.’

Further reading:

Mapping bushfire hazard and impact: http://www.bnhcrc.com.au/resources/poster/1233

Yebra M., Dennison P., Chuvieco E., Riaño D., Zylstra P., Hunt Jr. E.R., Danson F., Qi Y., Jurdao S., 2013, A global review of remote sensing of live fuel moisture content for fire danger assessment: Moving towards operational products Remote Sensing of Environment, 136, 455–468: http://www.sciencedirect.com/science/article/pii/S0034425713001831

Integrating geospatial information into fire risk assessment: http://www.publish.csiro.au/paper/WF12052.htm

Image: Ground-based Zebedee LiDAR (Light Detection And Ranging) can be used to provide precise information about fuel structure in woodlands. This is critical to improving fire danger assessment and fire behaviour modelling. Computer-generated image by Suzanne Marselis.

ZOE READ

Carbon sequestration – can our soils help reduce greenhouse gases?

Soil is an important pool of carbon, holding approximately three times more carbon than the atmosphere. Soil and its management therefore play a key role in the carbon cycle, regulating the storage and loss of the greenhouse gas carbon dioxide. Carbon sequestration – the trapping and long-term storage of atmospheric carbon dioxide – can be achieved in natural ecosystems by increasing the amount of carbon taken up by the soil and vegetation it supports. This makes good soil management in agricultural and natural landscapes an important strategy for reducing the level of greenhouse gases in the atmosphere.

Zoe Read, a PhD candidate at the Fenner School, and a grazier on the southern tablelands of NSW, recently monitored the effect of landscape restoration and land use change on soil carbon sequestration using two case studies. The first of these was undertaken near Nyngan, a small town in the semi-arid rangelands of NSW. Read says at the time of European settlement, this area was completely covered with native grasses and shrubland, but the spread of pastoralism, overgrazing, rabbits and drought all contributed to the complete loss of groundcover, exposing the soil surface to wind and water erosion. ‘The problem is that, over time, these soils have lost a lot of their “A-horizon”, or topsoil. All that’s left behind is a hard impervious crust on scalded clay pans almost completely devoid of vegetation cover’, she explains.

‘These areas of scalded clay pan soils, can be rehabilitated using a technique referred to as waterponding, which basically involves building specially shaped banks to trap rain water that would otherwise be lost through surface runoff. Large areas of scald can be rehabilitated fairly quickly and cheaply by using a grader to build a network of these banks, or waterponds, across the landscape.’

‘Once the water is trapped, it’s able to break down the surface crust and infiltrate into the soil profile, leaching soluble salts that have accumulated over time and allowing deep cracks to develop. Plant seeds blown across the surface become trapped in the cracks and germinate. Almost miraculously, within about five years the scalded soils become revegetated to the point where grazing can occur.’

For her study, Read compared 12 waterponded sites. The research showed that, while the scalded soils initially had very low levels of organic carbon – only about 19 tonnes per hectare, to a depth of 30 cm – within about five years of establishing waterponds, they were sequestering up to eight tonnes of carbon per hectare, to reach an average of 27 tonnes of soil organic carbon per hectare to a depth of 30 cm. Read also found that waterponds older than five years do not appear to sequester additional carbon, since most of the soil nutrients have been used up. Even so, her results suggest there are sufficient nutrients for the waterponds to sustain plant growth and allow ongoing moderate levels of grazing.

The second part of Read’s research featured a case study from the southern tablelands of NSW, examining changes to soil carbon after native trees and shrubs (typically eucalyptus and acacia species) had been planted. ‘These biodiverse environmental plantings, or BEPs as they are known, are often used by farmers to provide shade and shelter for their livestock, establish wildlife corridors, and bring biodiversity back into the agricultural landscape’, she explains.

After comparing 20 different BEPs, Read was able to show that establishing BEPs can lead to sequestration of carbon in soil, but only in relatively small quantities. The BEPs also sequester carbon in the trees, at a rate of about 2.4 tonnes of carbon per hectare per year.

’What I concluded from the case studies is that soils that contain very low levels of organic carbon, such as the scalded soils near Nyngan, have the capacity to sequester significant additional carbon’, says Read. ‘On the other hand, soils that already have relatively high levels of carbon, such as the agricultural land on the southern tablelands of NSW where BEPs are established, have much less potential to sequester additional organic carbon. That said, BEPs sequester a large quantity of carbon in their biomass and provide important farm and landscape ecosystem services.’

Read says the implications of the research are important, as they show that land-use change may lead to soil carbon sequestration. Her hope is that the findings will prove useful for decision-makers responsible for programs and policies for carbon sequestration, as well as for land managers seeking to trade on the carbon market.

Further reading:

Landholders who establish BEPs or water ponds may be eligible for carbon credits. See:

Carbon Farming (Carbon Farming Initiative) (Sequestering Carbon in Soils in Grazing Systems) Determination, 2014 (https://www.comlaw.gov.au/Details/F2014L00987)

Carbon Credits (Carbon Farming Initiative) (Reforestation by Environmental or Mallee Plantings-FullCAM) Methodology Determination 2014 (https://www.comlaw.gov.au/Details/F2014L01212)

Image: Waterponding is proving to be a very effective technique for transforming scalded soil into productive native pasture. Photo by Ray Thompson.

DEAN ANSELL

Getting more bird for our buck

Every year, billions of dollars are spent on protecting and restoring biodiversity on farms across the globe. There is much potential to make our dollars work harder by focusing on those conservation actions that provide the greatest benefit per dollar spent. Despite this, very little attention has been placed on understanding the cost-effectiveness of our investments.

Fenner School researcher Dean Ansell is focusing on this very issue for his PhD research, through a multi-disciplinary evaluation of biodiversity conservation in agricultural landscapes.

‘There is not enough funding available to fix all of the problems facing biodiversity in farming landscapes, so it’s critical we prioritise those activities that are the most cost-effective. The problem is there has been very little integration of the conservation and economic disciplines in this area’, explains Ansell.

With funding support from Greening Australia, Birdlife Australia, and the ANZ Holsworth Wildlife Research Endowment, Ansell and colleagues Associate Professor Phil Gibbons and Drs Nicki Munro and David Freudenberger are combining ecology and economics in an evaluation of the approaches typically used to restore biodiversity in agricultural landscapes. Focusing on the benefits of habitat restoration for native birds, their research is comparing the differences in the costs and benefits of revegetation and protection of woodland patches.

‘We tend to focus our conservation efforts on either the sites of highest conservation value, or sometimes the cheapest investment. When funding is limited though, what matters most is the increase or gain in conservation value as a result of the restoration investment, and the cost of achieving that gain’, Ansell says. ‘This research will identify the factors that influence the cost-effectiveness of habitat restoration, such as size, shape and location of a planting, and in so doing, will help restoration practitioners and decision-makers undertake restoration that provides the best value for money – the greatest “bird for buck”.’

Ansell says that it is still early days, but preliminary results suggest that conventional wisdom regarding where we focus our spending on farmland biodiversity may need to be reconsidered. ‘The biodiversity gains we observe in the revegetation sites are orders of magnitude greater than those generated by fencing remnant woodland patches. Even when we look just at woodland birds, we’re still gaining eight times more species in plantings.’

His research is also investigating the efficiency of agri-environment schemes – incentive schemes that involve payments to farmers in return for providing biodiversity and other environment benefits. Together with colleagues from the Fenner School and the University of Western Australia, he plans to publish a book later this year that collates the views and experiences of more than 20 ecologists, economists, social scientists, policy-makers and restoration practitioners on the effectiveness and efficiency of agri-environment schemes.

These research projects will not only reveal ways to improve the biodiversity outcomes of our investments, but also highlight the benefits of combining different scientific disciplines when trying to solve conservation problems.

Further reading:

The birds and the beef - striking the food demand balance: http://www.policyforum.net/the-birds-and-the-beef/

Getting more bird for your buck: http://decision-point.com.au/article/getting-more-bird-for-your-buck/

Ansell, D., Fifield, G., Munro, N., Freudenberger, D. Gibbons, P. 2016 Softening the agricultural matrix: A novel agri-environment scheme that balances habitat restoration and livestock grazing. 24(2):159-164 *Restoration Ecology*.

Image: Biodiversity restoration in agricultural landscapes includes forests, remnant bush, woodland patches and wildlife corridors. Photo from iStock.

MARK HOWDEN AND JANETTE LINDESAY

Adapting to a changing climate

Our climate is changing – almost certainly due to human-related greenhouse gas emissions – with 2015 being the warmest year on record by a large margin. Trajectories of emissions indicate further and more substantial changes are on the way. These climate changes are already impacting on natural and human ecosystems across the globe, often interacting with other drivers of global change such as population, economic growth and environmental disruption. The costs of current and future climate changes are likely large but uncertain. There is a strong rationale for us to take action now, both to reduce net emissions and to start adapting to these changes.

The Paris Agreement is an important step in moving towards lower emission trajectories, but even these modified trajectories will result in potentially dangerous climate, oceanic and environmental changes. Consequently, there is an increasing need to focus on developing and implementing effective climate adaptations. Not adapting means that human and natural systems will incur unnecessary risk and damage, underperform and, in some cases, miss out on opportunities for improvement.

Fenner School scientists Professors Mark Howden and Janette Lindesay, in collaboration with colleagues from ANU and across the globe, are working with decision-makers to develop effective adaptation approaches, with a particular eye for those that also reduce the emissions causing current climate change.

‘Most adaptation studies to date have looked at the far future (such as the year 2070), and have taken fairly simple approaches to integrating climate and other concerns,’ says Howden who, in addition to his research role at the Fenner School, also heads the ANU Climate Change Institute (ANU CCI). ‘There is a growing need for research to focus on adaptations that can be implemented now, that are developed in partnership with decision-makers, and that recognise and support their integrative capacity.’

An important component of this approach is to deliver more useable and relevant climate information. ‘We are exploring what information decision-makers really need, and comparing this with what climate scientists think decision-makers need. It turns out these are quite different,’ explains Lindesay. ‘We are also working to deliver better-targeted climate information that can link directly to climate risk assessments, as well as tools and processes that can better explore and assess climate adaptations.’

According to Howden and Lindesay, there is likely to be a large, varied and increasing demand for effective climate adaptation over the coming decades. ‘Many things that we as a society value are significantly influenced by climate, particularly climate extremes,’ says Howden. ‘These range from economic sectors such as agriculture, forestry and mining, to the houses and cities that we live in and other infrastructure that we depend on, through to the rivers, lands and oceans that host our biodiversity and provide the ecosystem services that we depend on for our food, water and health, both individually and as a community.’

‘Although there are often adaptation options available for these different systems, they are not necessarily being used. Hence, we are working with social scientists and institutional analysts to understand the barriers to adoption. Additionally, most adaptation options have implications for greenhouse gas emissions – sometimes increasing them, sometimes reducing them. One form of maladaptation is to choose adaptation options that increase emissions, so it is an important part of our research to assess adaptation and emissions together, as well as look at other co-benefits.’

Importantly, many of the available adaptation options focus on incremental changes to existing systems. However, these may become less effective as climate continues to change, requiring decision-makers to consider more systemic or transformative changes. ‘We are working with people and organisations who are planning or implementing more transformational changes to understand the whole decision process and the factors that influence success,’ said Howden. ‘It is important that the full range of adaptation options beyond the current system is considered, so as to not miss out on really good alternatives. This more strategic approach will also help limit people locking themselves out of good adaptation options in the future as a result of the decisions they make now.’

Further reading:

Climate Change Institute, The Australian National University: http://cci.anu.edu.au/

IPCC, 2014: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)] IPCC, Geneva, Switzerland, 151 pp.

Porter J.R., Xie L, Challinor A,. et al. 2014. Working Group II. Climate Change Impacts and Adaptation, Intergovernmental Panel on Climate Change; Chapter 7, Food Security and Food Production Systems. Cambridge University Press.

STEVE DOVERS, JAMIE PITTOCK,
MICHAEL EBURN AND KAREN HUSSEY

The governance of disasters

Recent decades have seen two extremely important phenomena. First, there have been increasing disasters and losses from disasters around the world and in Australia, including floods, storms and bushfires. This situation is likely to worsen, with a changing climate, population growth, and the shift of settlements into vulnerable locations. Second, the disaster and emergency management sector has shifted from a 'prepare and respond' approach to one that focuses on preventing and reducing human vulnerability, and on increasing the resilience of communities during recovery.

No longer considered 'acts of God', disasters are now viewed as a critical influence on our ability to progress sustainable human development. This international policy agenda is confirmed in the 2015-2030 Sendai Framework for Disaster Risk Reduction (www.unisdr.org/we/coordinate/sendai-framework).

Fenner School researchers Professor Steve Dovers, Associate Professor Jamie Pittock and Honorary Professor Karen Hussey, together with Dr Michael Eburn from the ANU College of Law, are at the leading edge of exploring the complex legal, policy and governance dimensions of this shift.

'Disasters are something we as societies can have control over', claims Dovers. 'Vulnerability to disasters is a result of natural phenomena, but much more so, it is a result of where and how we live.'

With the support of the Bushfire and Natural Hazards Cooperative Research Centre (B&NH CRC), Dovers and colleagues are undertaking collaborative research with leading emergency managers in a research project titled: The Policy, Institutions and Governance of Natural Hazards (known fondly in the sector as 'the PIGs project').

Policy and legal research in emergency management was virtually non-existent until very recently, and was pioneered in Australia by Eburn in legal research, and by Dovers and RMIT University colleague Professor John Handmer in policy and institutions. Eburn's text *Emergency Law* (Federation Press), now in its 4th edition, and Handmer and Dovers' *Handbook of Disaster Policies and Institutions* (Routledge, 2nd edition) laid the foundation for theoretical and practical work in the most crucial aspect in responding to disasters – the way in which we, as societies, organise ourselves to cope with major disruptions.

The focus of ongoing research is on the role of post-disaster inquiries in driving positive learning and change – can we learn and improve, or just blame? – and the role of the private sector in disaster preparedness and response. In a recent article in the *Australian Journal of Public Administration*, Eburn and Dovers explore how to learn from disaster events in more constructive and less adversarial ways. Working with colleague Dr Jessica Weir at the University of Western Sydney, they are also examining the interplay between scientific and other forms of knowledge in understanding risk and hazards.

In related research at the Fenner School, PhD scholar Susan Hunt is examining national policy coordination as a means to drive and coordinate our response to increasing disasters and vulnerability, and fellow PhD scholar Caroline Wenger is critically reviewing flood policy, furthering work she undertook with colleagues through the National Climate Change Adaptation Research Facility. Both are supported by the CRC.

A feature of the research is close partnerships with emergency managers, through the B&NH CRC and the Australasian Fire and Emergency Authorities Council. 'This is an area of research that is so important for society, the economy and the natural environment', says Dovers, who has worked across many issues and sectors over the past three decades. 'The leaders in the industry are deeply curious, supportive of research, and very proactive in terms of preparing for an uncertain future. If our research helps them in some way to do their important jobs, that in itself is a very rewarding outcome.'

The future promises worsening disasters, but Fenner School research will continue to inform how society can face that challenge and better protect lives, livelihoods and our environment.

Further reading:

http://www.bnhcrc.com.au/hazardnotes/13?utm_source=HazardNews&utm_campaign=1970445349-Hazard_News_January_20161_18_2016&utm_medium=email&utm_term=0_8199986967-1970445349-168704593

Image: Post-disaster response.

CONTACT US

Fenner School of Environment & Society

The Australian National University
Canberra ACT 2601
Australia

T +61 2 6125 2579
E fennerschool@anu.edu.au
W fennerschool.anu.edu.au

CRICOS Provider #00120C

MO_CMBE16020