THE UNIVERSITY of ADELAIDE

in sight

EMERGING RESEARCH FOR A BETTER WORLD

TAKING OUT THE TRASH

Targeting space junk with world-leading AI

BLUE CARBON

Recruiting one of the great natural allies against climate change

MENINGOCOCCAL B

The verdict's in from the world's largest study on herd immunity

stepping up on the global stage

Established in 1874, the University of Adelaide is renowned as one of Australia's premier 'Group of Eight' universities, and among the most respected research institutions in the world.

Our reputation for excellence is founded on a rich history of achievement—we're associated with four Nobel Prize-winning researchers—and strengthened by elite, contemporary talent.

In the 2019 Clarivate world Highly Cited Researchers list, 12 of our academics were recognised for the scale of their global influence—two in multiple fields. And in each of the past two years, we've had a young researcher recognised in MIT Technology Review's prestigious Innovators Under 35 list*. In 2020, we were the only Australian university represented; in 2019 we were one of just two.

adelaide.edu.au/research

**Asia Pacific region.*

taking on covid-19

We're doing everything in our power to help reduce COVID-19's global impact, and enhance physical, social and economic recovery. This page highlights many of the pandemic-related research projects we have been, or are still, involved in.

ANAESTHETIC PROCEDURES

Led international collaboration establishing best-practice anaesthetic procedures for COVID-19 patients.[1]

HOUSING POLICY

Leading national studies of COVID-19's impact on renting in Australia, and modelling potential national housing policy responses to the pandemic.[2]

PROGRAMMERS' WELLBEING

Co-led international collaboration establishing COVID-19's impact on software developers' productivity and wellbeing, and advising harm-minimisation measures.[3]

ECONOMIC IMPACT

Economic Briefing Report on long-term economic impact of, and recovery from, the pandemic. Delivered to Government of South Australia.[4]

contents

SNIFFER DOGS

International collaboration to train and test COVID-19 sniffer dogs to detect infection, even in pre-symptomatic and asymptomatic individuals.[5]

TRACING-APP SAFETY

Assessed 34 of the world's COVID-19 contact tracing apps for security and privacy vulnerabilities, and informed all stake-holders of findings to inform updates.[6]

BURNOUT RISK

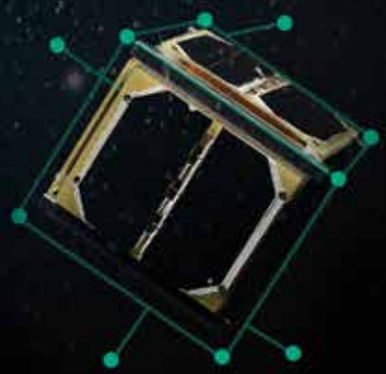
Led international collaboration investigating working adults' likelihood of burnout during the pandemic, based on their proximity to the outbreak's epicentre in Wuhan, China.[7]

IMMUNITY PHENOTYPING

Collaborative long-term study of recovering COVID-19 patients to inform vaccine development and public health management.[8]

[1] Thiru, V et al 2020, Anesthesia & Analgesia, vol 131, issue 3, p 677-689, doi: 10.1213/ANE.0000000000005043 [2] Baker, E 2020, Renting in the time of COVID-19: understanding the impacts, and Leishman, C 2020, Supporting Australia's housing system: modelling pandemic policy responses, both commissioned by the Australian Housing and Urban Research Institute. [3] Baltes, S et al 2020, submitted to Empirical Software Engineering. [4] South Australian Centre for Economic Studies, 2020. [5] Led by National Veterinary School, Alfort (France). [6] arXiv:2006.10933 [7] Zhang, S et al 2020, Psychiatry Research, Jun;288:112998 doi: 10.1016/j.psychres.2020.112998 [8] In partnership with the Royal Adelaide Hospital.

space dejunked



Gazing up at a starry sky, it's easy to imagine space as impossibly pristine—a vast, empty blackness interrupted only by sparkling celestial bodies. The reality, around our planet at least, is quite a bit messier.

Human-made debris, or 'space junk', orbits us in staggering quantities; there are currently around 23,000 pieces larger than 10cm across, and an estimated half a million smaller than that.

Moving at speeds exceeding 35,000 kilometres per hour, all are capable of causing serious damage to working satellites and other important equipment. In 2009, for example, an active US communications satellite was obliterated after colliding with an inactive Russian counterpart. Three years earlier, a tiny fragment chipped a window on the International Space Station.

Understandably, identifying space junk and mitigating the risks it poses—by collecting or destroying it—is a global priority. And some of the world's most advanced work in the area is taking place at the University of Adelaide.

The University's team was among the first internationally to effectively apply computer vision and machine learning principles to accurately estimate the position and orientation, or 'pose', of space objects relative to an approaching craft—an essential step to enable debris collection. Led by Professor Tat-Jun Chin, the group's success in the field was highlighted in 2019, when it won the European Space Agency's (ESA) global Pose Estimation Challenge, outperforming nearly 50 of the world's leading universities and space technology companies.

According to Chin, although the scientific 'tools' he and his colleagues are working with are familiar, applying them to work in space presents unique difficulties.

"Establishing the exact position of an object relative to another using computer vision and machine learning, or artificial intelligence (AI), is a task that researchers have been tackling for many years," he says.

"It requires algorithms informed by huge amounts of data, which is relatively easily done for many terrestrial tasks. I often use the example of autonomous cars; getting the data needed to inform their guiding algorithms is just a matter of capturing it from human-driven cars.

"But we can't do the equivalent in space, because satellites are just too expensive to develop and put into orbit. It's an incredible challenge, and one we're excited to meet."

Since their ESA win, Chin and his team have been awarded significant federal funding to expand their research, through Australia's SmartSat Cooperative Research Centre (CRC). Collaborating with research partners Inovor Technologies, along with scientists from the University of Queensland and Australian National University, they're playing a leading role in the CRC's overarching efforts to enhance space situational awareness—identified by the Australian Space Agency as an industry priority.

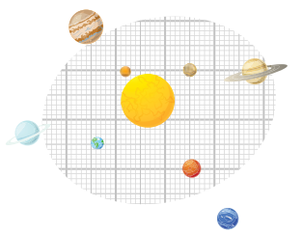
Their focus, however, is not limited to pose estimation alone. "We're also working on enhancing robotic manipulation equipment to perfect the task of actually collecting space junk once its position and orientation are identified," adds Chin.

"We've built a robotic arm that we can 'train' to acquire the debris. The next step is to work with a partner organisation to jointly take testing and development to the next level."

Right: Professor Tat-Jun Chin (right) and Mr Dan Lawrence, student in computer science (advanced).

KEY ACHIEVEMENTS

University of Adelaide AI technology, based on computer vision and machine learning, leads the world in space junk pose estimation.



The University's researchers are overcoming unique challenges to successfully develop AI for space applications.

The group's work now also includes developing robotic manipulation technology to acquire space debris once located.

finding fertile ground in orbit

DEFENCE, CYBER & SPACE

The University of Adelaide is leading research into a new plasma-based, space-ready process for the production of agricultural fertiliser.

The streamlined process could help make it possible for space travellers to grow their own food.

The resultant fertiliser can also be tailored to suit local conditions –also enhancing terrestrial farmers' self-sufficiency.

In-space manufacturing's potential has the whole world talking.

With the University of Adelaide's assistance, optical fibre production has already taken the first step (*see page opposite*), and in coming years numerous other industries are expected to enter orbit. Among these is agricultural fertiliser; here again, Adelaide-led research is paving the way.

A team from the University is using cutting-edge plasma technology to radically transform and intensify the production of ammonia, fertiliser's main ingredient. The process is waste-free, circular, highly streamlined, efficient and scalable, so could one day even be used to make fertiliser in space. This would help meet crewed spaceflight's requirement for autonomous operation by boosting astronauts' capacity to grow their own food. Adding to the promise, it could also enable manufacturers to readily customise fertiliser to local environmental conditions.

Known as SCOPE, which stands for *Surface-COnfined fast-modulated Plasma for process and Energy intensification in small molecules conversion*, the project represents a significant advance over traditional ammonia production methods.

"We're generating the targeted creation of unstable molecules or atoms during reactions between plasma—a gas-like substance, consisting of particles such as positive ions and electrons—and proprietary catalysts," says project leader Professor Volker Hessel.

"These plasma-chemical reactions are fundamental to efficient fertiliser production, produce no waste, and intensively produce fertiliser that can be 'tailored' for specific environments."

Hessel and his team have set up a process simulation study in South Australia to further refine and intensify, on a large scale, the first step of the ground-breaking three-stage processing technique: decomposing bio-methane, obtained from animal manure, into hydrogen and carbon by heating it with solar-powered plasma energy to 2,000°C. This high-temperature aspect of the process is owned by US energy company Monolith Materials and was initially developed by MINES ParisTech university.

Subsequently, hydrogen will be reacted with nitrogen in air to produce ammonia in a low-temperature plasma process, using original University of Adelaide technology. Then finally, the ammonia will be reacted with nitrate, or other chemicals, to produce fertiliser.

PROFESSOR VOLKER HESSEL
Project leader

"Unlike existing large-scale fertiliser production plants," Hessel adds, "this technology will enable the creation of production facilities small enough to fit on the back of a truck. Farms—or space travellers—could have their own 'plant' right on-site."

The ability to tailor output, he adds, will come through the addition of artificial intelligence (AI). "SCOPE could further enhance the possibility of autonomous farms by integrating new capabilities into bespoke agricultural technology solutions. AI could be employed, for instance, to tailor fertiliser according to local weather, soil and other characteristics to increase crop yields."

Enabling local self-sufficiency in this way will only be more relevant in a post-COVID-19 world, as it eliminates dependence on complicated and easily disrupted supply chains. But it's the off-Earth possibilities that most fire the imagination.

"Using abundant renewable energy from the sun, this self-sufficient technology could actually make growing crops on Mars a real possibility. Not too long ago that was science fiction."

PROFESSOR HEIKE EBENDORFF-HEIDEPRIEM
Team leader

extraterrestrial fibre extraordinary performance

Optical fibres are modern civilisation's neural pathways, enabling the vast, global information flows that drive and bind humanity.

Traditional silica-based fibre, however, is nearing its limits; higher-performing fluoride-based fibre—which must be drawn outside Earth's gravity for best results—is the future. Now, with University of Adelaide research leading the way, fluoride fibre's time has arrived.

The University's researchers have collaborated with US-based industry partner Flawless Photonics to develop novel processes and world-leading technology for the commercially viable manufacture of fluoride-based optical fibre in space. Their collective success was proven in 2020 when Flawless Photonics drew fibre, known commercially as SpaceFiber™, aboard the International Space Station.

The technological advance's potential benefits cannot be overstated, says the University team's leader, Professor Heike Ebendorff-Heidepriem.

"Fluoride fibre has a theoretical information loss limit 10 to 100 times lower than fibre made with silica. That means ultra-high-speed long-distance undersea cables could be laid without the expensive repeater stations that silica fibre requires.

"Several billion dollars are currently spent on those cables every year—there are over 1.2 million kilometres of them in service globally—so the savings on offer are enormous."

The new fibre, which will be the most transparent material ever produced, is also expected to open new commercial possibilities for several industries currently limited by silica fibre's performance capacity.

"It will enable entirely new products and applications that simply couldn't exist before," adds Ebendorff-Heidepriem, "such as disruptive photonic technologies in communications, defence, utilities and healthcare."

To support *SpaceFiber's* ongoing development and commercialisation, Flawless Photonics has established an Australian company and will be basing its headquarters adjacent to the University in Adelaide's world-class Lot Fourteen innovation precinct, also home to the Australian Space Agency. The robotic systems used to draw the fluoride fibre in space will be designed and manufactured at this facility.

"We chose Adelaide because of Professor Ebendorff-Heidepriem's world-renowned expertise in fluoride fibre, and the outstanding quality of her team," says Flawless Photonics chairperson and founder Rob Loughan.

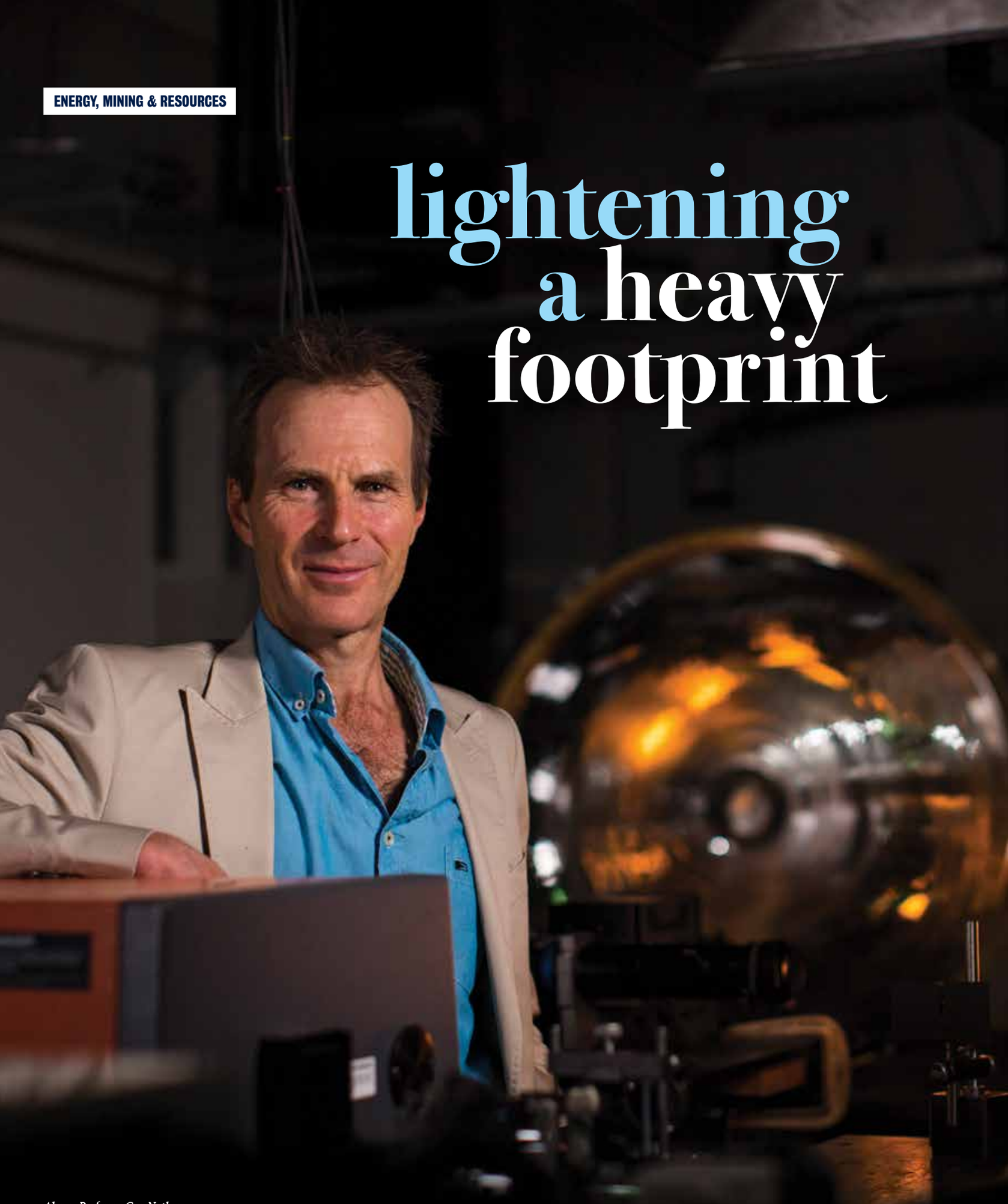
Though still very much focused on the science, Ebendorff-Heidepriem is aware that the project's value is as much symbolic as practical. "In hard terms, this is a high-value, high-tech new industry that—as production scales up—will attract significant investment, and create many long-term specialist jobs. But it also effectively marks the world's first concrete step towards in-orbit manufacturing.

"It's a great privilege to be playing a leading role in this historic step forward."

WHY MANUFACTURE IN SPACE?

Researchers have been aware of fluoride optical fibre's potential for decades. But terrestrially made fibres have never met expectations, due to unavoidable convection currents during fabrication causing harmful crystallisation. Drawing the fibres in microgravity eliminates this problem, allowing the production of fibres approaching their full theoretical loss limit.

lightening a heavy footprint



Above: Professor Gus Nathan

High-temperature heavy industry presents an almighty roadblock to combatting climate change. The production of critical materials such as steel, cement and aluminium—all vital to the global economy—accounts for around 15 per cent of CO_2 emissions worldwide, but has proven incredibly difficult to decarbonise cost-effectively. Innovative technology developed by the University of Adelaide, however, may be able to help overcome the barrier.

The University has led collaborative investigations into low-cost ways of incorporating concentrated solar thermal (CST) energy into the 'Bayer process', used to refine bauxite to alumina. Also involving Alcoa, Australia's largest alumina exporter, together with mining and resources company Hatch, the Commonwealth Scientific and Industrial Research Organisation, and the University of New South Wales, the project's results are promising.

"The new technology we're developing has passed every technical and economic milestone we've established," says lead researcher Professor Gus Nathan.

"We already have one patent and expect to submit further patent applications by late 2020. And—with additional government funding—we hope to start upscaling the technology for industrial implementation from 2021. This will again be in conjunction with Alcoa."

Funded by the Australian Renewable Energy Agency, the technology is being developed to directly use the heat from a CST system, together with other energy sources, such as electricity and/or hydrogen. "It's not economically viable to store heat during extended periods of low solar availability," explains Nathan. "So our CST system will also integrate other renewable energy sources as a back-up."

The CST component works by programming a large array of mirrors, known as heliostats, to collectively and continuously focus sunlight into a single solar receiver, producing extremely high temperatures. That heat is captured and stored with high efficiency and at much lower cost than electricity, such as via batteries.

According to Nathan, these characteristics make CST and heavy industry, in many ways, perfect partners.

"Heavy industry has almost no margin to absorb higher costs, as its products are globally traded commodities with prices that can't be controlled domestically. Nevertheless, new markets are emerging for low-carbon products and our system is expected to be cost-competitive in these markets.

"We're also aware that legacy heavy industrial facilities and equipment would be prohibitively expensive and difficult to replace, so we've targeted our system to enter the market via retrofitting into existing plants."

Reducing the Bayer process's climate impact will be a valuable step. In bauxite-rich Australia, for instance, it's responsible for around one quarter of the country's industrial emissions. But Nathan sees no reason why his team's work could not be applied to other heavy industrial processes.

"The use of carbon-neutral energy sources for heat, such as solar thermal, hydrogen and renewable electricity, has the potential to transform heavy industrial processes," he enthuses.

> **"Costs are reducing to the point where we can feasibly envision the gradual displacement of the energy currently supplied by fossil fuels for high-temperature process heat.**

"This is a vital step in enabling nations to meet their 2050 emissions-reduction commitments."

It could also, he adds, lead to big flow-on benefits.

"The low-carbon transition offers new potential for countries with a coincidence of mineral and renewable energy resources to produce high-value materials instead of simply exporting ores.

"That will increase gross domestic product, boost employment, and enhance manufacturing self-sufficiency."

KEY ACHIEVEMENTS

The University of Adelaide is leading development of a low-carbon alumina calcination technology with strong commercial potential.

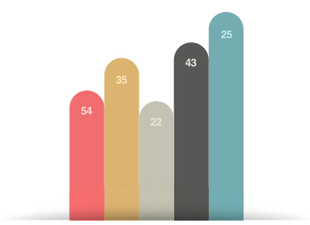
The direct use of concentrated solar thermal heat has strong potential to contribute to the reduction of heavy industry's carbon emissions.

Large ore producers in regions with strong renewable energy resources also stand to benefit from the potential to produce their own value-added products at lower cost than competitors.

KEY ACHIEVEMENTS

The University of Adelaide has created a world-leading Atom Trap Trace Analysis (ATTA) facility to enhance the sustainable management of Australia's precious groundwater.

The ATTA system counts individual atoms of noble gas isotopes, present in ultra-low concentrations.



It will enable precise tracking of groundwater systems' movement, flow rates and recharge speed over time.

atomic answers in the aquifer

PROFESSOR ANDRE LUITEN
Lead researcher

In the world's driest continent, where vast swathes of land are permanently parched or increasingly prone to periodic drought, water security verges on obsession.

Australia's surface-water scarcity makes the country's deep groundwater systems incredibly valuable—they provide around 30 per cent of national consumption—and their sustainable management is critical to life and industry.

Now, a research partnership between the University of Adelaide and the Commonwealth Scientific and Industrial Research Organisation has provided world-leading, cutting-edge technology to inform those groundwater management decisions with greater accuracy than ever before.

The partnership's Noble Gas Tracer Facility, incorporating the Southern Hemisphere's first Atom Trap Trace Analysis (ATTA) system, measures ultra-low concentrations of naturally occurring radioactive noble gases absorbed in the groundwater. This enables precise analysis of water systems' age, origin and interconnectivity—all vital for making informed, cost-effective decisions about the water's sustainable use.

"We can see how fast the water's flowing, how quickly and reliably the aquifer's recharging, and the directions in which it's moving," says lead researcher Professor Andre Luiten. "That makes it infinitely easier to predict the likely environmental impacts of extracting it, and the steps needed to avoid contamination by agriculture, mining and other industrial activity, such as carbon and waste storage."

Launched in late 2019 at the University's inner-city Adelaide campus, the ATTA technology uses state-of-the-art laser physics to count individual atoms of the isotopes Krypton-81 and -85, and Argon-39, which collectively enable accurate hydrological dating from 12 months to one million years. Notably, the system is the world's first to measure all three isotopes at once.

According to Luiten, these capabilities will also enhance investigations in other hydrological systems. "For example, it's going to allow researchers to look even deeper into Antarctica's climatic history through ice-core analysis, and expand our understanding of global environmental change."

Even this, however, barely touches the technology's potential. Further advances, Luiten enthuses, are already on the horizon.

"We recently identified new techniques that will substantially improve our ATTA method. We're now designing a second-generation instrument with 10 times the current throughput capacity, and 20 times the atom-counting efficiency."

WHY TARGET NOBLE GASES?

Noble gas isotopes are considered the gold standard in environmental tracers for tracking groundwater movement. Unlike established tracers, such as tritium and chlorofluorocarbons, noble gases do not react geochemically, so they are highly reliable and their input conditions are well defined.

in pursuit of net zero

Like the rest of the world, Australia has committed to decarbonising. And beyond the nation's official Paris Agreement obligations, there's widespread community agitation to reduce CO_2 emissions to net zero by 2050. But achieving this in a country predicting 40 per cent population growth over that period, and renowned as one of the world's worst per-capita emitters, won't be easy.

Multiple measures will need to be invested in, at the right times, to enable a smooth economic transition—and that's going to require vast, global intelligence and extensive data modelling capability. On both counts, the University of Adelaide is helping to make it happen.

A research team at the University has led two important collaborative projects at the Australian Government-funded Future Fuels Cooperative Research Centre (CRC): one, analysing the various paths being taken around the world to introduce 'green' hydrogen into economies; and the other, building a massive, highly detailed model of the entire Australian economy to predict the likely impact of emissions-reduction measures, including the introduction of green hydrogen.

"Our overarching objective is to help make it easier for Australia to reduce its carbon emissions by optimising the sequence of investments it makes," says research lead Professor Mike Young. "Getting that right will save the country huge amounts of money and help to build public support. Both of those outcomes are critical for maintaining our decarbonisation momentum."

The team's first step was an in-depth global hydrogen roadmaps review. This was completed in mid-2019 and submitted to the Australian Government to help inform its National Hydrogen Strategy, launched later that year.

According to Young, the review included nuanced analysis of hydrogen strategies being implemented in 19 different regions and nations—even some individual cities—including the US, European Union, South Korea, China and London.

"We looked at how each of these entities is approaching all aspects of building and strengthening their hydrogen infrastructure, industry and use. Then we identified a series of key takeaways that we felt were particularly pertinent for Australia—a nation blessed with all

PROFESSOR MIKE YOUNG
Research leader

the necessary resources to produce abundant green hydrogen."

The economy-wide modelling project was launched as a follow-on in 2020, and remains ongoing. Its potential benefits, says Young, are enormous.

"We're building the capability to assess the likely economic, societal and greenhouse impact of every conceivable emissions-reduction measure—and their timing relative to each other—right across the country.

"We're even enabling emissions hotspots, like Western Australia's Pilbara and South Australia's 'iron triangle', to be modelled independently.

"Hopefully this will help replace economic doubt and fear with excitement for a brighter future."

situation critical

It's decarbonisation's great irony: even as we stop plying the earth for fossil fuels, our shift to clean energy will require the extraction of ever more non-renewable resources.

A number of metals and non-metals, collectively known as "critical minerals", have essential roles to play in our low-emissions future. Including rare earth elements (REE), cobalt, lithium, germanium, gallium, tungsten and others, these minerals are variously key ingredients in items such as wind turbines, electric motors, batteries and solar panels. They're also vital components in high-tech electronics, from the ubiquitous smart phone to advanced national security and defence equipment.

ASSOCIATE PROFESSOR CARL SPANDLER
Lead researcher

For those nations manufacturing, or intending to manufacture, these technologies, a plentiful, responsible and reliable supply of critical minerals will be paramount; and research at the University of Adelaide is paving the way for Australia—already one of the world's top five critical minerals producers and the second largest source of REEs—to help deliver it.

In 2020, the University launched the Critical Minerals Research Centre to explore and overcome all challenges the country might face as it seeks to ramp up its global critical-minerals role. According to the centre's director and lead researcher, Associate Professor Carl Spandler, the work is becoming increasingly urgent.

"Currently, many critical minerals carry significant supply risk for a number of countries," he says. "Geopolitical tensions, environmental, economic and social issues are all contributing to make buyers uneasy.

"Alternate supply chains are needed, and Australia's one of the few countries in the world with the necessary balance of prospective geology and a well-established, modern mineral resources sector."

Integrating world-class expertise across geoscience, economics, geopolitics, metallurgy, environmental science and engineering, the centre's team considers all links in the mining value chain.

"What more can we learn about the geological controls on critical mineral ore formation, and what can that tell us about Australia's potential for new discoveries? Can we locate them more rapidly? Cost-effectively?

"Just as importantly, how can we minimise our environment impact? Can we recover more critical minerals from existing ores and mine wastes? And how can we innovate to use less energy and water?

"We're determined to find the answers."

meningococcal

Much progress has been made in reducing meningococcal B's global health burden.

A vaccine introduced in 2013, known as 4CMenB (Bexsero®), has been shown to significantly reduce the incidence of potentially fatal invasive meningococcal disease (IMD) the meningococcus bacteria can cause. The vaccine's effect on herd immunity, however, has been unknown. Now, world-leading University of Adelaide research has the answer.

From early 2017 through until the end of 2018, the University conducted the largest randomised controlled trial ever undertaken to investigate herd immunity. Called *B Part of It*, the study tracked 4CMenB's impact on meningococcal B carriage among a cohort of almost 35,000 students aged 15 to 18—the age group most likely to carry and spread the bacteria, and one of those at greatest risk of developing IMD.

Enrolled in years 10, 11 and 12 at schools throughout South Australia, the youths were immunised through the state's school immunisation program.

Below: Professor Helen Marshall

milestone

Doses were given at the trial's outset and after two months; throat swabs were taken at the outset and at 12 months.

According to lead researcher Professor Helen Marshall, the results, published in the *New England Journal of Medicine*[1] in early 2020, were conclusive. "Although 4CMenB protected young people from developing IMD—and very effectively, at that—it did not reduce the chance of them carrying meningococcal B in their throat," she says. "Community transmission was no less likely."

Although a herd immunity effect would have meant fewer individuals needed to be vaccinated to reduce IMD incidence across the community, which could reduce vaccination program costs, the findings are still incredibly valuable.

"We now know beyond doubt that all our young people need to be vaccinated against meningococcal B infection if they're to have direct protection against meningococcal disease.

"That's a different and important finding compared to meningococcal C vaccines, which have been shown to induce a herd immunity effect when given to adolescents.

"This knowledge has already been used in Australia and globally to support meningococcal B immunisation programs for children and young people, and to inform cost-effectiveness analyses for meningococcal B vaccine immunisation policy all over the world. It will also undoubtedly inform development of the next generation of meningococcal B vaccines in future."

Another of the study's valuable outcomes was the finding that 4CMenB did reduce carriage of other types of meningococcal bacteria. This supported emerging evidence that 4CMenB may also provide protection against gonorrhoea, something long suspected in countries using meningococcal B vaccine.

Marshall explains the link: "The various meningococcal B strains don't all have the same structures; most have what we refer to as a capsule around them—an outer coat—but some do not. Those that don't are more similar to the gonococcus bacteria, which also has no capsule. Both types of bacteria are from the *Neisseria* family.

"When looking solely at those meningococcal B strains without capsules, we did find some reduction in carriage among those vaccinated. So it's quite possible that 4CMenB would also reduce disease due to the gonococcus bacteria."

Based on this finding, Marshall and her team have since been funded by the Australian Government's National Health and Medical Research Council to head a collaborative research project assessing 4CMenB's impact on gonorrhoea in Australia's Northern Territory, where rates of the disease—which can cause infertility in women—are the highest in the country.

"As we're all now highly aware as a result of COVID-19, effective public health initiatives are just so important when it comes to looking after our communities and economies. We're very proud to be playing our part."

[1] *Marshall, H, McMillan, M, Koehler, A, Lawrence, A, Sullivan, T, MacLennan, J, Maiden, M, Ladhani, S, Ramsay, M, Trotter, C, Borrow, R, Finn, A, Kahler, C, Whelan, J, Vadivelu, K & Richmond, P 2020, Meningococcal B Vaccine and Meningococcal Carriage in Adolescents in Australia, New England Journal of Medicine, 382:318-327, DOI: 10.1056/NEJMoa1900236*

University of Adelaide research has established for the first time that meningococcal B vaccination confers no reduction in carriage of the meningococcus B bacteria and is unlikely to induce a herd immunity benefit.

The University conducted the largest study investigating herd immunity ever undertaken, involving nearly 35,000 adolescent participants.

The findings have global importance for vaccination programs and policy, and have led to additional research into 4CMenB's potential protection against gonorrhoea.

protecting the public purse

PROFESSOR TRACY MERLIN
Lead researcher

OUR HEALTH TECHNOLOGY ASSESSMENT TEAM'S IMPACT BY THE NUMBERS: 2002 – 2020

59
medical-service assessment reports commissioned by the Australian Government

43
new health services subsidised

>2.6m
uses of these proven-effective services between 2006 and the end of 2019

>869,000
service uses between 2011 and 2016 alone, worth almost AUD$160 million

Sometime between the fifth and third centuries BC, the Hippocratic Oath implored health practitioners to *do no harm or injustice*. Were it written today, that expectation would undoubtedly extend to publicly funded healthcare systems. Ensuring equitable access to safe, effective care is, in many countries, a key role of government. In Australia, it's actively facilitated by the University of Adelaide.

A specialist research group at the University has been evaluating new and existing healthcare services and technologies for the Australian Government's health department for 19 years. Their task: ensure all subsidies provided through the country's Medical Benefits Schedule, known as Medicare, represent money well spent.

According to lead researcher Professor Tracy Merlin, it's a part the team's incredibly proud to play. "Without Medicare, patients would have to pay in full for all healthcare provided by a general practitioner or medical specialist outside the public hospital system," she says.

"That includes consultations, medical or surgical procedures, pathology and blood tests, imaging services... The costs would become prohibitive very, very quickly, so it's imperative we keep the system running as effectively and safely as possible."

The impact of system failure, she adds, would be felt most keenly by those least able to absorb it.

"People living in rural and remote areas, and those with limited income, are disproportionately affected when necessary services aren't subsidised. Their health can really suffer."

Since their establishment in 2001, the team has evaluated a huge variety of medical services. Many they recommended, many they did not; some they pushed to conduct further clinical trials. But the most satisfying, reflects Merlin, have been those requiring the development of entirely new assessment methods, such as when personalised medicines were introduced in 2013.

"It was the first time we'd had to evaluate co-dependent technologies—medicines, primarily for cancer treatment, that are dependent on a companion diagnostic test to identify specific genetic targets in the tumours. There was no system in the world that assessed the genetic test and medicine together to see whether their combined use was safe, effective and cost-effective. So we created one.

"These methods inform government guidelines for drug companies and test manufacturers today."

cerebral palsy's gene team

For decades, the medical world suspected cerebral palsy (CP) was largely caused by perinatal asphyxia—insufficient oxygen to the brain at birth. Studies have shown, however, that this is true in just eight to 10 per cent of cases.

Premature arrival and birth trauma have also been proven to play a part. But as many as 40 per cent of presentations remain unexplained by these sources. Thanks largely to pioneering research by the University of Adelaide, we now know where the missing attribution lies: in the genes.

Playing a leading role in the Australian Collaborative Cerebral Palsy group it founded, the University's research team has over the past five years headed numerous peer-reviewed investigations into the debilitating movement and posture disorder's genetic and genomic origins. This research has effectively rewritten the CP textbook.

"We've established that in at least one in four children with CP the disorder's origin can be assigned to a genetic error or mutation," says lead researcher Professor Jozef Gecz. "Such errors in DNA can be passed on from the unaffected parents or occur spontaneously—and current technologies allow us to identify them very soon after birth."

PROFESSOR JOZEF GECZ
Lead researcher

This knowledge, Gecz continues, opens myriad opportunities. "We can devise precise medical interventions and better management plans from a very early age, which could lead to greatly improved quality of life for the child, and reduced stress and disruption for their family.

"It enables more informed counselling for parents of children with CP regarding the risk of recurrence as their family grows; this had been considered as low as one per cent, but factoring in genetic risks could put it as high as 10.

"Ultimately, it's possible that genetic CP could one day be prevented."

fat blocked metastasis stopped

University of Adelaide-led research has found fat-breakdown plays a critical part in prostate cancer cells' treatment resistance, survival and spread.

The enzyme DECR1 was found to enable and control the fat breakdown.

Blocking DECR1—which can be done using existing cardiovascular disease therapies—stopped the cancer cells spreading and killed them.

PROFESSOR LISA BUTLER
Lead researcher

For men past their mid-40s, prostate cancer is an ever-present threat. Worldwide, it's the second most common cancer among them, killing nearly 380,000 annually. Until now, a huge barrier to recovery has been prostate tumours' eventual resistance to treatment. But exciting University of Adelaide-led research has uncovered a hidden vulnerability in tumours' cells—and a ready-made way to exploit it.

The research team published two studies[1,2] in 2020 showing three key findings: one, the breakdown of fats in prostate cancer cells is an important cause of treatment resistance; two, one particular enzyme enables that fat breakdown; and three, blocking that enzyme—which could be done with drugs already approved for use against cardiovascular disease—can stop the cancer's spread, or metastasis, in its tracks.

"We're always wary of using the term 'breakthrough' in medical research," says lead researcher Professor Lisa Butler. "But this could make an enormous difference to prostate cancer patients' prognosis, and quality of life, in very short time.

"Translating research findings from the lab to the clinic normally takes years; the ability to repurpose pre-approved drugs could drastically reduce that timeframe."

The team first found that prostate cancer cells rely heavily on polyunsaturated fatty acids to fuel their survival and spread throughout the body. The fats were either taken up through patients' diets, or generated in the cancer cells themselves.

"Importantly, we noticed that the cancer cells needed to carefully control the levels of these fats," explains Butler. "An excess of them was toxic for the cells."

Building on this insight, the researchers sought to understand how that fat-level control was facilitated.

"We identified an enzyme called DECR1 as being essential for fat breakdown. The cancer cells were using it both to generate energy and to protect themselves from dying due to excess fat levels.

"And to our great delight, we found that by blocking the DECR1 we could not only stop the cancer cells from metastasising, but kill them."

The fact that approved medication already exists that mimics the DECR1-blocking role, Butler adds, is the icing on the cake.

"This discovery provides the opportunity to take proven-safe drugs that are already in use for conditions such as angina, and redirect them to improve—potentially dramatically—prostate cancer survival rates, not to mention patients' and their loved ones' peace of mind. So that positive impact can be felt in a fraction of the time it would otherwise take to create a new therapy."

The team hopes to undertake proof-of-concept clinical trials in 2021.

[1]*Nassar, Z, Mah, CY, Centenera, M, Irani, S, Sadowski, M, Scott, J, Nguyen, E, Nagarajan, S, Moldovan, M, Lynn, D, Daly, R, Hoy, A & Butler, L 2020, Fatty Acid Oxidation Is an Adaptive Survival Pathway Induced in Prostate Tumors by HSP90 Inhibition, Molecular Cancer Research, DOI: 10.1158/1541-7786.MCR-20-0570*

[2]*Nassar, Z, Mah, CY, Dehairs, J, Burvenich, I, Irani, S, Centenera, M, Helm, M, Shrestha, R, Moldovan, M, Don, A, Holst, J, Scott, A, Horvath, L, Lynn, D, Selth, L, Hoy, A, Swinnen, J & Butler, L 2020, Human DECR1 is an androgen-repressed survival factor that regulates PUFA oxidation to protect prostate tumor cells from ferroptosis, eLife, 9:e54166 doi: 10.7554/eLife.54166*

PROFESSOR GUSTAVO CARNEIRO
Lead researcher

ASSOCIATE PROFESSOR LOUISE HULL
Project leader

technology supporting endometriosis sufferers

It's been called 'the secret plague'. Endometriosis, the spread of uterus-like tissue elsewhere in the body, is estimated to affect around 200 million women worldwide. Yet, due to difficulty of diagnosis, many suffer chronic, often-severe pain—particularly during menstruation—unseen.

Complicating matters, even those diagnosed can feel reluctant to discuss their condition due to a lingering social stigma. Two new medical-technology projects underway at the University of Adelaide, however, offer cause for hope.

In the first, the University's health and computer science researchers are collaborating to create an alternative, non-invasive form of diagnosis, using machine learning. The technology will avoid the need for surgery, which—although a highly effective diagnosis method—does carry risks and can require a week or more for recovery.

"We've developed algorithms to detect endometriotic lesions, based on ultrasound imaging scans," says machine learning lead Professor Gustavo Carneiro. "The preliminary results have been promising and further research will allow for continued AI development to improve accuracy. Once fully developed, the algorithm will give women the answers they need sooner, without surgery, and will enable earlier access to treatment and support."

The second project is the development of an empowering new online platform through which endometriosis sufferers can manage their health. Supported by the Australian Government and Jean Hailes for Women's Health organisation, and designed in consultation with Australia's endometriosis community, the platform will enable women to make timely treatment decisions.

"It will be a one-stop shop," says project leader Associate Professor Louise Hull. "The portal will feature a wide range of research-based tools, resources and information to assist with managing endometriosis, and support patient-clinician engagement."

Importantly, it will incorporate advanced analytics, enabling the platform to 'learn' from users and deliver a personalised experience. "Women will be served the content and resources they identify as important to them, when they need it, and we'll be able to continually optimise the platform.

"We're bridging the gap between research, clinicians, public policy and the endometriosis community."

Photo: Unsplash, Alex Kalligas

doctorates of distinction

The University of Adelaide's higher-degree-by-research program produces a steady stream of world-class discovery and early-career talent. Our PhD students explore innovative solutions to challenges affecting people, industry and our environment. They develop high-level professional skills. And they're supported to apply their research in the real world.

Here are some recent highlights.

DR KATHARINA RICHTER

MIT Technology Review Innovators Under 35, Asia Pacific, 2019
South Australian Science Awards Winner for PhD Research Excellence, 2018

Dr Richter is developing novel treatments to kill antibiotic-resistant bacteria and bringing them to clinical applications, specifically for surgical site infections, non-healing wounds and chronic sinus infections. Two innovative therapies have progressed successfully through pilot studies in humans.

DR JESSICA BOHORQUEZ AREVALO

3MT (Three Minute Thesis) Asia Pacific Winner, 2019

Jessica's research centres on the custom-design of machine learning algorithms based on artificial neural networks for the condition assessment of pressurised water pipelines using fluid transient waves.

DR SAMUEL COSTELLO

South Australian Science Awards Finalist for PhD Research Excellence, 2020

Dr Costello is investigating faecal microbiota transplantation (FMT) as a treatment for ulcerative colitis. He co-founded the stool bank *BiomeBank* to supply patients in Australia and Asia with safe and reliable FMT access, and support further research and development in microbial therapies.

DR ERINN FAGAN-JEFFRIES

South Australian Science Awards Finalist for PhD Research Excellence, 2020

Dr Fagan-Jeffries is dedicated to discovering and describing new species of parasitoid wasps to better understand our biodiversity. A passionate communicator, she gives numerous public lectures and workshops, and runs a school-based citizen science project for students interested in entomology.

DR MELISSA MIDDELDORP

South Australian Science Awards Finalist for PhD Research Excellence, 2020

Dr Middeldorp's research is in atrial fibrillation (AF), risk factor modification and patient education. During her PhD, she established and implemented a risk-factor-modification program for AF patients that has already informed changes to AF patient management guidelines.

DR OLIVIA COUSINS

Joint PhD with University of Nottingham

Dr Cousins's research enhanced understanding of soil, water, nitrogen and plant interactions, and showed how variable water and nitrogen levels can be manipulated to maximise wheat-crop growth under sub-optimal conditions, in which lower quantities of both resources are available.

DR HAOYU LOU

Joint PhD with University of Nottingham

Dr Lou employed CRISPR/Cas9 gene editing and computer modelling in her research to show two related genes' roles in regulating the biosynthesis of important carbohydrates in barley root cell walls, and in barley root-tip development. This opens a promising new direction in barley breeding.

DR CAMILLE ROULIÈRE

Joint PhD with University of Caen Normandie Doctoral Research Medal (Adelaide), 2018
CHASS (Council for the Humanities, Arts and Social Sciences) Australia Prize for a student Winner, 2017

Dr Roulière's research explores spatial poetics: the manner in which people engage and interact with their environment through art. Her PhD focused on the relationships between humans, waters and sound—both intrinsic and human-produced—around the mouth of the Murray River in South Australia.

blue is the new green

In the search for potential natural allies to help combat climate change, marine coastal vegetation sits near the top of the list.

Known as 'blue carbon' ecosystems, mangroves, saltmarshes and seagrass meadows are carbon-storage machines, absorbing CO_2 up to 40 times faster than terrestrial forests and trapping carbon in the soil for millennia.

They are also incredibly valuable for many other reasons, supporting biodiversity, stabilising shorelines, providing nursery habitats for commercially fished species, improving water quality and enabling unique recreation and tourism opportunities—all of which helps to sustain regional economies. But if governments are to prioritise nurturing blue carbon ecosystems, they're going to need hard, local evidence. *Exactly what difference does coastal vegetation make to our emissions targets in our exact location and climatic conditions?*

Now, thanks to University of Adelaide-led research, the driest state in the world's driest continent has that data. The research team has quantified—for the first time—the total carbon-storage capacity of South Australia's coastal mangrove, saltmarsh and seagrass habitats.

"After mapping the state's entire coastline, we now know South Australia has 1.12 million hectares of blue-carbon ecosystems," says research leader Professor Bronwyn Gillanders. "That's almost the size of Qatar.

"We've calculated that this vegetation currently holds the equivalent of five to ten years' worth of the state's carbon emissions. And it has additional capacity to sequester another 0.36 to 0.83 million tonnes of CO_2 every year, offsetting up to 3.6 per cent of the state's annual greenhouse gas emissions."

Through various case studies, the team also confirmed that far more carbon is stored in healthy ecosystems than degraded ones, adds project leader Dr Alice Jones. "Considered in total, our findings put beyond doubt the importance of conserving and restoring our blue carbon habitats," she says, "particularly when these areas are facing increasing pressure from coastal development, pollution and rising sea levels."

For Gillanders and Jones, however, presenting an evidence-based case for holding ground is only half the job; they're equally concerned with identifying how best to achieve that objective. With this in mind, they've recently undertaken two important, complementary missions.

The first is generating maps to show South Australia's coastal vegetated habitats' blue carbon storage potential. "We've already finished this for the coastline around metropolitan Adelaide," says Jones, "and we hope to extend this approach across the entire state."

The second, closely related project is using the blue carbon potential maps to help identify area-specific management strategies. Gillanders explains: "It's likely that some saltmarsh vegetation will be lost because of its inability to retreat from rising seas beyond physical barriers, or because of human activity, whereas other areas will open up.

"So we're assessing the possible effectiveness of taking steps such as installing culverts to assist tidal flows; returning marginal drained or ponded farmland to its natural, coastal form; and fencing off areas to protect them from human impacts."

The University's work has already helped to inform the South Australian Government's Blue Carbon Strategy, and our researchers are now also advising the Australian Government on ways to include blue carbon in the country's Emissions Reduction Fund and carbon inventory. Jones is confident that, once the latter is finalised—providing a clear financial incentive for protecting and restoring coastal ecosystems—private enterprise will follow the lead.

"I've no doubt organisations will start setting up restoration projects in these ecosystems if they can get carbon credits, because they just have so many benefits for people and the natural world.

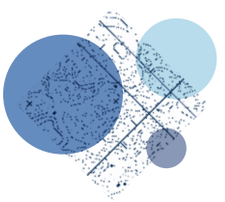
"This is a critical step to mitigate climate change."

Above (left to right): Dr Alice Jones and Professor Bronwyn Gillanders

Photo: Unsplash, Max Conacher

KEY ACHIEVEMENTS

University of Adelaide-led research has quantified, for the first time, local blue carbon coastal ecosystems' total contribution to absorbing South Australia's greenhouse gas emissions.



The research team is creating a map to show the state's likely blue carbon storage potential and inform regional preservation strategies.

Our researchers are advising the Australian Government on ways to incorporate blue carbon projects in the country's Emissions Reduction Fund and carbon inventory.

optimising the flow

With climate change threatening to double the number of people experiencing water stress globally by 2050[1], competition for water allocations will become extreme.

To maintain equity—and the social and economic stability that comes with it—best practice water markets will be critical; and University of Adelaide research is contributing significantly to improving their governance.

The University's Professor Sarah Wheeler and Associate Professor Alec Zuo are among the leading authorities on Australia's Murray-Darling Basin (MDB) water markets, considered the most developed and adopted in the world. Their ongoing research, both independent and commissioned by state and federal agencies, is providing critical insights into the effective design and governance of the country's water management systems.

A recent focus for the pair has been assessing water market governance failures and the impact of MDB water entitlement ownership by non-landholders—government and non-government organisations, and investors, such as superannuation companies and trade speculators[2,3].

"With increasing water scarcity and growing market participation, water is now one of the most valuable assets many MDB irrigators own," says Zuo.

"We've found considerable variation in financial valuation and accounting methods, and a large number of areas of market failure. That obviously makes it hard to maintain equity, so we feel there's a pressing need for standardisation and for water market governance changes."

Another recent project for Wheeler, this time collaborating with Oxford University's Associate Professor Dustin Garrick, has been identifying market participation drivers. She and Garrick analysed historical water market activity in both the southern and northern MDB to uncover the key factors, or 'policy levers', that most influence trading activity and volume[4].

"There were three stand-outs," says Wheeler. "Distribution of initial property rights in resource allocation; the need to prepare for and seize opportunities to strengthen property rights; and the institution of robust monitoring and compliance requirements."

Further research into water market governance by Wheeler and Zuo included the world's first comprehensive investigation into the area for signs of insider trading[5], and their studies into water scarcity's impact on landholders' mental health[6,7]—highlighting the need for urgent action to address rural suicide—similarly broke new ground.

"Ultimately we're seeking the most effective ways of sharing water to improve net social welfare," reflects Zuo. "Economic strength must come hand in hand with environmental and human health."

PROFESSOR SARAH WHEELER
Senior researcher

ASSOCIATE PROFESSOR ALEC ZUO
Senior researcher

[1] *Munia, HA, Guillaume, JHA, Wada, Y, Veldkamp, T, Virkki, V & Kummu, M 2020, Future transboundary water stress and its drivers under climate change: A global study, Earth's Future, 8, e2019EF001321*

[2] *Seidl, C, Wheeler, SA & Zuo, A 2020, Treating water markets like stock markets: Key water market reform lessons in the Murray-Darling Basin, Journal of Hydrology, 581, 124399*

[3] *Seidl, C, Wheeler, S & Zuo, A 2020, High turbidity: Water valuation and accounting in the Murray-Darling Basin, Agricultural Water Management, 230, 10592*

[4] *Wheeler, S & Garrick, D 2020, A tale of two water markets in Australia: lessons for understanding participation in formal water markets, Oxford Review of Economic Policy, 36, 132–53*

[5] *de Bonviller, S, Zuo, A & Wheeler, S 2019, Is there evidence of insider trading in Australian water markets?, Australian Journal of Agricultural and Resource Economics, 63, 307-27*

[6] *Daghagh Yazd, S, Wheeler, S & Zuo, A 2020, Understanding the impacts of water scarcity and socio-economic demographics on farmer mental health in the Murray-Darling Basin, Ecological Economics, 169, 106564*

[7] *Wheeler, S, Zuo, A & Loch, A 2018, Water torture: unravelling the psychological distress of irrigators in Australia, Journal of Rural Studies, 62, 183-194*

averting disaster

PROFESSOR HOLGER MAIER
Lead researcher

It's an unsettling prognosis. Driven by climate change, population growth and economic development, natural hazards —such as the recent bushfires in Australia and the US, heatwaves in Europe, and floods in Japan—will in coming years become an even bigger threat.

They will occur more frequently and with greater intensity. One will 'cascade' into another more regularly. Costs to life and economies will spiral.

So what are governments to do? How are they to identify which risk mitigation strategies will work today, in their specific environment, without causing new, unforeseen problems tomorrow? Ground-breaking University of Adelaide-led research is presenting an answer.

Collaborating with government agencies across four Australian states, and funded through the national Bushfire and Natural Hazards Cooperative Research Centre our team has co-developed the world's most holistic risk mitigation decision-support tool. Called UNHaRMED, which stands for *Unified Natural Hazard Risk Mitigation Exploratory Decision support system*, the software is the first to enable authorities to model changes in their spatial risk profile over time in response to multiple, interacting variables—including potential risk mitigation strategies themselves.

"It's a kind of risk mitigation policy wind tunnel," says lead researcher Professor Holger Maier.

"UNHaRMED lets decision-makers test how their local disaster risk will be affected by climate, population and economic drivers; mitigation measures, such as restricting land use, strengthening building codes, constructing sea walls or increasing controlled burns; and by all factors' cumulative influence on each other.

"Cost-benefit trade-offs can be explored over time, producing the most comprehensive evidence base yet possible for the adoption of robust, long-term risk reduction strategies."

Prototype UNHaRMED applications have now been developed for authorities in South and Western Australia, Victoria and Tasmania. And Maier and his colleagues are continuing to build even greater flexibility into the system, conducting ongoing research into ways of quantifying social vulnerability.

"We're currently looking at ways of accounting for the impact of people's lived experiences of disasters," he says, "and the fact that certain areas have multiple, different uses throughout the day, each creating its own unique risk profile."

The result, he believes, will be a tool suitable for embedding in government processes across the country to inform policy economy-wide, and reduce future disaster risk.

"The principles underlying UNHaRMED can be used for long-term planning in utilities, transport and just about any other sector to facilitate a truly integrated approach.

"For example, we've just launched an industry-backed PhD with South Australia's water and electricity authorities to investigate applying these principles to cyber-security risks threatening our state's water supply.

"This could be the difference that allows Australia to effectively increase its collective preparedness for disasters of all kinds, rather than being surprised and caught-out by future catastrophes. After the events of our last summer, that's something we're all hoping for."

KEY ACHIEVEMENTS

A University of Adelaide research team has led the co-development of the world's most holistic disaster risk mitigation decision-support tool.

The system is the first to enable authorities to model changes in their spatial risk profile over time in response to multiple, interacting variables.

Cost-benefit trade-offs can be explored for all potential mitigation strategies, even taking into account their impact on each other.

the bones are talking

ASSOCIATE PROFESSOR LEE ARNOLD
Lead researcher

DR LIZ REED
Senior researcher

South Australia's Naracoorte Caves are a UNESCO World Heritage-listed treasure. Among thousands of fossils already found there are nearly 20 species of megafauna and over 135 small vertebrate species. But there's much more to come; the Caves promise to provide a clear record of environmental change over the past 500,000 years, and priceless insight into shifts currently underway. University of Adelaide-led research is bringing it all to light.

In collaboration with other Australian universities, museums, government and industry partners, our researchers have taken on the mammoth task of excavating the multi-chamber limestone system's estimated 5,000 tonnes of still-untouched sediment; cataloguing its contents; and piecing together its unprecedented fossil and environmental record. Lead researcher Associate Professor Lee Arnold:

"Our study integrates all aspects of the Caves' preserved deposits—flora, fauna, wildfire records, sediment and calcite formations.

"We'll learn a huge amount about variations in rainfall and climate, which will allow us to understand past biodiversity responses to variability, and inform future conservation and climate change adaptation strategies."

The team is employing innovative approaches in geochronology, palaeontology and geochemistry to develop comprehensive palaeoecological and palaeoclimatic histories for the site. They're also creating, for the first time, a highly detailed 3D model of the entire known Naracoorte system and surrounding region.

As cutting-edge and valuable as the work is, it's the tantalising possibility of further megafauna discoveries that most excites the Caves' steady flow of tourists. "They're definitely the rock stars of the collection," says senior researcher Dr Liz Reed.

"The area's already known to have been home to gigantic short-faced kangaroos; a huge 5-metre snake, *Wonambi naracoortensis*; a large tapir-like marsupial, *Palorchestes azael*; and, of course, there's the king of the Pleistocene forests, *Thylacoleo carnifex*—a fearsome relative of koalas and wombats. So naturally visitors to the Caves are always wondering what fantastical creature we'll find next.

"I can't blame them, either. I still feel that raw excitement myself every time I head back in there."

Left: Dr Liz Reed (right) unearthing fossils in South Australia's UNESCO World Heritage-listed Naracoorte Caves. Photos courtesy Steve Bourne.

healthier at home

COVID-19 has touched every aspect of our lives: where we can go, what we can do, who we can see—even how closely we can stand. Throughout it all, homes, for many people, have provided valuable refuge, a place to retreat and take stock. But as University of Adelaide research has confirmed, housing too is experiencing profound change, and more must follow.

Researchers at the University have been helping to inform the Australian Government's COVID-19 response through a series of related investigations, documenting the immediate impact on housing and predicting necessary post-pandemic changes.

According to lead researcher Professor Emma Baker, the studies have revealed two overriding positives. "The first is that Australia's housing system has actually become an important public health asset," she says.

"It's enabled our federal and state governments to roll out lockdowns and quarantining strategies to isolate and slow the spread of the virus, in most instances quite effectively."

The second, closely related positive was that many people have found their homes to be far more acceptable places to work from than they'd realised, a trend mirrored in many developed countries. But, Baker emphasises, glaring inequalities have also been exposed.

"Cruelly, the pandemic hit the lowest income, most precariously employed people in our society hardest—and these individuals typically had the least resilient housing circumstances.

PROFESSOR EMMA BAKER
Lead researcher

PROFESSOR CHRIS LEISHMAN
Senior researcher

Continued from previous page

The University of Adelaide has conducted significant housing research to help inform Australia's pandemic response.

Housing has become a frontline COVID-19 defence, but needs are changing—our housing will almost certainly look different in future.

Private renters have been especially vulnerable—large-scale federal intervention is urgently needed.

"Having enough indoor space, being able to keep it warm, and being able to access quality green spaces outside has become a lot more important to people."

Looking ahead, Baker can see this bringing market change. "We think people's preferences are likely to swing away from both open-plan and apartment living, towards more energy-efficient housing that can allow for working, studying and isolating."

The research also highlighted high levels of financial risk among Australia's property investors. Senior researcher Professor Chris Leishman: "We now know there are about 50,000 Australian households in which people are struggling to pay their own housing costs, yet they also own an investment property.

"And without the Australian Government's emergency *JobKeeper* income support measures, that number would have doubled. The pandemic is a potential disaster for these households if the right support measures aren't put in place going forward."

Perhaps worst affected of all has been the rental sector, which houses about a third of Australia's population. The University's team hosts the Australian Rental Housing Conditions Dataset, the largest national survey of Australian renters and their experiences during the pandemic. Early analysis of its findings paints a bleak picture.

"Almost all tenants have been affected in some, or often multiple, ways—including employment loss or reduction, inability to pay rent, and risk of eviction," says Baker. "Almost half reported stress, depression or anxiety, many skipped meals, and more than a third had accessed their superannuation or savings just to get by."

Here, government support was found wanting. "There were no federal interventions in the private rental sector," adds Leishman. "Instead, the government's direction was vague, and advisory at best, leaving each state and territory to figure out their own interventions. And most commentators felt these largely favoured owners and investors; as a nation, we have still made little progress towards ending no-fault evictions, for example.

"This is a serious problem arising from Australia's constitutional arrangements and the distribution of housing policy responsibilities. It must be addressed."

Ultimately, however, the team remains hopeful. "If the pandemic has shown us anything," Baker reflects, "it's that change is possible. We've already started to think differently about housing, and good things will come."

driving surrogacy reform

DR DAVID PLATER
Lead researcher

When laws dealing with surrogacy first appeared, they were, by today's standards, far from progressive. The Babylonians formally allowed the practice from around 1701 BC, purely as a means to hold together marriages between infertile male-female couples.

Since then, of course, monumental social and technological change has swept the world. There is now widespread, and still growing, acceptance of diverse family arrangements; and huge advances in reproductive technologies have made the dream of parenthood infinitely more accessible.

But in many regions, the law has struggled to keep pace. In Australia, the issue has also been exacerbated by rising infertility rates increasing surrogacy demand, just as the numbers of women prepared to be surrogate mothers has declined, prompting many would-be parents to seek poorly regulated services overseas.

In response, the Government of South Australia in 2017 asked the South Australian Law Reform Institute, an independent body hosted and led by the University of Adelaide, to explore and suggest a suitable contemporary regulatory framework for surrogacy in the state. Their subsequent report, submitted in 2018, paved the way for major change, culminating in Parliament passing the standalone *Surrogacy Act 2019 (SA)*.

Dr David Plater led the research. "Our report provided 69 recommendations," he says, "all of which were accepted. Key was the need to enshrine the child's right to know their full history and family; to remove restrictions on single people accessing lawful surrogacy; maintain legal distinction between commercial and non-commercial arrangements; and discourage offshore surrogacy."

Plater and his team also recommended taking a flexible approach to jurisdiction throughout Australia, to recognise the interstate aspects of surrogacy, while still discouraging 'forum shopping'—moving around to find the most favourable conditions.

"We're delighted to have helped better protect future surrogate families in South Australia."

Notably, the report's authors included a University of Adelaide student, Madeleine Thompson, who was able to see her research ultimately translate to real-world impact.

ASSOCIATE PROFESSOR ROB AMERY
Lead researcher

an ancient language lives on

The Kaurna Australian Aboriginal language was thought to be irretrievably lost, last heard nearly 160 years ago. Linguistic researchers from the University of Adelaide and Kaurna descendants, however, retained hope.

Today, after more than three decades of collaboration, the language is again in daily use; some adults have gained remarkable fluency; the first semi-native speakers are emerging; and an entire people's pride is on the rise.

The Kaurna (pronounced: *GAR-na*) Aboriginal people have for tens of thousands of years occupied what is known today as the Adelaide Plains in South Australia. But like many indigenous peoples and cultures, their very existence and identity has been threatened by colonial settlement.

The loss of their language, thought to have occurred by the 1860s, was central to this experience. And for too long, its permanent disappearance was simply accepted as inevitable.

"As recently as the 1990s the prevailing attitude among linguists was that language retrieval and revival was an impossible dream," says Associate Professor Rob Amery. "And certainly in the Kaurna language's case there were challenges; 19th century documentation was incomplete and sound recordings non-existent.

"But fortunately, the written record has been sufficient to enable the reconstruction of a working language."

Amery is the founding leader of the University's KWP team, which stands for Kaurna Warra Pintyanthi: *creating Kaurna language*. A community body comprising numerous Kaurna people, teachers, linguists and language enthusiasts, KWP was established in 2002 in collaboration with Kaurna elders Dr Lewis Yerloburka O'Brien and Dr Alitya Wallara Rigney to generate and manage all Kaurna language revival activities.

To help achieve the team's goals, Amery developed what he calls the formulaic method for reintroducing an "awakening" language in the absence of native speakers. Considered world-leading, the method involves initially teaching easy-to-learn key phrases that can stand alone; these are then built upon with increasingly complex utterances, eventually expanding the speaker's repertoire.

KWP has developed many Kaurna language resources: a comprehensive learner's guide; Kaurna funeral protocols book; translations of the Lord's Prayer and well-known hymns; and a puppet show for school children. "We've even created a deck of playing cards featuring Kaurna cultural icons, elders and language speakers."

Much progress has also been made in terms of broad community awareness. "Welcome to Country" speeches are now commonly given in the Kaurna language at the start of events right across the city of Adelaide; and our University, which itself stands on Kaurna land, has increased the language's presence on campus. A traditional Kaurna learning circle was built on our grounds in 2020 as a ceremonial meeting place, bearing a plaque reading "Kaurna miyurna wangkanthi marni naa pudni, Kaurna yarta-ana": *Kaurna people say good you all came to Kaurna country*.

But perhaps most pleasing of all, reflects Amery, is the work's impact on Kaurna people's wellbeing. "Having their language revived has considerably raised the Kaurna community's cultural pride and esteem. For many individuals, it has totally transformed their lives."

KEY ACHIEVEMENTS

The University of Adelaide has led collaborative efforts with the Kaurna Australian Aboriginal people to successfully revive their language.

The University developed a world-leading method, initially teaching easy-to-learn key standalone phrases that are then built upon.

The Kaurna language—unheard for nearly 160 years—is now back in daily use.

giving voice to a dark past

PROFESSOR ROBERT FOSTER
Lead researcher

PROFESSOR AMANDA NETTELBECK
Lead researcher

That relations between British colonisers and Indigenous Australians were marked by bloodshed is no secret. Nor is the vast disparity of the conflict's impact. It's thought that between the 1790s and 1930s around 20,000 Aboriginal people died violently; by contrast, European casualties are believed to be around a tenth of that number.

These estimates, however, remain controversial. And while we have access to some settlers' personal accounts of these events, through journal entries, letters, government records and the like, the Aboriginal perspective remains tellingly absent.

Now, the University of Adelaide is leading efforts to clarify this important history, and redress the imbalance. A research team is building a comprehensive interactive geospatial map of colonial conflict in South Australia, populated with accounts of the events handed down through generations by Indigenous and non-Indigenous communities.

Jointly led by Associate Professor Robert Foster and Professor Amanda Nettelbeck, with support from historian Dr Skye Krichauff, the project will produce the first polyvocal account of the history, and historical memory, of frontier conflict in the state.

"We will engage, with great sensitivity of course, with Aboriginal and settler-descended communities right across South Australia," says Foster.

"This will allow us to capture and bring to light 'frontier' stories that may otherwise have remained hidden or could even be lost. And presenting them in this way will add additional layers of meaning, giving the narratives a strong sense of place and clearly illustrating their spatial relationships."

The map is being developed in association with the History Trust of South Australia, the South Australian Museum, State Library of South Australia, State Records of South Australia and Reconciliation South Australia, and will be hosted by these partners upon completion.

"We're pursuing this research in the spirit of 'truth-telling'," adds Nettelbeck.

"We need a better understanding of Australia's colonial past if we are to advance the objectives of reconciliation."

'A fight at the Murray' by William Anderson Cawthorne, 1844
Image courtesy Mitchell Library, State Library of New South Wales

mitigating climate migration

Predictions regarding the potential impact of climate change on environmental health and biodiversity are stark. But the issues don't stop there.

ASSOCIATE PROFESSOR YAN TAN
Lead researcher

The UN 's estimates regarding the number of people likely to be forced into environmental migration start at around 25 million; at the upper end, they stretch to one billion.

Recognising the critical importance of governments and communities understanding how to prepare for this social upheaval, the University of Adelaide has led pioneering research in two of the most instructive regions in the world: China's desertifying west, and the sea-level-rise-prone Yangtze delta.

Collaborating with colleagues from Lanzhou University and the Chinese Academy of Sciences, the University's team investigated the theoretical, behavioural and policy dimensions of climate change and population mobility in these regions of China between 2011 and 2015. According to lead researcher Associate Professor Yan Tan, the findings show a relationship that's far from simple.

"If there was one thing that stood out to us, it was that this one thing—climate change—is not causing migration on its own.

"It's the result of a complex web of interactions between climate change and numerous other factors—demographic, social, economic and political. These interactions can work to exacerbate people's sense of vulnerability and inequality, and it's the degree to which they feel that cumulative pressure that shapes their migration behaviour and intent.

"Ironically, conducting state-led climate-change mitigation and adaptation projects actually increased population displacement and resettlement, as it raised people's awareness of their vulnerability."

This population mobility was found to have significant impacts in terms of people's livelihoods; the need to reconstruct social and cultural systems; and the provision of infrastructure and social services. It even created environmental consequences of its own.

Although focused on specific Chinese regions, adds Tan, the research offers salient lessons for authorities worldwide. "There's an urgent need for provincial and local governments to plan cohesive development programs in which local urbanisation and human resettlement are integral.

"We need to facilitate, rather than inhibit, people's willingness to take responsibility for their own livelihoods and improve their adaptive capacity."

targeting taint

Vision of the wholesale destruction to life and property wrought by the Australian bushfires of 2019-20 shocked the world. But for some of our winemakers, the fires' most damaging impacts were inflicted on assets left standing.

Right: Professor Kerry Wilkinson

Where smoke-exposed grapes were rendered incapable of producing wine without unpalatable smoky and ashy characters, fruit went unharvested—and an entire vintage was lost.

To put the issue in financial perspective, 2007 bushfires affecting the state of Victoria alone caused smoke-taint losses in excess of AUD$100 million. The 2019-20 blazes spanned prominent wine regions in Victoria, New South Wales, South Australia and the Australian Capital Territory. Although still not fully known, their economic toll could feasibly approach half a billion dollars.

Recognising the urgent need for action, the Australian Government has invested heavily in a major collaborative industry-university research project to develop new smoke-taint-management tools and strategies for the Australian wine industry. The University of Adelaide is taking the scientific lead.

"This is an incredibly important project," says head researcher Professor Kerry Wilkinson, "not just for our domestic wine industry's sustainability, but for those in fire-affected wine regions all over the world, including the US, Canada, South Africa and Chile."

Much of the biochemistry underlying smoke taint has been established over the last decade, in many cases by Wilkinson herself. The way in which smoke affects grapevine physiology, and the composition and sensory properties of grapes and wine, is all well understood.

Now, the University's team, collaborating closely with the project's industry lead, Cassegrain Wines, and research partners at the Australian Wine Research Institute and international technology companies Ligar and VA Filtration, is taking the next step: applying the science to overcome the problem.

According to Wilkinson, numerous promising innovations are being pursued. "One direction we're taking will evaluate novel technologies for removing smoke taint compounds during winemaking, such as Ligar's molecularly imprinted polymers. This builds on a previous project that I was involved in[1], in which we demonstrated the use of membrane filtration and adsorbents to mitigate the intensity of smoke aromas and flavours in wine made from smoke-exposed grapes."

Methods will also be explored for rapidly quantifying grapes' levels of smoke taint, to enable accelerated decision-making during vintage.

"We're developing new analytical tools of our own for monitoring grapevines' real-time smoke exposure," continues Wilkinson. "This again builds on some of my previous work[2], which demonstrated the use of a commercial sensor that measures particulate matter as a way of monitoring vineyard smoke exposure."

Finally, the team will investigate alternative uses for wine that retains its smoke taint, such as distillation for use in spirits.

With the incidence of bushfire predicted to increase as a result of climate change, and many Australian producers already struggling to cope with drought, the magnitude of the situation is not lost on Wilkinson.

"The last thing we want to see in our wine regions is hard-working producers pushed even closer to the edge by bushfires and smoke taint. We're doing everything we can to help mitigate the impact."

[1]*Fudge, A, Ristic, R, Wollan, D, Wilkinson, K 2011, Amelioration of Smoke Taint in Wine by Reverse Osmosis and Solid Phase Adsorption, Australian Journal of Grape and Wine Research, 17, S41-S38*

[2]*Szeto, C, Ristic, R, Capone, D, Puglisi, C, Pagay, V, Culbert, J, Jiang, W, Herderich, M, Tuke, J, Wilkinson, K 2020, Uptake and Glycosylation of Smoke-Derived Volatile Phenols by Cabernet Sauvignon Grapes and Their Subsequent Fate during Winemaking, Molecules, 25, 3720*

KEY ACHIEVEMENTS

University of Adelaide research is developing new tools and strategies to help grape growers and winemakers avoid, or mitigate, smoke taint.

Lost production due to smoke taint following the 2019-20 Australian bushfires could approach half a billion dollars (AUD).

The risk of bush-fires, and therefore smoke taint, is expected to increase with climate change.

PROFESSOR ANDY LOWE
Project supervisor

PROFESSOR SETH WESTRA
Lead researcher

vines' smart-tech lifeline

Australia's winegrape production is facing a trifecta of challenges: a drying climate, increasing water costs and more expensive labour. Consequently, growers from South Australia's Riverland, the country's largest wine region, are looking to use digital technologies to enhance their resource efficiency and bottom lines—and the University of Adelaide is converting their hopes to reality.

In consultation with Riverland growers, the University's researchers have established the VitiVisor project—developing a viticultural information, prediction and advisory platform that will help lower the cost of winegrape production.

"In the first phase, the project is focusing on one of viticulture's most costly resources—water—and its management within the vine canopy during the growing season," says project supervisor Professor Andy Lowe.

"The objective is to develop an integrated system supported by the latest technologies, such as machine learning, computer vision, analytics and robotics.

"We're producing an automated, 'smart' irrigation system for wine grapes that lowers labour and water costs, but increases the crop's value by optimising water delivery at every stage of the vines' growth."

The project brings together expertise from across the University—in viticulture, plant physiology, machine learning, computer vision, robotics, engineering, hydrology, systems analysis, modelling, economics and producer behaviour.

"'Hands-free hectares' is a term applied to farming systems that seek to reduce the amount of labour required by growers, and this is the approach supported by VitiVisor," says lead researcher Professor Seth Westra.

"Historically, vine management requires intensive labour and energy, with a lot of tractor use for spraying and pruning. With VitiVisor, we want growers to have the confidence to use water efficiency as a management tool to control canopy growth, lowering the cost of production by reducing water costs and tractor use."

The project is supported by Wine Australia and industry representative body Riverland Wine, with growers as core members of the design team.

future-proofing almonds

PROFESSOR MICHELLE WIRTHENSOHN
Program leader

Arguably the most nutritious of all foods[1], almonds are an incredibly beneficial part of the world's diet. They're also a valuable industry for many nations. But for some time, clouds have been gathering over the global crop; the vast majority of almond varieties require pollination by bees, which are in serious decline.

Recently, however, the Australian Almond Breeding Program, industry-funded via Hort Innovation and led by the University of Adelaide, has presented answers. The program has successfully developed four new almond varieties capable of self-fertilising—an Australian first. All require fewer bees for pollination. What's more, they have greater water-use efficiency and are significantly higher yielding than established breeds, such as Nonpareil, Carmel and Price.

This combination of traits, says program leader Dr Michelle Wirthensohn, is timely for all growers, but particularly those in Australia—the world's second largest almond producer.

"Our almond industry has grown steadily since 2010," she says. "Today in 2020 it covers 53,000 hectares, enabling us to produce around seven per cent of the world's crop.

"But the majority of that production is based on varieties developed over 100 years ago in California, all of which require complementary plantings and bee pollination; water stress is also an increasing issue. Consequently, up to half the trees in some orchards are starting to lose productivity, and many older orchards will require replanting in the coming decade."

With the new trees now available, orchard productivity can again accelerate. When considered together with gains offered by other new varieties released by the program, the new genetics could boost production by up to 15 per cent.

"Based on today's prices, that could equate to increased revenue of around AUD$133 million."

[1]Kim, S, Sung, J, Foo, M, Jin, Y-S & Kim, P-J 2015, Uncovering the Nutritional Landscape of Food, PLoS ONE 10(3): e0118697, https://doi.org/10.1371/journal.pone.0118697

more cream for indonesian dairy farmers

PROFESSOR WENDY UMBERGER
Research project leader

Indonesia's dairy demand is soaring. Fuelled by a burgeoning middle class, consumption has more than doubled in the past two decades. But local producers, the majority of whom operate smallholder farms, have struggled to keep up; local production provides less than 20 per cent of the country's supply.

A University of Adelaide-led project is helping to turn the tide. The IndoDairy project, with support from the Indonesian Government and Australian Centre for International Agricultural Research, is delivering improvements in both smallholders' productivity and their families' livelihoods.

"To keep up with this growing demand for dairy in Indonesia, there have been a variety of extension programs aiming to bridge the gap between new science and the local farmers," says research project leader Professor Wendy Umberger.

"But they haven't always been effective at introducing the right technology to address the farmers' unique needs or business goals. This has consequences throughout the value chain—from the smallholder farmers to the end consumer."

The University of Adelaide team researched both innovative extension methods and business models that incorporated meaningful incentives for smallholder dairy farmers.

"We wanted to understand what could lead to behaviour change, ultimately addressing the project goals of increased dairy production and improved milk quality and safety," says Umberger. "And I'm delighted to say the initiatives we've recommended to date have had outstanding impact."

Across the industry, she adds, there's been new investment in farm infrastructure, farmers are collaborating and learning from each other, receiving greater support for farmers from dairy cooperatives, and taking up enhanced extension and training opportunities.

"We've also seen significant increases in farmers' adoption of, and intent to adopt, eight key dairy management practices, including teat dipping, making silage, record-keeping, and feeding calves colostrum.

"They're now well positioned to meet that growing consumer demand."